Proceedings of DRS 2018 International Conference: Catalyst 3.

Cristiano Storni, Keelin Leahy, Muireann McMahon, Peter Lloyd y Erik Bohemia.

DRS 2018 | Design as a catalyst for change

25–28 June 2018 Limerick, Ireland.

ISSN 2398-3132

VOLUME 3

Proceedings of DRS2018

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Design Research Society

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Proceedings of DRS 2018

Catalyst

Volume 3

Editors

Cristiano Storni, Keelin Leahy, Muireann McMahon

Peter Lloyd and Erik Bohemia

Proceedings of DRS
2018 International Conference
25–28 June 2018, Limerick, Ireland
www.drs2018limerick.org
Volume 1, 2, 3, 4, 5, 5, 7

Cover and conference identity design by Piquant
Conference identity design initial concept: Tamara Stone & Selina Kindt, Limerick Institution of Technology.
Proceedings compiled by Laura Santamaria, Cristiano Storni and Erik Bohemia

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Proceedings of DRS 2018 International Conference: Catalyst

ISSN 2398-3132

ISBN 978-1-912294-16-9 (ebook, volume 1)
ISBN 978-1-912294-17-6 (ebook, volume 2)
ISBN 978-1-912294-18-3 (ebook, volume 3)
ISBN 978-1-912294-19-0 (ebook, volume 4)
ISBN 978-1-912294-20-6 (ebook, volume 5)
ISBN 978-1-912294-21-3 (ebook, volume 6)
ISBN 978-1-912294-22-0 (ebook, volume 7)

Published by the Design Research Society
Loughborough University, London
3 Lesney Avenue, The Broadcast Centre, Here East
London, E15 2GZ
United Kingdom

Design Research Society Secretariat
email: admin@designresearchsociety.org
website: www.designresearchsociety.org

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How Organisations Employ Design as Vehicle for Change

Editorial

doi: 10.21606/drs.2018.000

DRS2018, hosted by the University of Limerick and the Limerick Institute of Technology is the first international biennial conference of the Design Research Society since the 50th anniversary conference in Brighton. This represented both a challenge and an opportunity; a challenge to meet the high standards set in 2016, but an opportunity to contribute to a growing design research field. The balance between these has translated into the conference theme of *Catalyst*. A catalyst is something that precipitates events; it is the coming together of different entities to generate something new; it is the spark for wider change. Framed by the Catalyst theme, these proceedings explore existing and emergent areas at the intersections of design research, practice, education and policy.

The conference itself built further on innovations from the past two conferences; developing more interactive conversation and debate formats, and providing a forum for practice-based research through the increasingly popular workshops. A *PhD by Design* day, first initiated at DRS2016, provided a platform for PhD researchers to learn new skills, present their work, and network with other researchers. The design of the conference, however, was largely formed around the managed theme tracks which included themes relating to the Special Interest Groups of the DRS. In some cases theme tracks emerged from conversations held at previous conferences, representing a pleasing continuity.

From the initial calls for participation there was a great deal of interest in the conference. Once again we had a truly international range of work presented and published in these proceedings. The original call for theme tracks yielded 46 proposals from which 24 were selected. These formed the backbone of the conference and of these proceedings. The theme tracks represent an increasing engagement with new technologies and data but also reflect contemporary social and political concerns, and the need for different types of design research voices to be heard. In particular, the programme committee were committed to bringing diverse global perspectives into play during the conference.

Following the call for theme tracks, the call for papers resulted in 470 submissions of which, after a rigorous peer-reviewing process, 218 (46%) were finally accepted for presentation and publication. This is a slightly decrease in the acceptance rate from the previous conference indicating a corresponding increase in the quality of the proceedings papers. Although some papers were submitted to an open call, the majority of papers were submitted to theme tracks, with each track being managed through the peer-review process by a track chair and all peer-review overseen by the Programme Committee. In total nearly 1000 paper reviews were written by 330 reviewers. The opportunity for authors to rate and comment on the reviews they received has further helped drive up the quality of peer review for future conferences.

DRS2018 reflects the coming together of many different perspectives and themes. As with previous conferences its design has been emergent, developing over the two years prior to the conference. It has been the result of many discussions and collaborations both within the Limerick team and the DRS more generally. The conference, and the proceedings that have resulted, are an extensive collaboration between many people but we would especially like to thank the local organising committee comprising members from the University of Limerick (UL), The Limerick School of Art and Design (LSAD) at the Limerick Institute of Technology, as well as members of other Irish academic institutions all of whom contributed valuable insight and experience. We'd also like to thank the track chairs who worked tirelessly and diligently to organise their tracks, and the reviewers who have ensured the high quality of the papers within those tracks.

Lastly but not least, we need to acknowledge the system that helped shape the way we worked together and made our decisions: the ConfTool conference management system. For the uninitiated ConfTool represents an awkward and mysterious interface. For the initiated it represents an indispensable way to manage the complexity of every stage of the conference process. In a way that echoes the conference theme, ConfTool has been a catalyst for our collective effort in bringing DRS2018 together.

In this sense *Design as a Catalys*t becomes a *thing*; a thing in the Heideggerian sense of a gathering of different entities coming together to deliberate on shared issues and reaffirming the role of DRS as a leading forum for discussing design research from multiple angles. But also a *thing* in the sense of something that escapes a specific definition, reflecting the impossibility and perhaps undesirability of a specific definition of what design research is, and should be.

With this sentiment in mind, we sincerely hope that these proceedings catalyse positive change and that the changes propagate to DRS2020 and beyond.

Go raibh maith agaibh,

Cristiano Storni, Department of Computer Science & Information Systems
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Muireann Mcmahon, School of Design
Peter Lloyd, Vice Chair of the Design Research Society
Erik Bohemia, Events Secretary for the Design Research Society

Volume 3

Section 9.

Designing for Transitions

DRS 2018 Design Research Society 2018 Catalyst

University of Limerick
25th – 28th June 2018

Editorial: Designing for Transitions

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doi: 10.21606/dma.2018.008

> *"Transition Design acknowledges that we are living in 'transitional times'. It takes as its central premise the need for societal transitions to more sustainable futures and argues that design has a key role to play in these transitions. It applies an understanding of the interconnectedness of social, economic, political and natural systems to address problems at all levels of spatiotemporal scale in ways that improve quality of life. Transition Design advocates the reconception of entire lifestyles, with the aim of making them more place-based, convivial and participatory and harmonizing them with the natural environment" (Irwin et al 2015).*

The *Designing for Transitions* track at DRS 2018 encompasses emerging approaches to design research at the intersection of sustainable design and sociotechnical systems theory. Exemplary are the growing international research communities explicitly centred around Transition Design (e.g. Irwin *et al* 2015) and Systemic Design (e.g. Sevaldson 2017), aiming to strengthen the role of design in the context of societal challenges. Whether considered in terms of everyday social practices, at a community scale or at the level of global challenges, a framing around designing for transitions brings together considerations of temporality, futures, different types of literacies, participation, social innovation, human needs, and interconnectedness; designing for transitions involves designing how transitions are conceived, enacted, governed and managed.

Our aim at DRS is for the track to build bridges between scholars and designers who work on transition in design, whether their work is explicitly framed in terms of transitions, or whether they encompass expertise and framings which take a broader view of design for social sustainability. The selection of ten full papers on designing for transitions from the 33 submissions to the track provide a window onto a range of diverse current work from researchers with different disciplinary specialities, from social innovation to futures to energy use practices—but all also strongly congruent with the wider theme of DRS 2018, 'Catalyst'.

The first session clusters five papers that explore 'Future Visioning and Worldviews in Transition' – recognising the importance of exploring narratives, mindsets, and visions of different possibilities and alternatives in considering designing for transitions. In the first paper (Hesselgren et al 2018), authors Mia Hesselgren, Elina Eriksson, Josefin Wangel and Loove Broms look at future images of energy transitions with newly designed tools to initiate dialogues and reflections for the future. The second paper is a theoretical reflection on the myths of modernity by Renata M. Leitão. The paper

(Leitão 2018) considers myths that are hindering the transformation of our ways of thinking and conditions that will enable new epistemologies to emerge. The third paper (Srivastava and Culén 2018) investigates pathways for decreased consumption amongst millennials. Authors Swati Srivastava and Alma Leora Culén describe Zygo, a future service based on the second-hand marketplace. The fourth paper entitled 'A Vocabulary for Visions in Designing for Transitions' by Dan Lockton and Stuart Candy considers a set of concepts relating particularly to vision in designing for transitions by building on perspectives and projects from other fields (Lockton and Candy 2018). The final paper in this first session is by Jonas Fritsch, 'Affective Interaction Design at the End of the World'. This paper (Fritsch 2018) proposes a rethinking of affect in HCI and interaction design based on recent theoretical advances in cultural and critical theory, especially affective attachments on a macro-level.

Our second session stresses 'The Practice of Transition Design', through both papers reporting on practical cases, and more theoretical contributions to the analysis of practice in transition contexts. Terry Irwin kicks off, outlining an emerging Transition Design approach for addressing 'wicked' problems (such as climate change, loss of biodiversity, crime, poverty, and pollution) and catalysing societal transitions toward more sustainable and desirable futures, including describing how Transition Design is being tested on a community-based project (Irwin 2018). Next, Stacie Rohrbach and Molly Wright Steenson examine teaching and learning in Transition Design, creating a theoretical basis that informs the practice of transition design, outlines methods and tools and proposes opportunities for development (Rohrbach and Steenson 2018). İdil Gaziulusoy and Elif Erdoğan Öztekin's paper 'Design as a Catalyst for Sustainability Transitions' contributes a literature review on theories of sustainability transitions and design, also linking very clearly to DRS 2018's overall theme of examining design as a catalyst for change (Gaziulusoy and Erdoğan Öztekin 2018). The fourth paper, entitled 'Catalysing pathway creation for transition governance' by Sampsa Hyysalo, Sofi Perikangas, Tatu Marttila, and Karoliina Auvinen, reviews transition management for catalysing vision building, experimentation and pathway construction for sustainability transitions in a Finnish energy context (Hyysalo et al 2018). Our final presenters, Niti Bhan and Rinku Gajera, examine users in an informal trade ecosystems and the creation of a 'value web' or the value creator's entire value web, as a basis for systemic design interventions (Bhan and Gajera 2018).

While the authors presented visions and practices that demonstrate the critical role of design in the context of societal challenges, they generally stayed on the safe and perhaps 'conventional' side. There is not much explicitly *political* in these papers. What do we *not* see represented here? From our perspective as track chairs—drawing on our own research areas as well as others'— we stress the need for an increasing focus on power, politics and the political economy of design for transitions. Transition Design must engage with politicised issues such as migration, decoloniality, the politics of climate change mitigation (not just adaptation) and other complex and controversial problems. Perhaps the de-politicised nature of these papers (and typically DRS papers in general) reflects the political economy of design research – and those voices who are able to participate in the Design Research Society community? We note the Decolonising Design group's DRS2016 statement: "We strongly believe that design, as a field of study, has systematically failed to address the questions of power that have shaped its own practice" (Ansari et al, 2016). One might argue that design research is insufficiently engaged with the debates in adjacent disciplines and that designers will find it hard create the change to which Transition Design aspires without better theory and practice around the politics of Transition Design. This expanded focus on of attention at the intersection of design, the environment and politics has been developed in some depth in recent work of one of the track chairs (Boehnert 2018) and in Arturo Escobar's recent publications (2015, 2018). Ultimately, Transition Design must engage with the system structures that determine whose interests are served by design.

Transition Design's focus on systemic approaches must be developed in greater depth. With this collection we see little work which really employs systems thinking or cybernetic ideas beyond fairly basic notions of complexity or simple feedback loops; it seems as though there is a great opportunity here for a deeper systems investigation of transitions in different contexts, including via participatory methods (e.g. Birney et al 2017; Aguirre Ulloa and Paulsen 2017). As the field matures, we will also—hopefully—see more applied case studies of how a Transition Design approach works in practice, complementing the examples we have in this track at present. This might include more attention to the experience of transitions in everyday life—the ways in which the futures of everyday practices might evolve and change, and how design which centres on lived experience can address that (e.g. Scott et al 2011), how changes in agency (mediated by technological change) may trigger changes in social practices (e.g. Kuijer and Giaccardi 2018) and how that might relate to concepts such as commons and commoning (e.g. Onafuwa 2018 ; Morelli et al., 2017) or even situated 'experiments in transition' such as living labs (e.g. Keyson et al 2016) or living 'in prototypes' (e.g. Desjardins and Wakkary 2016).

In keeping with Mulder and Loorbach (2016) a multi-level perspective approach as well as a transition in the design regime itself are needed to bring both the emerging debate and the corresponding practices around 'transition design' forward. Hence, transitions are long-term, complex, and non-linear processes of systemic change, which usually only become visible at societal level over decades. The high level of ambiguity, unstructuredness, and uncertainty, makes it hard to plan and design transitions. The role of design is, however, visible in the various niches, experiments and design interventions indicating their proneness to address societal challenges. Key is how these niches together can shape the contours of the changing design regime. See for example, De Koning and colleagues (2017) who studied emerging city makers to understand how their design capabilities can enable systemic change through a focus on participatory design. These new types of city makers generally bring value to the cities, however, their value could be enriched through more participatory networks that stimulate crossovers and accelerate the transition towards sustainable futures. Track chair Ingrid Mulder's work on participatory city making, working with communities and co-design of transitions is relevant here (Mulder & Loorbach 2016). Transition Design is practice linked to Transition Town movements and community activism. Here again power imbalances need to be theorised, and are all too often poorly articulated in design theory.

In this DRS track, we have brought together various niches in design research, which we hope not only contribute to the corresponding debate more widely at DRS 2018, in our track and in the foreseen keynote "Whose Design?" by Sadie Red Wing and Arturo Escobar, but also will enable a better framing of design for transitions, and mature our design repertoire and actions for transitions.

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DRS 2018 Design Research Society 2018 **Catalyst**

University of Limerick
25th – 28th June 2018

Affective Interaction Design at the End of the World

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We are living in a time of ecological and humanitarian crisis that requires imminent action from the joint fields of HCI and interaction design today. This paper presents Affective Interaction Design as an emerging research agenda directly targeting end-of-world challenges. To arrive at this, the paper proposes a re-thinking of affect in HCI and interaction design based on recent theoretical advances in cultural and critical theory, in particular emphasizing how a broadened understanding of affect is necessary to better address affectively charged and uncertain situations such as those connected to the end of the world. The paper sketches out how Affective Interaction Design combines conceptual guidelines, design methods, a situational ethics and new ways of assessing the value of affective interactions over time. Finally, the paper outlines three end-of-world frames for engaging with concrete affective design experiments – the end of nature, the end of culture and the end of the human – where digital and interactive technologies can being used on a micro-level to catalyze changes in affective attachments on a macro-level.

affective interaction design; affect theory; transition design; design theory.

1 Introduction

In the last years it has become increasingly clear that the world is reaching a number of far- from-equilibrium tipping points related to recent developments in major environmental and societal crises facing us. In a very palpable way, we seem to be moving towards the “end of the world”. This image might be most clearly associated with the climate crisis, but is also present in such affectively tensed areas as the ongoing civil wars in Syriah and Yemen, the current refugee and immigration crisis, the post-Brexit EU, the right-wing populism sweeping through politics in Europe and the US, a constantly looming terror and, lately, nuclear threat and the pervasive effects of the financial crash in 2008. According to the Belgian philosopher Isabelle Stengers, we are indeed living in ‘catastrophic times’ facing the imminent end of natural resources and a disequilibrium of the ecological and cultural systems with which we are familiar today (2013). In his book from 2010, *Living in the End Times,* Slovenian philosopher Slavoj Žižek identifies four so-called ‘riders of the apocalypse’, namely:

"(...) the ecological crisis, the consequences of the biogenetic revolution, imbalances with the system itself (problems with intellectual property; forthcoming struggles over raw materials, food and water) and the explosive growth of social divisions and exclusions." (2010, p. x)

Living at the end of the world means living in times where "choices in the present become highly charged affectively with fear for the uncertain future" (Massumi 2015, p. 4). For many this means coping with a growing urge to change this condition, accompanied by a feeling that it is impossible to find ways to act in the light of the overwhelming complexity presented by these interconnected global, ecological and humanitarian problems (Klein 2014). This is partly due to the difficulty of rationally comprehending the globally interconnected effects of a range of societal and environmental challenges that seem to be overlapping and spilling into each other (Tsing 2015).

Within HCI and design research, a response to this situation might be located in the emergence of Transition Design as an encompassing design-led agenda for engaging with a range of interconnected social, economic, political and natural systems to form more sustainable ways of living (Irwin 2015). Light et al. have also forcefully put forth a call for action under the heading of design for existential crisis in the anthropocene age (2017). The authors argue that technology designers and design researchers have a stake in the production of futures, and are hence implicated in the waves of change and uncertainty in a world characterized by ecological crisis, populism, mass migration, rising refugee numbers, automation and the like. Light et al. frame their project in relation to design as an existential challenge with a range of ethical concerns and the need for new design values to be explored in order to potentially "save humanity". Within this frame, the authors point towards concrete suggestions for attuning designers' towards meaning, purpose and fulfilment in difficult, unstable and rapidly changing times. Specifically, they argue that designers should focus on being "attentive, different, critical and in it together" (ibid., p. 6).

This paper extends the general call for action presented above while at the same time situating it in a tangential conceptual and genealogical trajectory presenting an emerging research agenda on Affective Interaction Design for end-of-world challenges. Essentially, the argument presented in this paper is that Affective Interaction Design can offer a research agenda that facilitates a sustained engagement with uncertain and affectively charged design situations at the end of the world. In cultural and critical theory, a large body of work within the so-called 'Affective Turn' has been instrumental in theorizing and analyzing situations characterized by uncertainty and trauma in more than a decade (Clough 2007, Gregg & Seigworth 2010). Starting from a basic Spinozan definition of affect as an "ability to affect and be affected" (Spinoza 1678), the paper introduces this affect theoretical genealogy into HCI and interaction design. Affect here is understood as a pre-personal intensity, that influences our bodily, vital forces directly (Massumi 2002). According to Spinoza, positive affects are those that make us feel alive and act in the world. Negative affects have the opposite effect, reducing our possible activity in the world and making this reduction felt. In this conceptual framing, end-of-world contexts would be characterized by negative affect, making it difficult to act or be acted upon. Living at the end of the world – or perceiving to be living at the end of the world – both has an impact on our ability to affect (what can we do?) and our ability to be affected (what matters?).

Based on three concrete affectively charged end-of-world design situations, this paper will show how it might be possible to design affective interactions on a micro-level for positive changes in affective attachments (Bennet 2001) and new possibilities for action on a macro-level. Importantly, though, this is not a trivial process, and often requires painful transitions tied to personal development and negative affects when effectuating this change (Massumi 2015). This means that Affective Interaction Design is not to be understood as an "easy-fix" for making people 'feel good' in difficult situations, or as overly relying on the supposed power to design your "way out of trouble". Instead, this paper provides a call for action for a sustained engagement with affectively charged design situations at the end of the world.

To arrive at a working notion of Affective Interaction Design, the first section will present a new affect theoretical foundation for understanding affective concerns in HCI and interaction design based on recent findings from cultural and critical theory. It will be shown how this conceptual reframing better allows for a designerly engagement with affectively charged situations such as end-of-world contexts. Based on this, a more detailed description of how Affective Interaction Design can be developed as a research agenda comprising conceptual guidelines, methods, situational ethics and longitudinal assessments of affective design experiments leveraging the potential for affective mobilization in existing digital and interactive technologies. Finally, the article frames three concrete design experiments relating to three different "ends of the world"; the end of nature, end of culture and end of the human. This feeds into a general discussion of the Affective Interaction Design research agenda and points in the direction of future work to be pursued under this heading.

2 Rethinking Affect in HCI and Interaction Design at the End of the World

In the past two decades, affect has played a central role in broadening the scope of both the theoretical foundations and practical design implications of interaction design and HCI. Intensive work has been carried out under the heading of Affective Computing in an attempt to make computers better at displaying and recognizing human emotions as a central part of improving the interaction with interactive systems (Picard 1997). Emotional Design (Norman 2004) argues for understanding affective and visceral attachments to product design as a central aspect of a product's success or failure, much in line with e.g. Jordan's work on pleasurable object design (2002). However, within HCI and interaction design, Affective Computing and Emotional Design have been criticized for attempting to overly structuralize, formalize, and represent emotions and affect as 'informational' (see, e.g., Sengers et al. 2002, Aboulafia and Bannon 2004). A range of researchers have advocated rethinking the 'informational' or 'cognitive' understanding of affect, arguing that emotions and affect are in the affective interaction between a user and a system, and not to be found in the code or hardware (Boehner et al. 2005, Höök 2008). Recently, Lottridge et al. have defined an *'affective interaction'* as any interaction that is coloured by an emotional experience (2011, p. 201). These 'interactional' approaches all emphasize the centrality of affect and emotion to understanding the richness and complexity of human experience and consequently the need to explore this in the design of interactive systems. In this body of work, the aim is less to contain affect than it is to unfold a range of different affective relations to be experimented with in the crafting of interactive system for design values such as self-reflection or ambiguity. Höök has further argued that in addition to the 'informational' and 'interactional' approaches to affect a third approach exists, where affect more generally falls within an experience-oriented (McCarthy & Wright 2004) approach to HCI and interaction design (2012).

Notable examples within an Affective Computing approach to design include projects on affective learning in how to train autistic children to express and recognize affective states (Blocher & Picard, 2002) and a range of projects aimed at measuring and reducing stress in computer tasks, combining facial readings and physiological data (e.g. McDuff et al., 2016). Recent work includes studies of how emotion tracking through various forms of data logging can promote successful behaviour change through affective forecasting (Hollis et al., 2015) and the design of a context-sensitive smartphone app to naturally embed inspiration to express gratitude in everyday life (Ghandeharioun et al. 2016). Concerning design projects within the 'interactional' approach, a prototypical example is the *Influencing Machine* (Sengers et al. 2002), an enigmatic installation where users influence the emotions of an (invisible) artificial agent expressing its emotions through visuals and sound. In line with this, *Affector* is an experiment in the co-interpretation of affect, where a video window between the offices of two friends communicates their moods by systematically distorting the video feed according to sensor readings (Sengers et al. 2008). A more recent example is *AffectAuru*, an emotional prosthetic that allows users to reflect on their emotional states over time, combining a multimodal sensor setup for continuous logging of audio, visual, physiological and contextual data and an interface for user reflection while using the system (McDuff et al., 2012).

Whereas the ‘informational’ approach to affect has rightly been criticized for sometimes reducing the complexity of emotional and affective concerns in HCI and interaction design to make them fit within a computing perspective, the ‘interactional’ approach often leads to designs that attempt to make people reflect on the richness of their own emotional situation, it might be argued that this also reduces affect to an individual’s immediate feeling, and lacks in ambition and scope for unfolding the potential of affective interactions when considering affect as constitutive force for both human experience and larger societal formations. Indeed, the end-of-world challenges that we are facing today point to the necessity to engage with the long-term evolutions of affective relations and attachments while extending the focus of inquiry from the immediate feeling of the interaction towards larger relational issues.

To mobilize a theoretical starting point for Affective Interaction Design that deals directly with these issues, this paper combines the advances in affect theoretical studies in philosophy, aesthetics, cultural and critical theory with interaction design research targeted at crafting interactive and digital technologies. Indeed, the interest in addressing affective guidelines in HCI and interaction design as seen in e.g. Affective Computing and Emotional Design should be seen relative to a general acknowledgement over the last decades of articulating and conceptualizing affective and emotional forces as basically constitutive for understanding human experience and development in a number of disciplinary fields (Stern 1985, Damasio 1994, LeDoux 1996, Kahneman 2011, Dolan 2012). In critical and cultural theory, there has been an ‘Affective Turn’ towards research into the impact on a non-cognitive and bio-social level of new media and technologies on our possibilities of experience in a globalized world (Massumi 2002, Sedgwick 2003, Clough 2007, Gregg & Seigworth 2010, Blackmann 2012, Karatzogianni & Kunstman 2012, Hillis et. al. 2015). Importantly, this research has emphasized how affect must be understood not only as relating to an individual’s self-relation or assessment of emotions (“how do I feel”), but also as a constitutive force in a range of larger societal formations such as economic markets and stock trade (Massumi 2015), networked and social media (Hillis et al. 2015) and activist politics and Culture Wars (Reestorf 2016). Affective Interaction Design draws on this work and cultivates established philosophical theories of affect (e.g. Spinoza 1678, James 1912, Whitehead 1929, Bergson 1907, Deleuze 1970) that will be applied in order to clarify how these conceptual starting points can lead to new affective concerns in interaction design.

In Affective Interaction Design, affect is conceptualized as a pre-personal intensity that influences our bodily, vital forces directly. This is to be understood as a capacity to act and be acted upon through increase or decrease of e.g. joy, sorrow or desire (Spinoza 1678, Massumi 2002). Affect is neither purely natural/physiological, nor solely cultural. This also means that affect can neither be contained as the properties of a person, nor the properties of a system. Affective experience lies ‘in-between’ and thus brings together the natural and cultural in affective-felt tendencies that modulate the potential for action in a given situation (Massumi 2009). In earlier work, I have explored how this can be used in HCI and interaction design as a way to challenge basic notions of interaction and interactivity in material, processual and experiential terms (Fritsch 2009, Fritsch 2011). Here, the argument presented has been that starting from affective experience entails looking into the very formation of experience; that which *makes us* experience and the forces that modulate this. Importantly, affect differs from emotion, which is understood as recognized affect; affect is pre-personal and non-conscious whereas emotion has individuated to a conscious form. An example is feeling angry; you are already feeling something, before you recognize this feeling as anger. Munezero et al. have presented a framework based on the work of Massumi to better differentiate between affect, feeling, emotion, sentiment and opinion in relation to text detection, arguing that affect is non-conscious and a predecessor to feelings and emotions (2014, p. 104). Further, Massumi has argued that affect works on a microperceptual level with macropolitical consequences (2009).

Starting from an affect theoretical foundation means starting with affect as an in-between dimension of experience that modulates how we experience and the relations and attachments we form. Within the frame of Affective Interaction Design, this allows us to tentatively define affective interactions as interactions with concrete digital and interactive technologies (on a micro-level) that catalyze new affective attachments and mobilize affect towards end-of- world problems (on a macro-level). End-of-world contexts are characterized by negative affect, making it difficult to act – and inter-act. Affective Interaction Design thus attempts to effectuate changes by altering affective attachments through affective interactions towards positive affects that offer new possibilities for action. Importantly, though, this is not a trivial process, and often requires negative affects as part of the process of change (Massumi 2015).

In addition to the explicitly affect-oriented approaches to design, Affective Interaction Design also draws on a range of findings from a number of design research approaches. The need to engage in critically challenging real-world issues, politics and policymaking through explorations of technology design adheres to longstanding perspective from Participatory Design (Greenbaum & Kyng 1991), Critical Design (Dunne 1999), Adversarial Design (Di Salvo 2012), Design Activism (Markussen 2013) and Transition Design (Irwin 2015). In relation to the proposed design experiments concerned with the climate and cultural crises, Sustainable Interaction Design (SID) serves as a foundational inspiration for exploring "(...) how interactive technologies can be used to promote more sustainable behaviors (Blevis 2007, p. 503). Affective Interaction Design adds to these design explorations an agenda for addressing affect conceptual guidelines, when intervening into design situations at the end of the world. The next section further develops how such an agenda might be comprised.

3 Sketching a Research Agenda for Affective Interaction Design

The societal imperative to find new ways of tackling the transversal nature and complex issues related to end-of-world challenges is coupled with the need presented in this paper to radically broaden the notion of affect in interaction design and develop Affective Interaction Design as a new design research agenda. In the following, the paper sketches out the different aspects of an affective research agenda in HCI and interaction design that fully acknowledges affect as a constitutive force of human experience and larger social and societal formations, such as those presented by end-of-world challenges.

3.1 Conceptual design guidelines and values

The majority of the research on affective design guidelines in HCI and interaction design has been aimed at establishing affect as a concept, which should be considered in the design and evaluation of computers to help people better perform specific tasks (Picard 1997, Norman 2004). Lottridge et al. present a range of guidelines for putting emotion research into practice, such as 'to enhance performance through emotional input and regulation', 'to visualize emotion for decision support' and 'to foster the appropriate emotion for different learning goals' (2012, p. 228f). However, what Affective Interaction Design aims to provide are specific conceptual guidelines for addressing behavioural change by altering affective attachments in relation to emotionally saturated issues such as end-of-world problems, through affective interactions. Developing appropriate affect conceptual guidelines and values to orient the design work in the proposed design experiments is a key activity in this respect. As opposed to design principles, which might be considered clear rules of thumb (Blair-Early & Zender 2008), the main task of these guidelines is to offer to interaction design researcher concepts, directions and themes of engagement that can guide the practical design work without in any way predetermining it. These guidelines will be formulated based on the presented theoretical foundation in the light of end-of-world challenges and refined through practical experiments.

3.2 Developing affective design methods and a situational ethics

It requires great considerations and care to intervene into affectively charged design situations at the end of the world, characterized by uncertainty and vulnerability. There is a substantial amount of literature in HCI and design addressing e.g. designing for vulnerable user groups but no established methods for addressing affective issues in the design process. Among others, Munteanu et al. describe this situation and call for a need to establish a 'situational ethics' (2015) for intervening into such problematic design settings. The authors argue that a situational ethics is necessary to meet the ethical challenges in field work or design experiments involving at-risk or vulnerable user groups, both in the planning and execution stages of the research (2015). Since Affective Interaction Design deals with concrete affective tensions in cultural, natural and physiological situations of crisis, it will be imperative to consider the ethical challenges for both users and researchers. According to Munteanu et al., a strategy to build a situational ethics requires looking for 'ethical triggers', continuously assessing risks and adjusting protocols accordingly and ensuring a multidisciplinary design team (ibid. p. 113). A situational ethics will also outline viable ways of entering, leaving and sustaining the design initiatives. It will also affect the design methods and techniques occurring at all stages of the design process. Some of these methods will be appropriated in the light of the affective design agenda. In addition, new methods and techniques must be developed to cater specifically for affective data and concerns. Developing an extensive repertoire of affective design methods and a situational ethics is therefore key to guiding the practical design processes related to end-of-world problems.

3.1 Assessing the value of affective interaction design over time

Measurements of affect have a long history of influencing the development of HCI, where extensive research has been carried out to explore methods of assessing affective and emotional features in the evaluation of interactive systems (Lottridge et al. 2011, Pollak et al. 2011). However, this research is primarily concerned with establishing an accurate account of an individual's experience of a given interaction with a computer system and this system's capability to influence affective states and does not engage with the end- of-world issues presented above. There is a need to develop non-reductionist ways of assessing the value of Affective Interaction Design that go beyond the individual's immediate feeling, when interacting with the system, and accentuate long-term affective mobilizations and changes in affective states and relations towards specific societal issues. Therefore, it will be necessary to develop a model for studying affective attachments over time combining longitudinal digital ethnographic studies (Markham 2015) and continuous logging of physiological measurements (Lottridge et al. 2011) for observations on relational changes (macro). This will be combined with qualitative micro-analytical interviews (Stern 2004) and video- cued recall methods (Suchman & Trigg 1991) unfolding the micro observations of the affective qualities of the interactions with the different technologies. The aim is to combine the micro-analytics of the affective interaction with the long-term relational impact on affective attachments to cultivate new design values in an affective perspective.

3.2 New technologies and affective design exemplars

Affective Interaction Design must be established as a form of research-through design (Frayling 1993), where the theoretical mobilization should continuously be informed through a practice-based engagement with building affective design prototypes. It will be necessary to develop a range of affective design exemplars (Binder & Redström 2006), i.e. designs that specifically embody the Affective Interaction Design research agenda. As shown above, prior design experiments engaging with affect include work on the display and measurements of affective states in computer systems for learning and motivation and artistic interventions aimed at making people reflect on their emotions. The existing affective design prototypes within HCI and interaction design present a multifaceted interpretation of affect; from physiological measurements, facial recognition and computers aiming to express emotions to systems that foster affective and emotional reflections. However, there are no prototypes concerning the explicit use of an affective approach to meeting end-of-world challenges. Hence, Affective Interaction Design will develop affective design prototypes that can serve as guidance for future explorations. These prototypes will explore particular technologies believed to hold a potential for changing affective attachments, which will be further explored in the next section.

4 Framing Affective Design Experiments for End-of-world Challenges

This section presents three potential 'ends of the world' that can be used to suggest three overall frames for directing affective design experiments within the overall agenda of Affective Interaction Design. Some of the experiments draw on existing explorations, others remain on a more conceptual level, but they are all in-the-making. All three frames attempt to give an indication of how specific technologies can be developed and tested in the design of real-world applicable affective design prototypes proposing to change affective attachments and relations through micro-interactions targeting three end-of-world design situations: the end of nature, the end of culture and the end of the human.

4.1 End of Nature

The end of nature relates to the challenges we face with the current climate crisis. Data from the UN's *World Meteorological Organization* (WMO) indicate that 2016 was the world's hottest year ever on record, with devastating consequences for the melting of the Arctic Sea and a growing number of natural disasters worldwide[1]. Within the overarching frame of Affective Interaction Design, a starting point for engaging with design experiments related to the end of nature might explore the design of affective interactions for changing habits related to the climate crisis deploying advanced and distributed sensor and actuator technologies. The goal would be to technologically stage affective attachments to issues related to the climate crisis, such as food or product consumption, CO2 emission, carbon footprints, deforestation and other environmental issues. The hypothesis would be that creating a stronger affective link between people and the environment can lead to changes in behaviour and habits. This might be achieved through sensorial augmentation, which refers to an augmentation of the senses, using technological enhancement to detect something that the body cannot normally perceive (Linden et al. 2011). In an earlier project, we have developed Feltradio (Grönvall et al. 2016), which is a portable technology for sensing WiFi through sensorial augmentation and Electric Muscle Stimulation (EMS). In relation to the end of nature, we are currently exploring how to use the same infrastructure to affectively relate to e.g. the level of CO2 emission, so people can actually experience that which they cannot normally sense. This might foster a critical awareness of the relations between people and the natural resources being used and lead to changes in behavior and action. The experiment thus utilizes micro-perceptual triggers (the sensor and actuator technologies) to create a sustained engagement with macro-issues (environmental challenges) through augmentation of big data streams into our affective and embodied experience of the world. This would potentially lead to a better sense of how one's actions might be connected ecologically to the greater environment, thus creating the foundation for making different choices and facilitating new forms of positive action.

4.2 End of Culture

The end of culture relates to the ongoing Culture Wars (Reestorf 2016), not least in the wake of the current migration and refugee crisis (especially from a European perspective), but also from a result of the geopolitical challenges caused by climate change. The *UN Refugee Agency (UNHCR)* reports that we are witnessing the highest level of displacement of people on record with an unprecedented 65.3 million (21.3 million refugees) people being forced from their homes[2]. In addition to this very concrete end of culture, the increase in right-wing populism in a range of European countries is very much based on the perceived cultural threat posed by the flows of refugees and immigration which to many warrants an end to the culture they are familiar with. From an Affective Interaction Design perspective, one way of engaging with theses issues might explore affective design experiments that use location-based and interactive platforms for affectively engaging storytelling to provide spaces for lasting cultural dialogue around issues of integration. The hypothesis is that it is necessary to

[1] http://public.wmo.int/en/media/press-release/global-climate-breaks-new-records-january-june-2016
[2] http://www.unhcr.org/figures-at-a-glance.html

initiate an actual dialogue between people to actually create changes in affective attachments towards refugees and migrants, but also to different fractions within native groups in increasingly culturally divided societies. Here, we would follow Guattari's call for individuals to "(…) become both more united and increasingly different (2000/1989, p. 69). Creating conditions for cultural dialogue and differential attunement might be explored through the use of mobile technologies, as a way of collecting and curating people's personal stories and sound in real-time from a range of distributed locations. These might include refugee camps, asylum centers or different residential areas in cities and villages. In the context of this paper, this would be a European country, but the scope is not limited to Europe. Around these sound recordings, spaces will be facilitated where people can listen to and engage with the stories and people behind those stories. These experiments extend an ongoing project with the use of interactive audio design in the creation of an affectively engaging interface for attuning to the differential qualities of people's voices (Fritsch & Jacobsen, 2017). In the overall project frame this experiment stages different encounters between people, stories and voices creating changes in affective attachments towards more positive forms of cultural dialogue.

4.3 End of the human

The end of the human relates to recent advances in technological implants and the rise of automation and robots replacing human skilled labor. The latter is closely connected to advances in AI and machine learning – e.g. in stock trading – once again challenging notions of intelligence and agency. Important existential questions have re-merged with new intensity due to a number of advances increasingly challenging and blurring boundaries between humans and technology. The prospective of 'human enhancement', which aims to increase human capacities above normal levels through the use of different kinds of technology (Savulescu and Bostrom 2011), is inextricably tied to discussions of loss of humanity and economic inequality on a global scale. Affective Interaction Design experiments targeting this framing might explore different interfacial engagements and uncertainties connected very concretely with implantable technologies, for instance the Implantable Cardioverter Defibrilator (ICD) pacemaker. In short, an ICD is a device implantable inside the body (the heart) and able to perform cardioversion, defibrillation and pacing of the heart. In addition, the ICD collects and sends data about the patient's heart to the hospital via a router that comes with the device. People get the device implanted through an operation due to severe heart problems, potentially following a heart attack or stroke. This is in itself a life-changing situations characterized by anxiety, affective saturation and uncertainty, often involving a near-death experience. Following this, patients' need to both cope with getting used to living with a life-threatening disease and an implantable technology in their heart. This presents a range of challenges, as explored by e.g. Andersen et al. (2017) who have developed an app that makes the data from the ICD accessible for the patients. An Affective Interaction Design approach would seek to design concrete affective interactions through technologies that might change people's relations to their bodily vulnerability towards more positive affective attachments.

The three frames for affective design experiments presented in this section all concern design situations characterized by affective uncertainty and crisis, where the affective tensions are far more palpable and form part of larger, collective eco-systems of power, politics, technology and resources. They are far-from equilibrium design situations saturated with fear since they very clearly present affective encounters with "difference as alterity – as otherness" as noted by Susan Ruddick (2010). This is most obviously the case for the end of culture and the current refugee and migration crises in Europe, where the feeling of cultural identity and values for many is being questioned in the encounters with refugees and immigrants defined as 'others'. Difference as alterity, however, is also central to understanding design challenges at the end of nature and the human. Concerning the end of nature and the climate crisis, 'the other' can both be used as a way to frame the clash of alternative positions in the climate debate, but also in our lack of establishing a real relation or affective attachment to nature understood as an 'other'. Here, cultivating affective attachments through sensorial augmentation becomes a way of bridging between culture and nature. Concerning the end of the human, an implantable technology might be immediately understood as an 'other' – but the same might be said about the relation to the whole body, which has been altered into something completely different from what you were used to. In direct continuation of this, Massumi reminds us that "(a)ffective politics, understood as aesthetic politics, is dissensual, in the sense that it holds contrasting alternatives together without immediately demanding that one alternative eventuates and the others evaporate. It makes thought-felt different capacities for existence, different life potentials, different forms of life, without immediately imposing a choice between them." (2009, p. 12). This calls for design experiments that explore "actual differentiation" and conditions of emergence, and do not attempt to impose solutions in advance. This is very much in line with the ideas presented in a Transition Design approach to engaging with "wicked problems" on an ecological, social and societal scale, and in a non-reductionist way (Irwin 2015).

In all of the proposed frames above, affective interactions would attempt to catalyze experiential changes creating more positive affective attachments during the long-term use of the design, leading to new abilities to act. The suggested experiments both highlight how it is possible to define design challenges from an end-of-world perspective, and how it might be possible to engage with these challenges through design from an affective point of view. While this move into concrete contexts and technologies comes with a risk of reducing the overall design agenda, they are necessary to connect the conceptual guidelines with an interventionist design agenda. Importantly, though, it must be stressed that the presented experiments are in no way the only experiments that could be carried out within the presented ends of the world.

5 Discussion

Affective Interaction Design is an emerging research that arguably poses a range of questions and strikes many themes that must be critically discussed both in relation to the framing of end-of-world challenges as well as the overall affective framework. First, it should be noted that the argument put forth in this paper is not that the world is about to end any time soon – statistically speaking it has never been more peaceful, prosperous or connected as it is today (e.g. Pinker 2011) – or that digital technologies can save us or provide sustainable solutions to the multifaceted problems we are facing today. Rather, the argument is for interaction design to develop a serious commitment and engage explicitly with affectively saturated design situations at the end of the world to be able to change the current course towards more sustainable transitions. As has been shown, the 'ends' also hold a generative potential, and point to a need for rethinking our existing affective attachments and habits and thus stimulate positive shifts in attitudes and policies that will help us better act in the face of the challenges we are facing.

As emphasized above, this attitude should not be mistaken for a naïve optimism based on a too strong belief in the role of design in making these transitions. There are a number of seemingly insurmountable dilemmas and challenges that characterize an engagement with design situations at the end of the world. And there is a fair chance that processes and proposed designs will fail. This should not, however, prevent the joint fields of HCI and interaction design from engaging with these issues. Affective Interaction Design tries to pose a nuanced approach to thinking interaction design's role in changing our current conditions for living in the light of the challenges presented at the end of the world. The presented research agenda embodies a commitment for making a difference through a sustained engagement. To achieve this, the agenda must be conceptually founded, bound up with concrete methods and ethics and develop strategies for making sense of the potential impact and value of the different designs in a non-reductionist perspective over time. In addition, it would also be necessary to cultivate Affective Interaction Design into an engagement with broader issues of large-scale policymaking to ensure a continued impact.

Affective Interaction Design does not attempt to 'annex' existing design approaches such as Adversarial Design, Transition Design or Sustainable Interaction Design under an affective heading. These are existing approaches that all deal with pertinent aspects when it comes to developing a critical, reflective and interventionist approach to interaction design in order to engage with some of the most important societal problems we are facing today. Indeed, some of the main values and motives going onto Affective Interaction Design draw on and relates to a range of different design approaches that are not directly affectively motivated. However, the argument presented is that HCI and interaction design can greatly benefit from developing a long-lasting design agenda that explicitly aims to engage with the affective complexity characterizing design situations at the end of the world. As has been shown, in order to do this, it will be necessary to revise the existing definition of affect as it is currently presented in Affective Computing and Emotional Design. Again, it is important to stress that an affect theoretical foundation opens a way of thinking affect as a constitutive force in an experiential, societal and socio-cultural perspective, which goes beyond reflecting on one's own emotions or trying to teach computers to register and express human emotion to smooth out interaction.

A valid point of critique concerning both the overall framework and the presented design experiments would be whether it might not be possible to engage in activities that would contribute even better to a more sustainable future than the examples in this paper. A derived question might be, whether a range of the things you could do would in fact not work better and more sustainably without technology. Here it is important to remember that the outset for the Affective Interaction Design research agenda is to develop a different approach to developing digital and interactive technologies in the light of the challenges presented at the end of the world. This does not mean, however, that a non-technological solution might work better in a concreted design case, e.g. for creating spaces of cultural dialogue and lasting integration. A continuous awareness of the possibilities and limitations of the design agenda should be integral to the situational ethics developed.

6 Conclusion

This paper presents Affective Interaction Design as a new research agenda for engaging with end-of-world contexts and challenges in HCI and interaction design. The agenda introduces an affect theoretical foundation for understanding design contexts characterized by crisis and uncertainty, and comprises conceptual guidelines, methods, a situational ethics, measures for assessing the longitudinal value of affective interactions and novel affective design exemplars. Three frames for design experiments have been proposed targeting affectively charged end-of-world challenges through concrete interactions with different technologies (micro-triggers) that might lead to positive changes in relations and attachments, potentially triggering behavioral changes or changes in habits (macro changes).

In the future, it will be necessary to further cultivate this research agenda to develop be fundamental new insights into design processes concerned with affectively saturated design situations, and strategies for leveraging the affective potential of existing and new digital and interactive technologies. The sheer complexity of the presented affectively saturated design situations at the end of the world and the pervasive and transgressive nature of the challenges they embody, provide a complicated starting point for a necessary engagement with a range of issues. There are no signs that end-of-world challenges will disappear in the coming years, rather on the contrary. In this light, Affective Interaction Design functions as general call for action for HCI and interaction design to rethink existing and explore new ways of thinking and doing design.

Acknowledgements: This article has matured over many years, and I want to express my gratitude to the numerous colleagues, students and others with whom I have had the pleasure of discussing and developing the line of thinking presented. In particular, I would like to thank Emilie Møllenbach for critical encouragement and close collaboration in the early and defining stages of this process. This work has been supported by the project *Affects, Interfaces, Events* (4180-00221) funded by the Danish Independent Research Council.

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DRS 2018 Design Research Society 2018 Catalyst

University of Limerick
25th – 28th June 2018

A Vocabulary for Visions in Designing for Transitions

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doi: 10.21606/dma.2018.558

Visions of sustainable futures have been proposed as a key component of transition design, offering a way for today's situations and design proposals to be compared and critiqued in the light of desired future states. Such ambitions are necessarily wide-ranging, and call for drawing together strands on design and speculation from diverse sources. Here we seek to add to the momentum by exploring a set of concepts relating particularly to this role of vision in designing for transitions. Building on perspectives and projects from other fields, we present elements of a visionary vocabulary, situating these terms in relation to challenges and opportunities for transition thinking and practice in design research.

futures, imaginaries, visioning, transition design

1 Introduction

Among the proposed elements of transition design, "visions of sustainable futures" feature centrally, in order that "contemporary lifestyles and design interventions can be assessed and critiqued against a desired future state" (Irwin, Kossoff, Tonkinwise, & Scupelli, 2015a, p.8). The big-picture ambitions of such an agenda point to a need for exploring and synthesising approaches from practitioners and researchers in other fields whose work deals with questions of vision, futures, and how they relate to the present. One starting point here, to follow from this need, is to take steps to equip transition designers with a vocabulary—a repertoire of concepts—which can both make these approaches more salient, and help make them easier to engage with.

In this piece we seek to explore a set of concepts relating particularly to this role of vision in designing for transitions, which start to build up elements of a vocabulary. In preliminary fashion we build on perspectives and projects from other fields, and aim to situate them in relation to challenges and opportunities for transition thinking and practice. Some have been noted in transition design literature before, while others have not, but all are established concepts rather than new coinages. Our purpose is to identify and borrow from existing practice some potentially useful heuristics, moves, philosophical prods, or *lenses* that seem to offer promise to those keen to engage in design with transitional agendas in view. Assembled here, then, are seven ways of seeing, for tackling the 'visionary' aspect of designing for transitions. The seven are: *Lenses* themselves;

Imaginaries; *Backcasting*; *Dark matter*; *Circularity*; *Experiential futures*; and *New metaphors*. What follows describes each lens and explains its relevance to the emerging practice as we currently see it.

A note on this paper's structure: we have experimented somewhat with a more modular structure, including a short Discussion section, *Why have we included this?*, after each concept. Our intention is that this potentially makes it easier for ourselves and others to add to the vocabulary, by keeping discussion close to the concepts themselves.

2 Methodology: Lenses

Our methodology in choosing the elements for this vocabulary is centred around the idea of lenses—we are claiming nothing more than collecting together a set of different tools for seeing, which in a poetic way we feel are complementary, as a proposition and starting point for others to build on. There are many other concepts we could have chosen, but this is the set that we did choose.

This first set of lenses overall draws inspiration from a number of works that have sought to expand the vocabulary of concepts or repertoire of gambits readily available in one domain or another. The architect Alexander and colleagues' classic *A Pattern Language* (1977) is one such; designer Hill's more recent *Dark Matter and Trojan Horses* (2012) is another. Musician Eno and artist Schmidt's *Oblique Strategies* cards (1975) hover generatively in the background; likewise the *Group Works* card deck created by the Group Pattern Language Project (2011), a deck collecting concepts and moves for facilitation; and theatre director Boal's *Games for Actors and Non-actors* (2002). Games maker Schell's *The Art of Game Design: A Book of Lenses* (2008), another member of this extended family, is a helpful reference even if we are not necessarily using his focal term in quite the same way. Lockton, Harrison, and Stanton (2013; 2010) discuss a variety of pattern-like formats for design tools, arriving at 'lenses' as a metaphor for different worldviews of human behaviour. Our own use of 'lens' here is probably a bit closer to the spirit of philosopher Dennett's inventory of "handy prosthetic imagination-extenders and focus-holders", in *Intuition Pumps and Other Tools for Thinking* (2013, p. 2). And one final model to mention, psychologist De Bono's *Wordpower* (1977, p.4) collects a range of terms with the popular expansion of systems literacy in mind:

> *[A]n understanding of dynamic and interactive systems means a whole new way of looking at processes rather than just at things. For this purpose we are only now beginning to build an adequate vocabulary. When we have built this vocabulary and assimilated the related concepts our understanding of the world around will be much improved. This I see as the next quantum step in our cultural development.*

We do not pretend that these fragments contain anything as impressive as their sources of inspiration, or that the small starter set gathered here is necessarily part of an impending 'quantum step in cultural development'. However, we are interested in contributing to the reservoir of available approaches to the worthy, ambitious forms of emerging practice outlined in transition design literature to date (Kossoff, Irwin, & Willis, 2015). The promise of usefulness for guiding an aspiring transition designer's attention and action in the area of vision has served as the main basis for selecting these lenses.

And the first lens to highlight is that of lenses themselves. The various works cited above all seem to manifest a similar impulse—a kind of modular, tactical, pragmatic, creative, open-minded collector's approach to gathering and indexing elements of intellectual, operational and artistic usefulness. Many fields of course have their own master term for such collections: the 'playbook' in certain sports; cookbook; songbook; encyclopedia. The term 'score' as an organising category is perhaps best known in connection with music, but in the hands of landscape architect Halprin (1970) extends to many other activities. Unsurprisingly perhaps, the area of language offers many organising frames (and there's another metaphor) at different levels, including 'language' itself, library, vocabulary, dictionary, grammar, and alphabet. One of the most fruitfully catalytic organising concepts for modular collections of knowledge parlays the component 'pattern' (fashion) into a designerly aggregate, ‘pattern language’, first elaborated in architecture (Alexander et al., 1977), and since widely taken up in software development (Gamma et al., 1994) and interaction design (Tidwell, 2005; Fincher, 2012).

All of the above are alternative metaphors carrying different entailments (see **New metaphors**) and, admittedly, considerable potential for self-referential confusion. We have chosen ‘lenses’ as a deliberate extension of the ‘vision’ metaphor and a central challenge contained in designing for transition: imagining and catalysing a (presumably) radically different systemic state. New ways of doing and seeing go hand in hand; the latter are perhaps marginally easier to write about, but we try to blur that boundary wherever possible.

2.1 Discussion: Why have we included this?

Designing for transitions is ambitious. It is inherently multiscalar and inter- if not fully transdisciplinary. Its would-be practitioners need ways of sharing what they are doing, what seems to work, and at this stage the appropriate thinking and learning tools are bound to be modular and piecemeal rather than all-encompassing. We suggest that this notion of patterns or lenses — the modular collection and deployment of approaches to examining, thinking about, and acting in various situations — itself harbours potential as part of the development of transition design practice.

*Related: heuristic, **new metaphors**, pattern language, playbook, score*

3 Imaginaries

Mindset has been named a core component of transition design (Irwin et al., 2015b), primarily expressed through the idea that “openness, mindfulness, and self-reflection” are crucial when designing with transition in view. In addition to these attitudinal aspects, another level at which mindset considerations and ways of thinking can be explored, particularly in the context of visioning, is found in the notion of *imaginaries*. Here we argue that, as a lens, tuning into and investigating the ‘imaginary’, with regard both to current situations and to possible futures, promises invaluable insights for visioning.

What are imaginaries? The very broad sense in which we use the term here includes: societal-level conceptions (Appadurai, 1990) or (at least partly-) shared visions of issues such as climate change, health, immigration, identity, law, or even countries themselves (Anderson, 1983); myths and beliefs which can motivate collaboration (Harari, 2014); or sociotechnical narratives about how certain types of technological development could affect the way we live (Jasanoff & Kim, 2015); along with more individual or small-group scale notions perhaps more familiar to interaction designers, such as mental models (e.g. Revell & Stanton, 2017; Jones et al., 2011), mental imagery, associations, metaphors (see **New metaphors**), and so on. There is an argument that imaginaries of futures can affect people’s actions in the present (Lanzeni, 2016; Jasanoff & Kim, 2015), and the related concept of a culture’s ‘images of the future’, developed by sociologist Polak in the 1950s, proposes precisely this (1973 [1955], p. 19):

> *Any student of the rise and fall of cultures cannot fail to be impressed by the role played in this historical succession of the future. The rise and fall of images of the future precedes or accompanies the rise and fall of cultures. As long as a society’s image is positive and flourishing, the flower of culture is in full bloom. Once the image begins to decay and lose its vitality, however, the culture does not long survive.*

This may be said to represent a kind of self-fulfillingness (see **Circularity**), but imaginaries do not emerge independently: those that we have are constructed, over the courses of our lives, through both our social and experiential contexts. They are not permanent, but they are often persistent.

Design—and arts more broadly—can be seen as a form of language encompassing the fictional or imaginary, making it real enough to be addressable, to be considered and critiqued and reflected on.

Dilnot (2015) suggests that design simultaneously *states* “This!” and *asks* “This?” It has the power to render visible and tangible imagined situations, whether better or worse than the ones we are in; to design artefacts as ‘tokens of better ages’; to apply ideas of utopia as a method (Levitas, 2013); and to inspire and open up vistas—if not always actual maps—towards different futures, through speculation and design fiction. What do designers do, if not, in some sense, give us experiential pockets of imaginaries—our own, reflected back at us, as well as visions of alternatives, fictional for the time being, but towards which we might be in transition? (see **Experiential futures**)

As a process, investigating imaginaries starts by engaging with, and seeking to understand, people’s existing collective or individual conceptions of their situation; how the systems around them work, from their perspective; and what mindsets accompany those conceptions (Figure 1; Figure 2). Then, through externalising those imaginaries, or making them tangible or engageable-with (e.g. Bowden, Lockton, Gheerawo & Brass, 2015; Aguirre Ulloa & Paulsen, 2017), a community has the opportunity to reflect on and learn about its own thinking. Turning from this general process to consider futures imaginaries more specifically; surfacing a community’s expectations, aspirations and beliefs about its own prospects can inform the development of deeper and more robust visions — while being firmly planted in and cognisant of the contexts and cultures where those imaginaries are found. A simple way to do this is found in “The Polak Game”, a brief and lively classroom activity based on the work noted above regarding the sociology and history of images of the future (Hayward & Candy, 2017). There are various typologies available for describing and mapping future imaginaries found among a population, including Ethnographic Futures Research (EFR) (Textor, 1995), Generic Images of the Future (Dator, 2009; Candy et al, 2006), and the Systems Mythology Toolkit (Hendricks, 2014). A framework for customising particular deployments following the whole process suggested above (map, multiply, mediate, mount, and map again) can be found in Ethnographic Experiential Futures (EXF), “a design-driven, hybrid approach to foresight aimed at increasing the accessibility, variety and depth of available images of the future” (Candy & Kornet, 2017).

3.1 Discussion: Why have we included this?

Using the lens of imaginaries helps to sensitise both ourselves and others to the functioning and dynamics of what and how we imagine the systems we are in, as they are and as the might be. In this area, transition designers can serve a valuable role as translators or mediators between minds and ideas, and the world, between current situations and possible new ways of living.

*Related: ethnography, **experiential futures**, images of the future, phenomenography, mapping, mental models.*

4 Backcasting

Suppose you’re trying to figure out how change could unfold—for yourself as a designer, or for a community.

One way to try to do this is to examine the evidence, past and present, and seek to discern in the tea leaves some pattern or portent of what is likely to occur next. There is a family of approaches for “forecasting”, and quantities of effort and ink are expended in pursuit of this form of inquiry (Tetlock & Gardner, 2016; Silver, 2015). Efforts to extrapolate from what is known today into times to come, to cantilever conclusions from the seemingly sure footing of the present into the future’s murky zone, often fail (Funk, 2017; Taleb, 2007), and many professional and academic futurists warn of the folly of a predictive stance when it comes to human affairs (Dator, 1996).

But one might also approach the question in precisely the opposite direction. This other tack, another way of seeing, is about the creation of scenarios *backwards* from a posited point in the future. What if we stipulate, for the sake of argument, that the future we are interested in looks and operates *like so*, some number of years or decades from now. *What would it take in order for that to happen*? What would need to occur?

Figure 1. Teenagers at the Derby Silk Mill, Derby, UK, pinning up their drawings of "What does energy look like?", an investigation of energy imaginaries by Flora Bowden and Dan Lockton as part of the Helen Hamlyn Centre for Design and SustainRCA's SusLabNWE project. Photo by Dan Lockton.

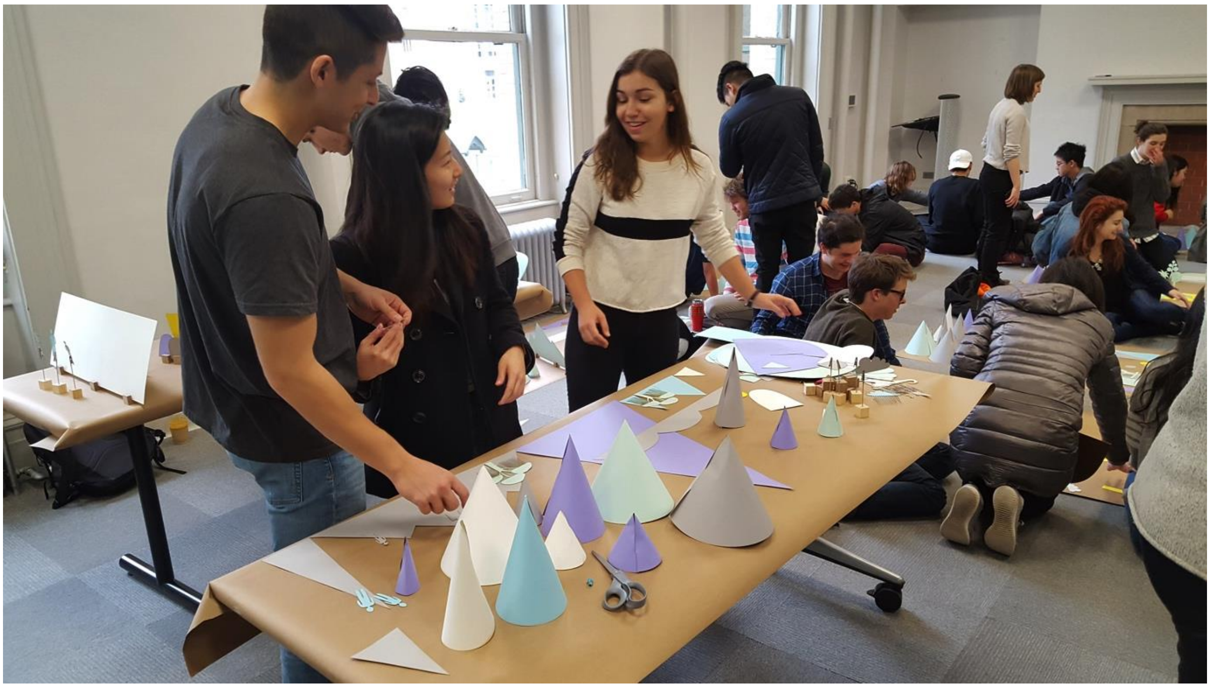

Figure 2. Students at Carnegie Mellon School of Design construct 'mental landscapes' representing group imaginaries of projects, part of an investigation by Delanie Ricketts and Dan Lockton of the Imaginaries Lab. Photo by Dan Lockton.

A prediction-minded onlooker may wonder what in the world could possibly be the basis for such speculation, and if accurate extrapolation is the name of the game, what we are suggesting here may seem a very odd thing to do: backwards, indeed. But understanding "the future" calls for inquiry ranging beyond whatever happens to seem most likely at any given moment. While an important frame, the probable shows us only part of the bigger picture. As the second author points out in introductory futures classes, "Any single image of the future, no matter how compelling, is incomplete." For one thing, the probable is a constantly changing vista: Look at the moment-to-moment meanderings of any share price for a demonstration. Think how the punditry morphs on the day after a surprising election outcome. In the futures field there is a classic trio of possible, probable and preferable futures (Toffler, 1970; Amara, 1981), which helps serve as a reminder that the question of what appears most likely to transpire, if taken too narrowly, leaves underexamined equally vital questions of what else might occur instead (the possible) and what we might want or not want (the preferable).

The word 'backcasting' was coined and the approach originally proposed for a normative use of scenarios in the energy industry: "backcasts are not intended to indicate what the future will likely be, but to indicate the relative implications of different policy goals." (Robinson, 1982, p. 337). Its use has broadened in the years since, including development of participatory approaches incorporating perspectives from diverse stakeholders, although still typically with a normative bent: "The essence of the backcasting approach to future studies is the articulation of desired futures, and the analysis of how they might be achieved" (Robinson, Burch, Talwar, O'Shea, & Walsh, 2011, p. 756).

Here we are using the term slightly more broadly still, not to refer exclusively to the development of normative scenarios, but as a lens or angle of approach, a structure of thought, which could be used to try to reason backward in exploratory fashion from any posited future outcome. This is the heart of a scenario generation process originated by Dator (2009, p. 16), elaborating 'generic images of the future', where the narrative pathways examined are not just preferred futures, but the most divergent set of trajectories possible; growth, collapse, discipline, and transformation (Dator, 1979; Dator, 2009; German, 2017).

The backcasting lens invites us to ask: in order for this to occur, what would need to happen? One can use it to inquire into the boundaries of the possible, and to deduce the approximate shape of what would be necessary to realise a particular pathway, positive or not. It may reveal new possibilities — or impossibilities.

Take for example entrepreneur and inventor Saul Griffith's examination of global renewable energy. Calculating humanity's annual energy spend for the early 2030s at a modest total of 15 terawatts, he describes the challenge of renewably meeting this target: "It's not the Manhattan Project, it's not the Apollo Project — they were science projects. The project we have to do is much more like World War II, except this time [all countries] play on the same side. That's [the scale of] what you need industrially" (Griffith, 2008).

A particular method that may help operationalise this lens (again, for any scenario) has been developed over the past decade; a heuristic for looking at transitions through "Three Horizons" (Hodgson and Sharpe 2007; Curry and Hodgson 2008; Wahl 2016). In essence this method divides the transitional process, whatever it may be, into three phases: now (horizon one), then (horizon three), and the interim phase between (horizon two). It provides a way of attending to and creating a narrative out of whatever is really at stake in transitioning from one state of affairs to another (Figure 3).

Effective use of the backcasting lens would help not only with avoiding the vicissitudes of extrapolative thinking, but also the temptation of dominating discussion with a single preferred future. Just as it is insufficient to examine change with an eye only to the probable, in designing for transition with normative ideals in view, the risk perhaps lies in excessive focus on defining a single positive future; navigating, as it were, with only one point of reference. Here too: Any single image of the future, no matter how compelling, is incomplete. The attempt to try to deduce one's way backward from there to actions today, a simplistic 'deficit model' for planning, embeds a dangerously brittle and linear conception of what bringing desired change into being entails. What is called for instead is a thinking environment or mental ecology (see **Experiential futures**), one rich enough with reference points that you know what you're looking to avoid, as well as what to pursue, and so that you are poised to meet whatever comes along. To venture an analogy to the importance of biodiversity in an ecosystem, or disciplinary range and neurodiversity in a team investigating a complex topic; resilience comes from requisite variety (Conant & Ashby, 1970; Dubberly & Pangaro, 2007).

4.1 Discussion: Why have we included this?

Backcasting may not be the only way to stretch and test our mental models of what tomorrow may bring, but it might be one of the most useful. This lens, applied not solely to 'planning' but to ensuring a diverse range of images of the future, we surmise, may well be a critical part of a healthy and transition-capable society (see **Imaginaries**). It seems a good candidate for key resources one might identify as necessary for navigating the wildly multivariate, hyperdimensional process of moving through history. Not a single, official, doctrinaire commitment, monomaniacally pursued (numerous instances of which, particularly from 20th century history, we leave the reader to imagine for herself). A constellation of alternatives to think with; not the ideal or preferred alone, but imaginal diversity.

*Related: alternative futures, deductive forecasting, **experiential futures**, **imaginaries**, scenario generation, visioning*

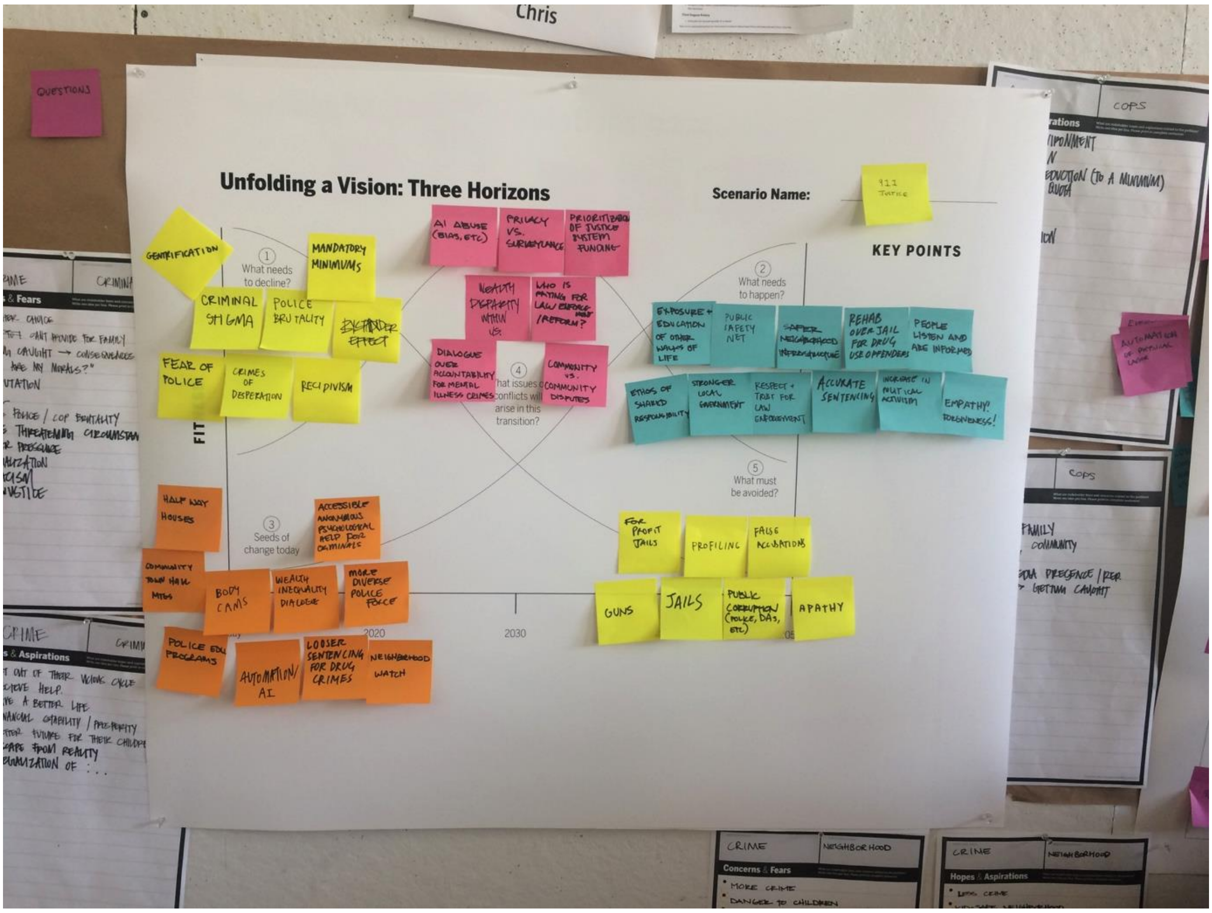

Figure 3. A transitional scenario in progress, constructed by Carnegie Mellon School of Design undergraduates working backward from their own ideal visions for 2050, as part of a class taught by Stuart Candy, Terry Irwin and Stacie Rohrbach. Photo by Stuart Candy.

5 Dark Matter

The systems approach embraced by transition design (e.g. Kossoff, 2015; White, 2015) recognises explicitly that there is more involved in change at scale and over time than simply the decision to redesign a product or service in isolation. Designed artefacts, services, and even software, are embedded in contexts, bound up in the practices and cultures of everyday life, and the organisational priorities, traditions, and structural legacies which end up determining what actually gets designed, by whom, and who has agency to change it. Laws, standards, conventions, histories, prejudices, algorithmic biases, path dependency, the actions of actors elsewhere, and a whole range of other factors (see **Imaginaries**) are all part of the systems within which designers seek to act.

A transition designer should thus be able to be more effective through paying attention to these (evolving) contexts as much as to the 'thing' itself, to design with insight into the ways in which the (often largely invisible) aspects of systems will work to support or constrain change. As transition design education develops, we might find it necessary to incorporate modules for learning about these systems, through classes about as well as practical engagement with public policy, management, community organising, and a range of other topics not usually included in a 'design' education. This could be framed as a call for more attentiveness to *infrastructures* within design. Infrastructure "never stands apart from the people who design, maintain and use it. Its designers try to make it as invisible as possible, while leaving pointers to make it visible when it needs to be repaired or remapped. It is tricky to study for this reason" (Star & Bowker, 2002, p, 230). Urbanist Keller Easterling, describing her concept of 'infrastructure space', notes that "[s]ome of the most radical changes to the globalizing world are being written, not in the language of law and diplomacy, but in these spatial, infrastructural technologies" (Easterling, 2014, p.15).

Star (a sociologist) and Bowker (an informatician) note that infrastructures often only become visible on breakdown, only apparent when they fail or stop working, or perhaps impede planned changes to a system. This relates to what Hill (2012, pp. 83–85) has called "the dark matter of strategic designers… organisational culture, policy environments, market mechanisms, legislation, finance models and other incentives, governance structures, tradition and habits, local culture and national identity, the habitats, situations and events that decisions are produced within". Hill uses the term specifically to refer to "what makes it difficult for installations to scale", the (metaphorical) "material that absorbs or rejects wider change" beyond a one-off prototype or demonstration. He argues that "[a] genuine and concerted engagement with dark matter is what would enable an intervention to become systemic, permanent, influential… the strategic designer has to understand the characteristics of dark matter just as designers might understand wood, steel, glass, pixels and grids." There is an extension to this argument which suggests that the ways in which different actors or stakeholders may perceive the dark matter (Figure 3), or not, is also worth paying attention to: what is invisible to one person may be very visible to others. For example, Mata-Marin and Lockton (2017) examine how migrants in the US experience 'borders' in everyday life, through designed artefacts such as credit cards and drivers' licences—regulating access and exerting control by embodying politics of difference—but which may be completely seamless to other people in the system. Perhaps part of a designer's role is to make this dark matter not just visible, but *legible* to those who are affected by it, but for whom it may be unreadable. Jain, Jankauskas and Ardern (2016), Lockton (2016a), Galik (2016), Bosch (2016), Gómez-Mont (2016) and others have examined how approaching policymaking in Mexico City and London with the aim of legibility could lead to new approaches for engaging the public in understanding and being involved with future directions for their cities, including aspects of the use of sensor technologies and other 'smart city' approaches.

There are also parallels with concepts such as Conway's Law (Conway, 1968; Brooks, 1975)—an organisation designing a system will create a system which replicates the communication structure of the organisation that designed it. Does transition design necessarily involve attention to (re-)designing the organisations involved in a project, to improving or reforming communication structures within a community, or between the community and other interested stakeholders such as local councils, utilities, transport authorities, and so on? Star and Bowker (2002, p. 233) suggest that "[f]requently a technical innovation must be accompanied by an organisational innovation in order to work: the design of sociotechnical systems engages both the technologist and the organisation theorist."

For Le Dantec and DiSalvo (2013, p. 247), the role of the designer engaged with infrastructure should be "the work of creating socio-technical resources that intentionally enable adoption and appropriation beyond the initial scope of the design, a process that might include participants not present during the initial design". This approach which would see dark matter, perhaps, as something transition designers could actively consider using and manipulating, to turn it into a platform for communities to adapt and adopt themselves.

5.1 Discussion: Why have we included this?

Dark matter can be a useful lens for reminding us to pay attention to the elements of the system which designers might not traditionally have considered relevant, and for developing a more comprehensive account of how change happens.

Related: infrastructuring, sociotechnical systems, complexity

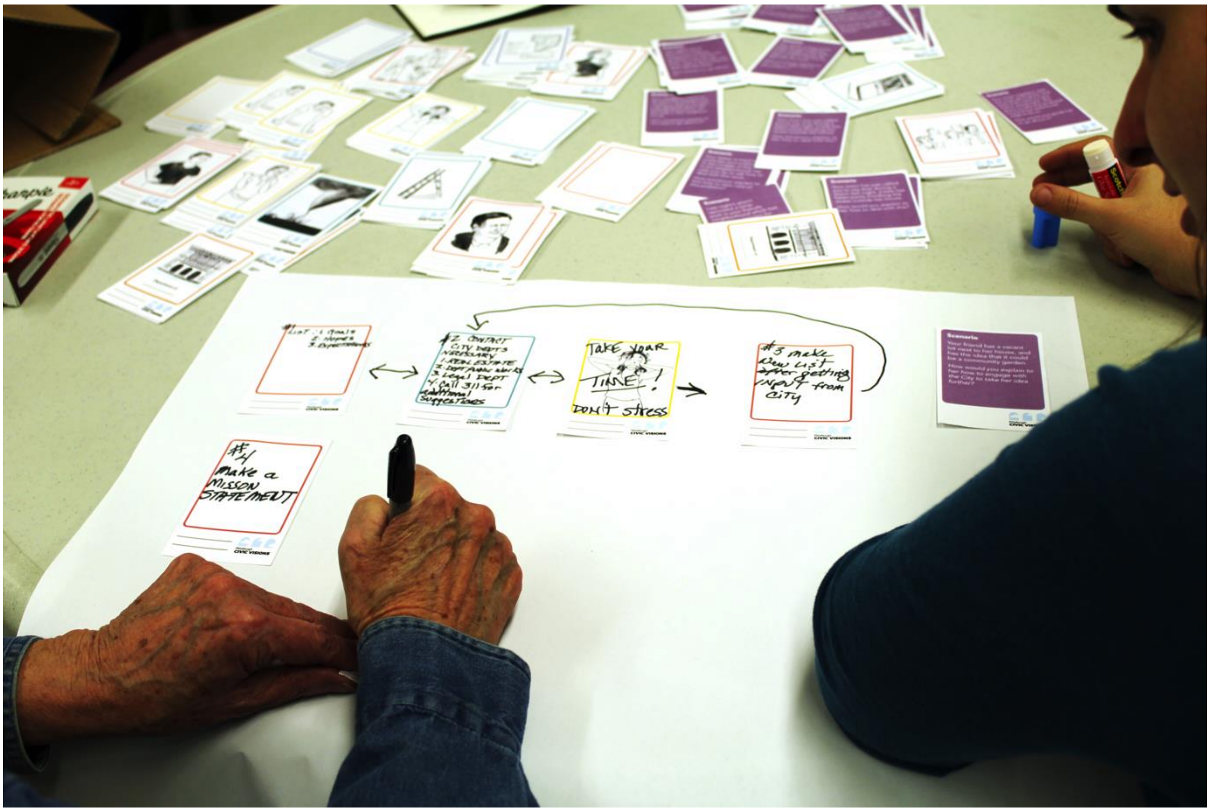

Figure 4. Members of the public in Pittsburgh, PA, create maps of their perceptions of the 'dark matter' of local government, as part of the Imaginaries Lab's Civic Visions project (Ashlesha Dhotey, Theora Kvitka, Nehal Vora, Matt Prindible, Silvia Mata-Marin and Dan Lockton). Photo by Ashlesha Dhotey.

6 Circularity

The idea of the *self-fulfilling prophecy* (Merton, 1948; 1995) is well-known enough to pass without much comment. But it is worth explicitly considering it in relation to visioning and transition design. Most obviously, there is the point that compelling visions of "desirable" futures are partly, presumably, intended to inspire people to work towards making those visions reality—to fulfil the prophecy. More nuanced treatments of futures (see **Experiential futures**) tease out some of the issues wrapped up in this idea.

Equally, though, prophecy can bleed into our imaginaries of the present—the ways in which we define our current situation, and how potential futures link to it, can end up structuring and determining the ways we act now. The sociologists Thomas and Thomas (1928, pp. 571–2) suggested that "If men define situations as real, they are real in their consequences", and thinking along these lines, we see that there can be a self-fulfilling nature to imaginaries. If we believe something to be real, and act as if it is real, and design and build institutions and infrastructures around that 'reality', the effect may be the same as if it had been real in the first place. What were once fictions become fact.

For example, the journalist Metcalf (2017) discusses the self-fulfillingness of imagining society as a market, drawing on Hayekian ideas: "The more closely the world can be made to resemble an ideal market governed only by perfect competition, the more law-like and 'scientific' human behaviour, in the aggregate, becomes." In a design context, the idea of a kind of circular causality in which designers' models of users (Lockton, Harrison & Stanton, 2012) or the assumptions or models imposed by clients, funders or other commissioners of work end up being designed into systems which then effectively make those imaginaries real, is not uncommon. Conversely, as pioneering scenario thinker Herman Kahn observed, "prophecies can be self-defeating as well as self-fulfilling" (Kahn, 1962, p. 18).

Design affects what people do, and what people perceive they *can* do. Everything around us that has been, or is being, designed, from the layout of our cities to the infrastructure of our governments to the way our doctor's surgery receptionist answers the phone, in some way influences how we engage with and make use of it, how we make decisions, what is easy and what isn't. It also, over time, affects how we think, and how we understand the world that we're part of, both individually and together as a society. And it affects our belief in our own agency, our own ability to change things (Lockton & Ranner, 2017). Designed artefacts, services, software or other elements of systems which embed particular notions of human nature (Lockton, 2016b) can, over time, lead to people acting in ways which come to *match* the models that the designers have of us or want us to become. As both Lanier (1995) and Dunne (2006) have expressed in different ways, if things that people use are designed with a caricatured model of a human, they may end up making that caricature real: we may end up behaving in the way the models assumed anyway, because we are configured by the systems and structures in which we live our lives—a curious form of self-fulfilling prophecy. Or put another way, perhaps, irony.

So in designing for transitions, within systemic contexts, it is worth reflecting on the *circularity* of the endeavours we are engaged in: to what extent are the variables that we believe they are shaping actually in turn shaping us, and the actions we take? Architect and cybernetician Glanville (1995) used the example of a thermostat 'controlling' the room temperature, but itself being controlled by the room temperature. Even this simple causal shift—considering a system from the perspective of the entity we normally assume to be in control—can provide new insights into the agency we have as designers. For example, how are transitions shaping designers, just as designers shape transitions? How does our work contribute to or co-create the issues we are seeking to address? Does concern or panic about futures lead to concern and panic being normalised or designed into the system? How can we use this approach in a more positive way? By analogy to the idea that the legal system and lawyers co-create the need for each other, how do we avoid this happening with transition design?

6.1 Discussion: Why have we included this?

Much design which aims to have an effect on social or environmental issues becomes itself constrained by or locked into assumptions about those issues, becoming part of the system it seeks to affect; or the changes it makes end up reproducing the structures of the problems that led to the need for intervention in the first place. There is value in transition designers being attuned to irony, aware of this self-fulfilling risk, and examining closely the assumed causal links embedded within projects and approaches.

*Related: **circularity**, **imaginaries**, irony, reflexivity, second-order cybernetics*

7 Experiential futures

To design is to grapple with the future. To design for civilisation-scale transition, even more so. The trouble with 'the future' is that it doesn't exist. It's a construct, a stew of more or less examined assumptions and interpretations carried over from the past, blended with extrapolations of trends and emerging issues in the present, inflected through hope and fear to produce fantasies and imaginaries projected into various quarters of the possible, probable, preferable, and their opposites.

It turns out that the troubling nonexistence of the yet-to-be is also an opportunity. Pages unwritten await their authors. The futures in our minds may sometimes pretend to us that they simply reflect on and respond to the outside world, but they are a technology of discourse and agency, a special subset of imaginative storytelling. While seeming merely to be inspired by observed change, they are in fact covertly shaping it.

Experiential futures refers to a set of approaches to make alternative futures present. The juxtaposition of 'experience' and 'future' is a deliberate contradiction: the here and now, the impressions of senses and mind, 1:1 scale reality as we experience it moment to moment; all this set against an inherently abstract notion of the to-come, by definition absent, forever at a temporal remove. Experiential futures (XF) seeks to make productive use of that contradiction, and harness the energy of its friction, by collapsing the distance, rendering absent and abstract futures cognitively and culturally tractable.

An experiential scenario is a future brought to life. It's a tangible 'what if', more textural than textual, and a way of thinking out loud, materially or performatively, or both. Seeking to collapse temporal distance and offset our habitual discounting of future events (Ainslie, 2001), XF angles for 'what ifs' real enough to trick the body into taking them seriously. Its contours are generous, taking in "the gamut of approaches involving the design of situations and stuff from the future to catalyse insight and change" (Candy, 2015, p. 18). XF "involves designing and staging interventions that exploit the continuum of human experience, the full array of sensory and semiotic vectors, in order to enable a different and deeper engagement in thought and discussion about one or more futures, than has traditionally been possible through textual and statistical means of representing scenarios". (Candy, 2010, p. 3)

As a lens, it is an invitation: how might you take your idea — any idea — of a future and bring it concretely to life, now? This move may be motivated by a wide diversity of agendas from the exploratory to the evangelical, the entertaining to the educational (Candy, 2010, p. 114). Any reason to think or feel into any future is a reason to mediate it, make it experiential. The matter of interest is not the design of artefacts per se, but the design of circumstances for thought (which may manifest as or incorporate artefacts). Less contents than context; less stuff than situations; less the things themselves than the conversations, insights and actions they enable. In each case, the latter implies and includes the former as appropriate (Figure 6).

> *We must make our freedom by cutting holes in the fabric of this reality, by forging new realities which will, in turn, fashion us. Putting yourself in new situations constantly is the only way to ensure that you make your decisions unencumbered by the inertia of habit, custom, law, or prejudice--and it is up to you to create these situations. (Graeber, 2015, p. 96)*

Some experiential futures examples from among many (for more see Candy, 2010; Candy & Dunagan, 2017):

- A product that immerses its user in a simulation of natural environments, apparently promoting the health of stressed-out urban office workers in the early 2020s, launched and demonstrated in the midst of a large (real, present-day) interior architecture trade show (Alter, 2016; Figure 5).

- A technology for babysitting infants in a virtual pod, presented in a present-day art museum, but surrounded by the accoutrements of a commercial sale context (product specifications, price banners, brochures), as one might find them in an electronics store in the next decade (Furness, 2017).
- A special future edition of the New York Times, reporting from the following year and embodying a fulfillment of progressive/liberal fantasies, handed out to commuters in the streets of Manhattan (Lambert, 2009).

The view through this lens is the capacity to regard the effective engagement with futures as about the generation or construction of scaffolding to think and feel with. The entire sensory and semiotic context of the body is the relevant canvas – and not just for the individual, but also for groups. 'The Time Machine', a room where you can inhabit a pocket of (say) the year 2040 for (say) 20 minutes, is one example of a pattern for immersive scenario creation that becomes possible through this lens (Candy, 2013; 2014).

Consider the philosophical concept of the 'extended mind' (Clark & Chalmers, 1998; Dunagan, 2015): thought isn't contained exclusively inside our skulls, but it occurs in and with our environments. This view could be adopted as a frame for examining all sorts of ordinary, existing practices, but it can also be taken further. If a notebook or whiteboard is a convenient prosthesis for memory, an experiential scenario is a prosthesis for imagination. It is a provisional, localised, and made-to-order 'mental ecology' (Bateson, 1972). The manifestation an imagined future context (see **Imaginaries**) variously in forms tangible, material, interactive, playable and performative, provides a wealth of opportunities to think and feel with beyond producing the most eloquent report. Experiential futures uses the idioms of reality to mediate hypothetical as *hyper*thetical, something *more than* just a thesis; an almost-real place.

Media theorist McLuhan's concept of the anti-environment may be useful here. The anti-environment relates to the environment in a sort of dialectical figure/ground relationship whereby the former highlights the unnoticed or taken-for-granted properties of the latter (the fish out of water realises with a jolt, at last, what it has been swimming in). "It is useful to view all the arts and sciences as acting in the role of anti-environments that enable us to perceive the environment." (McLuhan, 1967, p. 42)

So: all possible futures (literally an unimaginably vast space of stories one might tell) multiplied by all possible situations and stuff from within each. This represents a dazzling astronomical superabundance of theoretical design possibility. It is both wildly transdisciplinary and transmedia in character. That does not mean that the result or the ideal is an all-encompassing, extravagant *gesamtkunstwerk*: it is simply a medium-agnostic design opportunity. Simplicity will often be best, but it is perhaps the "simplicity on the other side of complexity" (reputedly prized by Oliver Wendell Holmes). It's more a matter of producing circumstances than a report, a video, or a telling artifact: any one of those things may indeed turn out to be the best thing for the job, but noting and avoiding unjustifiably mediumist assumptions is key.

7.1 Discussion: Why have we included this?

All of the above brings into focus the critical need for thoughtful and critical attention: what futures to choose to manifest in this way, when we consider transitions? Prototyping or performing something random that is purportedly 'from the future' might seem worth it as a lark, the first time or two, but sooner or later the mere conceptual novelty of long-range prototyping for its own sake has to wear off (Candy, 2018, p. 243). What is left is perhaps a closer attention to *which futures*, in *whose interests*, with *what effects*. Deeper questions. More critical questions. Opportunities to do better.

Related: critical design, design fiction, experiential scenarios, guerrilla futures, ***imaginaries****, immersive storytelling, speculative design, transmedia, worldbuilding*

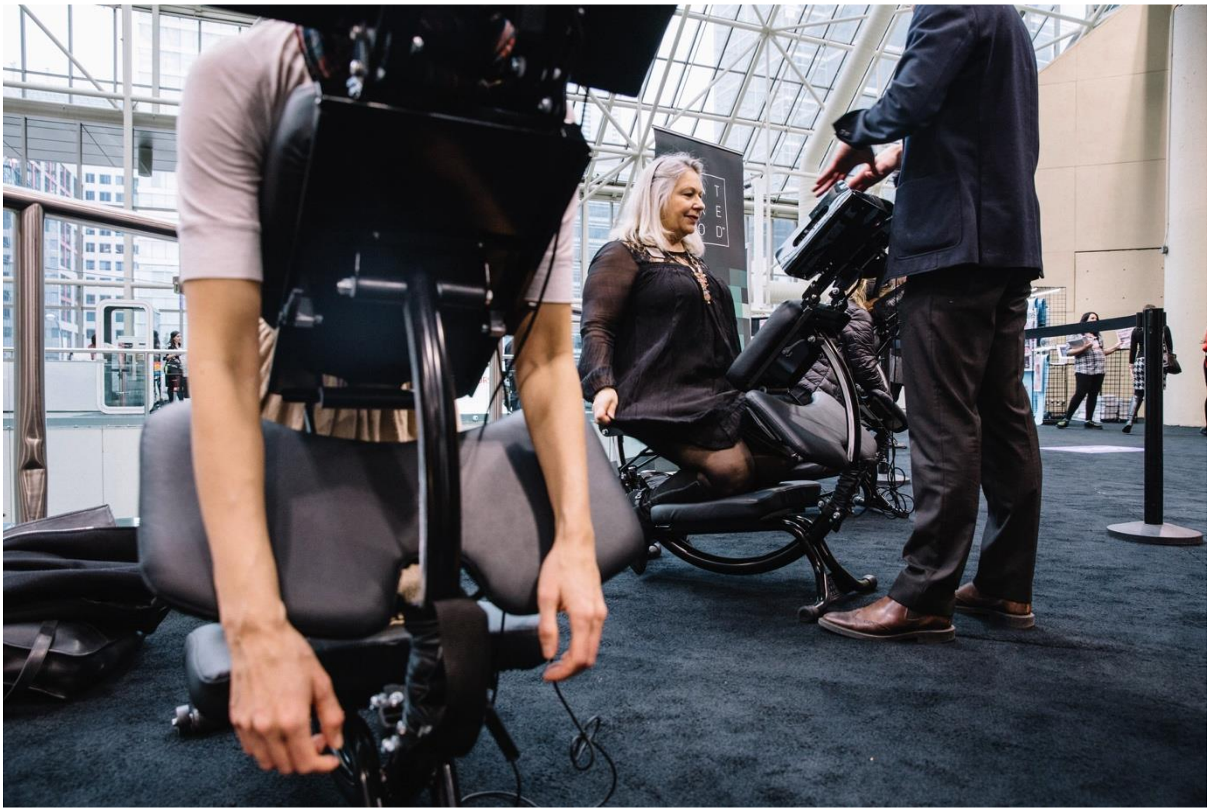

Figure 5. Visitors to a large interior design and architecture show interact with NaturePod, a hypothetical future product demonstrated and launched at the show as if it were commercially available. Installation by Situation Lab, photo by Connie Tsang.

8 New Metaphors

It has been argued that metaphors and analogies are central to much human reasoning, understanding, and creativity (Hofstadter, 2001), as well as the language we use (Lakoff & Johnson, 1980). Here we use the term ‘metaphor’ in a broad, intentionally imprecise way, to refer to a class containing a variety of ways in which one thing can be understood in terms of another.

One simple reason for metaphors’ prevalence is that by mapping features of an existing or familiar situation onto a new or unknown one, we are enabled to grasp and (be more confident that we can) understand it more quickly. As such, metaphors are often used strategically in design (Saffer, 2005; Cila, 2013; Hekkert & Cila, 2015). Nevertheless, metaphors are not *the thing itself*—they are always an abstraction, a model of the situation rather than the situation modelled. They can be a map to a territory, but should not be mistaken for the territory. As with models, all metaphors are wrong, but some are useful (Box & Draper, 1987). The constraints, affordances, and assumptions that a metaphor suggests or imposes can themselves condition or structure our interaction with, or approach to, a new situation, as we understand, or come to understand it in terms of the old. Metaphors become “enabling constraints” (Hayles, 2001, p. 144). The hunt for “defensible metaphors”, to use cybernetician Gordon Pask’s term (Scott, 2017), is not trivial.

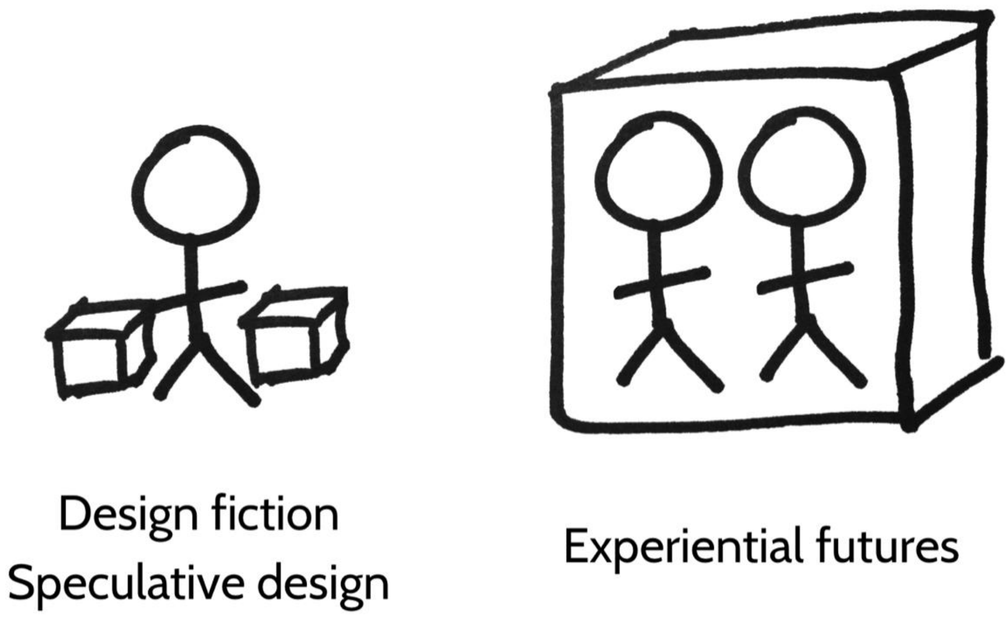

Figure 6. The lens of experiential futures invites attention to whatever it takes to create an effective context scaffolding thought and feeling about possible futures. Diagram by Stuart Candy (thanks to Greg Van Alstyne). Originally published in Candy & Dunagan (2017).

So, how does this apply to transition design? As a corollary lens of '**imaginaries**', we suggest not just attempting to understand the existing metaphors in use in a situation, but actively generating, proposing, and following through the implications of *new* metaphors (Cila, 2013; Schön, 1979; Jung et al., 2017) for concepts pertinent to the frame of transition taking place—and the potential futures embodied in visioning. This is not primarily about devising novel metaphors for the specific design of products or interfaces—although this work is interesting—but, at a system level, something closer to Klaus Krippendorff's (2006, p. 11) notion that designers could "create and start using new metaphors, new vocabularies, and new ways of languaging, like poets and science fiction writers do, thus bringing forth new ways of conceptualizing the world and encouraging new practices." Mary Catherine Bateson (1984), in her own work, and in discussing the work of her parents Margaret Mead and Gregory Bateson, has also frequently employed the idea of reframing societal issues through using new metaphors, for example "the idea of 'home' as a place to give and receive nurture" becoming "a new metaphor for the workplace" (Moyers, 1988). It is worth noting here that White (2015) considers aspects of transition design itself to be based around the application of metaphors from ecosystems to social systems.

One significant area where new metaphors might offer opportunities for transition is the economy. A number of economists (e.g. Landau & Keefer, 2014) have noted the ways in which the metaphor of 'the national economy is a household budget', commonly employed by media and politicians alike, is not just an oversimplification but a structural error in terms of many key features of the systems under discussion, such as fixation on 'balancing the books'. This leads to specific decisions being made (austerity policies for example) that arguably cause harm or restrict the ability of the system to adapt to changes in circumstances. How would public political discourse on the economy be different if a different metaphor were used? (We can imagine ideas such as 'the economy is a garden' or 'the economy is a loaf of bread being baked.') Would it be better used to *explain*, or to *persuade*? Or both?

8.1 Discussion: Why have we included this?

The art of designing new metaphors and framings is well advanced in political contexts (Lakoff, 2014) and increasingly in corporate settings (Erard, 2015), but has been underexplored in design and futures, and offers potential for transition designers to enable communities to think about, envision, and understand their current situation and possible futures, both locally and at global scale, in new ways. The new metaphors can be generated in a number of ways, from matching 'structural features' of situations, to a semi-random process of bisociation (Koestler, 1964; Lockton et al, 2018—Figure 7). But a participatory process in which communities co-design the new metaphors, involving people in understanding their own and each other's understanding as the metaphors are constructed and explored seems preferable from a transition point of view to one where new metaphors are imposed by an authority seeking to persuade.

*Related: frames, **imaginaries**, lenses, worldbuilding*

Figure 7. Participants at an Imaginaries Lab New Metaphors workshop run by Dan Lockton and Sarah Foley at the Google SPAN conference, 2017, talk through their ideas for new metaphorical representations of concepts. Photo by Dan Lockton.

9 A Conclusion

One of our aims in entering the transition design research discourse is to find ways of working practically which embody and advance the ideas inherent in the transition design paradigm, while making use of the many techniques and methods developed in other fields (among them design research more widely, foresight and futures studies, design for social change, systemic and strategic design, and more) and iterated over the course of many projects and engagements. This modest collection of ideas is put forward partly as a provocation, partly as potential departure point for a more comprehensive endeavour, and partly as an invitation for others working within, or interested in, designing for transitions to contribute lenses they find useful for new ways of seeing. The authors welcome readers' suggestions.

At this time, the vocabulary is of course fragmentary. But this will change. Part of the transition at stake is our internal, collective, developmental shift from preliminary, tentative and miscellaneous beginnings, to an expanding reference universe of cases and terms, and a better-established sense of how to do what needs to be done. Lately, efforts inspired by the framing concept of the 'pattern language' have begun to outline the makings of a body of practice with similar large-scale transitional and transformational intent (Finidori et al., 2015; Baumgartner et al., 2016). The questions we conclude with for the moment, then, concern how we might ultimately build a collection of transitional lenses into something more systematic. What would a pattern language for transition design look like? What other areas of design research have lenses to contribute?

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Transition-oriented Futuring: integrated design for decreased consumption amongst millennials

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doi: 10.21606/dma.2018.512

This paper is concerned with the problem of overconsumption and opportunities to create alternative marketplaces that could ease the transition towards less, and different ways of consuming in everyday life. We argue that a more holistic view of the design context, multiple perspectives, and approaches, give more profound insights, explorations, and framings of the problem. Zygo, a future service for teens and young adults, based on the second-hand marketplace, illustrates our approach. Zygo challenges consumer lifestyles and provides a possibility for designing alternative practices around the use of everyday things. Repositioning the second-hand market as a scaffolding that supports and connects the youth in the transient, different and yet complementary phases of their lives, Zygo helps manage aspirations and needs of the youth, while raising awareness around consumption practices. Zygo is both an argument for an integrated design approach, drawing on service, system and interaction design, as well as social practice theory, and a designed proposal with the potential to promote transition design thinking.

integrated design; service futuring; transition design; sustainable consumption

1 Introduction

Conventional design of artifacts for everyday living and marketing strategies for including these in our everyday lives are still engaged in positioning consumer goods for short adoption and disposal cycles, and a long-term consumer engagement with the brand. The basic value proposals are still related to profit. One of the key strategies for securing profit from goods and services is by gaining social status through ownership of exclusive items. It is, however, becoming increasingly obvious that strategy of focusing on the unrealistic vision of the future with continued economic growth and maximization of the profit on the one hand, and social status perceptions based on ownership of goods on the other, have resulted in environment-eroding, unsustainable consumption, and use practices. Societal passage towards a more sustainable everyday future is needed (Irwin, 2015; Irwin, Kossoff, Tonkinwise, & Scupelli, 2015). Design has the potential to chart this passage and make the transition easier. Design's potential lies in considering systemic changes, and the ability to address the interconnectedness of social, economic and environmental aspects by framing a design space in which the resolution can be found. Understanding of the role of design in these larger, complex transformations and transitions that goes beyond the design of artifacts is currently unfolding and includes holistic, integrated, and meaning-oriented approaches. For example, when considering sustainable living, previously disconnected studies of made environments, nature and its resources, society and culture, and values and drivers of economies are all important and needed when engaging in rephrasing questions around eco-technological, cultural and political tensions through design (White, Gareau, & Rudy, 2017).

In this paper, we tackle the current "throwaway culture" and look at alternative propositions and ways of increasing the use time of durable consumer goods. Recently, this problem gained traction in sustainable design discourse within human-computer interaction (HCI) (Blevis, 2011; Cooper, 2004; Odom, Pierce, Stolterman, & Blevis, 2009; Pierce & Paulos, 2011; Pierce, Strengers, Sengers, & Bødker, 2013; Remy & Huang, 2015) and sustainable design discourse (Hinte, 1997; Lubin & Esty, 2010; Manzini & Vezzoli, 2003; Roy, 2000). In response to the environmental concerns related to the large volume of acquisition and disposal from the first-hand market offering new and unused goods, the second-hand market has been discussed as a viable alternative that might reduce the demand for new goods by reusing and extending the lifespan of durable and functional consumer goods (Gregson & Crewe, 2003; Pierce & Paulos, 2011; Thomas, 2003). However, second-hand marketplaces have existed for quite a long time, yet they continue to remain a niche practice (Pierce & Paulos, 2011). Online and mobile based second-hand marketplace services are more recent. While in theory, they present potentially more sustainable alternatives (Hanks, Odom, Roedl, & Blevis, 2008; Odom et al., 2009; Pierce & Paulos, 2011) to traditional marketplaces, in practice, the experience with such services remains unfulfilling. As a consequence, their uptake is limited, and there is a danger that also these may fail to become a real, mainstream alternative to the first-hand market.

The research presented in this paper is part of a larger research project that involves industrial partners and focuses on the design of services for more sustainable consumption, exploring the potential of second-hand marketplaces to prolong use of consumer goods. We focus specifically on service futuring for millennials, age group of 16-27 years old, because they use technology in everyday life comfortably and naturally (Selwyn, 2013), and have a strong role as influencers for other age groups (Prensky, 2001; Selwyn, 2013). Additionally, the emphasis on a younger demographics supports the possibility of designing for rituals and routines of second-hand use. These rituals and routines can evolve over time and be carried forward later during the adult life through what is referred to in transition design literature as a "sustained and gradual change" (Irwin et al., 2015).

While several strategies for facilitating more sustainable consumption patterns through design have been proposed, design for second-hand marketplaces has remained predominantly focused on seamless discovery and inclusion of second-hand consumer goods as service offerings. In contrast, we primarily focus on practices of acquisition, dispossession, and reacquisition (Pierce & Paulos, 2011). The secondary theoretical premise draws from transition design on changes rooted in, and extrapolated from, the existing system it intends to slowly transform (Irwin et al., 2015). We argue that it is essential to ground *future* service design concepts and approaches in a fuller, integrated understanding of current *practices* related to consumption of consumer goods in general, and second-hand marketplaces in particular. To this end, we use service futuring and visioning methods to discuss and create preferred futures, as exemplified by *Zygo* (Srivastava, 2017). To create Zygo, Research through Design (RtD) (Fallman, 2008), social practice theory and practice-oriented design (Kuijer, 2017; Shove, Pantzar, & Watson, 2012), service design (Manzini & Vezzoli, 2003) and systemic design (Sevaldson, 2011) were used. Thus, Zygo is an example of a designed concept for futuring, as well as an argument in favor of an integrated and holistic design approach towards a sustained and situated shift to decrease consumption among millennials by creating new, more sustainable everyday practices.

2 Background

In Manzini and Vezzoli's work (Vezzoli & Manzini, 2008), the emphasis is laid on systemic approaches towards sustainable product consumption. They suggest that sustainability should be discussed separately from approaches directed towards optimizing operations and materials. The work of Kuijer, de Jong and van Eijk, (Kuijer, Jong, & Eijk, 2013), brings forward the idea that alternatives to existing everyday practices of consumption can be designed. They point out that, while there is no consensus on establishing and measuring optimal consumption levels, there is a widespread agreement on the fact that current consumption levels are dangerously higher than what can be socially sustained in the very near future. Pierce et al. suggest that *"sustainable interaction design has less to do with redesigning material technologies themselves than with redesigning how we think about, and relate to those technologies already made*" and reframe consumption practices in terms of acquisition, possession, dispossession and reacquisition (Pierce & Paulos, 2011, p. 2392). They also suggest that, while building functional and durable goods is crucial, the problem of premature disposal of perfectly functional durable goods is still there. Thus, a purely functional perspective is not sufficient to tackle the problem. Building on this body of work, we explore design approaches for reconfiguring practices of *reacquisition* based on an understanding of the current everyday practices of *acquisition* and *dispossession* in the consumer marketplace. We start by framing everyday practices.

2.1 Framing everyday practices

Social practice theory conceptualizes human actions and the ways people conduct their everyday lives in terms of their routinized behaviors, or practices (Wakkary, Desjardins, Hauser, & Maestri, 2013). In (Shove et al., 2012), the authors deconstruct practices into three constituent elements: materials, competences and meanings, see Figure 1.

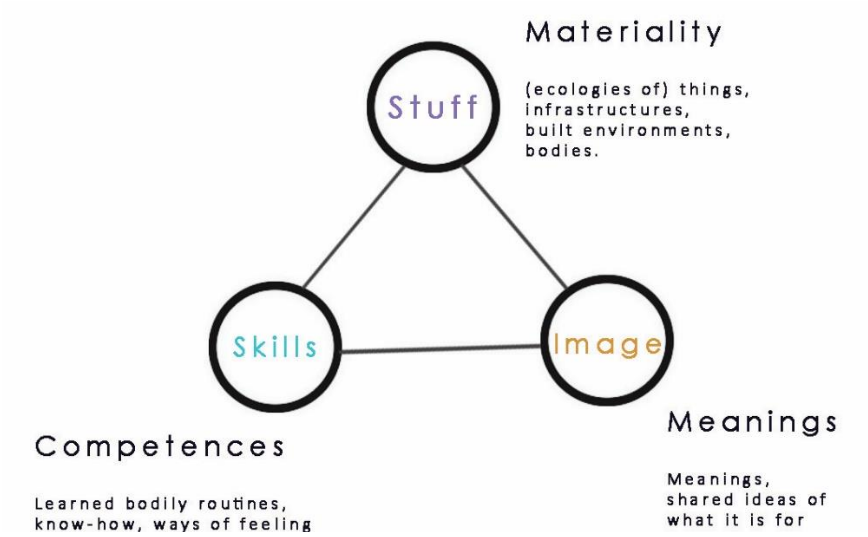

Figure 1 Model of social practice. Based on the model from (Shove et al., 2012)

Shove et al. argue that a specific configuration of these elements, with minor variations at the time of performance by a community, constitutes what is known as a practice. Elaborating further, practices, when performed in a specific context, show some variations in the configuration of the constituting elements and this is referred to as *practice as performance*. However, *practice as entity* is comprised of a variety of similar performances and constitutes a common understanding of a practice within a community. Lastly, the authors differentiate between *proto-practices, practices and ex-practices* as the three stages practices move through. Proto-practices are understood as proposals for future practices and ex-practices refer to practices that are dying or dead. While practice theory acknowledges that practices have their own internal logic and may be hard to change due to inertia, they also offer the promise of change at a scale far beyond that of the traditional service design based on discovery and inclusion (Ingram, Shove, & Watson, 2007).

Two aspects of framing practices in (Shove et al., 2012) are central in the context of design for second-hand reacquisition and reuse. First, the authors identify *materiality* as a key element, which helps position and determine the role of durable goods, as well as digital artifacts, in this study. Secondly, the framing of '*practice as entity* that is *performed* in endless variations', presents an interesting opportunity to explore the temporal and malleable aspects of reacquisition practices. The value of this approach is in being able to uncover complexities, interdependencies, and dynamism of the *collective and cumulative actions* and make design efforts at that level (Pierce et al., 2013; Wakkary et al., 2013). We argue, in line with Kossoff, Pierce, Kuijer, Wakkary and others (Kossoff, 2015; Kuijer, 2017; Pierce et al., 2013; Wakkary et al., 2013) that social practice theory allows for reframing of reacquisition and reuse as socially constructed practices. This underlines the need for exploratory research and design approaches to reacquisition and reuse.

Service futuring is one way to engage in reflexive conversations about the role of theories, practices, products, services, values and other ingredients needed for transition towards more sustainable consumption. When discussing service futuring in relation to Zygo, we also make use of the rich set of concepts presented in (Ingram et al., 2007) related to general mechanisms the acquisition of goods (social comparison, self-identity, mental stimulation and novelty, matching or the Diderot effect), specialization, appropriation, assembly and normalization, as they relate to practices of acquisition, possession, dispossession and reacquisition.

2.2 Other Influences

Apart from the practice and interaction-based approaches, a more systemic view on the use of durable goods has also been suggested (DiSalvo, Sengers, & Brynjarsdóttir, 2010). This research direction led to reexamination of production, use and reuse, as a holistic approach, calling it strategic sustainable design. The discussion around strategic sustainable design hinges on the concept of service economy (Manzini & Vezzoli, 2003) and Product Service Systems (PSS) (Roy, 2000). It is driven by value exchange, where people interact with services and not material goods, hence positioning strategic sustainable design directly within the discipline of service design.

We argue that dealing with practices as a unit of design in sustainable interaction design (SID) should be explored as an important complement to the service-oriented perspectives. In (Kuijer, De Jong, & Van Eijk, 2013), the authors argue that systemic approach towards SID implies that practices themselves need to be designed. From a design standpoint, the framing of *proto-practices* as design proposals (Shove et al., 2012), offers a parallel to *prototypes* that are commonly discussed as outcomes of the interaction design process. Further, we argue that systemic solutions need to consider the role of services in the design of practices that address the short usage of consumer goods. This is important because durable commodities do not exist in isolation. They are a part of a larger ecosystem that addresses extended usage scenarios such as support, replacement, refurbishment, all of which have been discussed in strategic service design and PSS literature, e.g., (Manzini & Vezzoli, 2003; Roy, 2000). The interdependence of interaction and service design in the context of artifacts and their ecosystems, has been featured in discussions within design research (Buchanan, 2001; Fallman, 2007; Holmlid, 2009). While Buchanan and Fallman have approached this interdependence through concepts of fourth order of design and services as digital artifacts respectively, Holmild emphasized the value of integration of identified interdependencies of service and interaction design.

3 Zygo: Integrated Framework

Integration of service, interaction design and social practice theory perspectives, we argue, creates a hybrid lens through which we can view the design context for second-hand use and reacquisition of durable goods. In this way, discussion of the materiality of goods is brought into service design, as well as the ability to consider a larger service ecosystem within interaction design. Further, we argue that dispossession and reacquisition need to be discussed as practices. Working with futuring of a service, calls for an approach that allows for objective descriptions of social practices and behaviors in the present, while cultivating emergent futures through abductive and creative processes, assisting in tracing the path of transition. Generally, design research has been known to be especially effective in future focused and exploratory situations when dealing with complex issues with no perfect solutions. Thus, Research through Design (RtD) (Gaver, 2012) provides an overarching framework to guide our inquiry. In particular, we use the interaction design research triangle (Fallman, 2008) as a tool to drift between design studies, design explorations and design practice. We find the triangle to be a useful tool, regardless of the order of design (symbolic, material, service, or complex systems). Research through Design positions the design practice as a means to engage in informed speculations about the future, based on an empathetic understanding of a situation of a theoretically and topically relevant problematic, resulting in proposals, rather than predictions (Zimmerman, Forlizzi, & Evenson, 2007).

In the context of our research, design practice is framed by our engagement with industrial partners in a larger project that is concerned with more sustainable consumption. Thus, a real-world service organization and its second-hand marketplace has been evaluated at the start of our research. However, our work is guided by our research intent to explore a radically different future and thus, the design practice is focused on design and implementation of presently possible alternatives and visions of future services, as if they existed today, that link consumers, service providers, goods, values, goods, practices and the underlying technologies in a holistic manner.

In design explorations, the focus is on extrapolations from the present to what *can be*, in other words, exploration of future practices and future-oriented design proposals. In the context of second-hand use and over consumption, explorations of technological or alternate service-centric proposals are not based on current market expectations. By way of providing an exemplar from this activity, we explored the role of designed artifacts as enablers of second-hand use. One of the objects designed for this purpose is called *Radius* and was designed as a metaphor for the price and other kinds of tags found on new objects. However, rather than providing expected attributes, Radius exposes a demand or a supply of items in the second-hand market. This object was designed as a behavioral nudge to place consumer goods on the second-hand market. Radius was a conceptual exploration, created free of market, or even technical constraints. Through engagement in reflective making, key discussions emerged, such as how the ecosystem in which Radius is placed affects its form and function, how to ensure decrease in consumption, how it can be shared with household members, etc.

Reflections related to seamless integration of diverse design approaches and practices are related to the design studies area of Fallman's design research triangle (Fallman, 2008) and show how the three design activity areas influenced and informed each other in this research.

3.1 Zygo: Service

Knowing that services focusing on second-hand goods are in theory an opportunity for transition towards more sustainable use of goods, but that in practice the situation is a lot more complicated and problematic (Gregson & Crewe, 2003), we began by understanding current services in the local context. The largest local service for repositioning of second-hand goods is something like Craigslist in the USA. It was established in the early 2000 and has been the biggest and the most influential second-hand market service since. In terms of online services, although not local, eBay has had the most significant presence. However, local mobile services have started growing since 2014, and several have been targeting youth and young adults. All of them are based on traditional service design concepts, based on functionality supporting optimal discovery and placement of goods as service offerings. This, in turn, influences people's perceptions and engagement with such services, which they view as mobile digital classifieds rather than marketplace alternatives, see Figure 2.

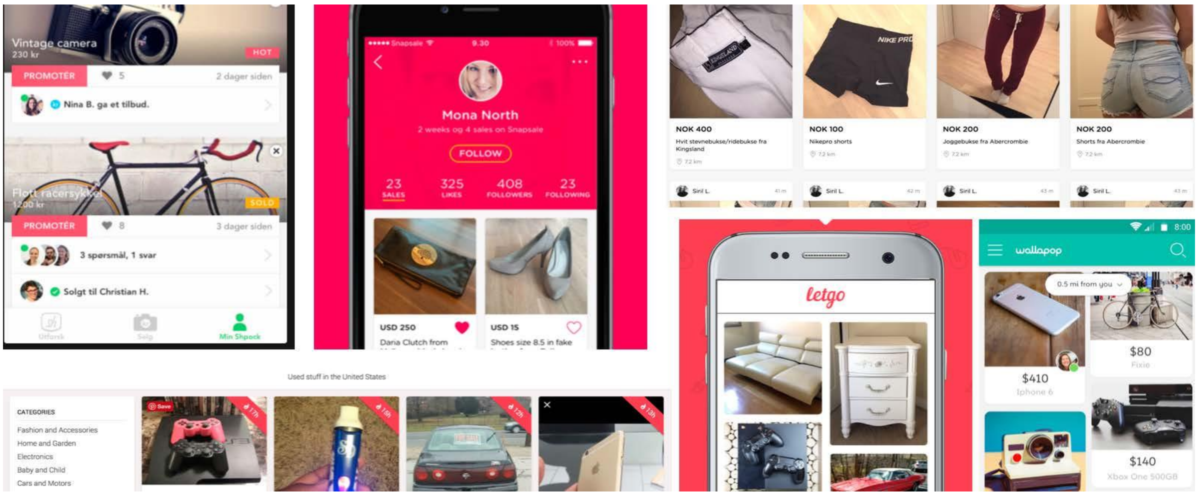

Figure 2 Collage of current online second-hand marketplaces. The images aim to show that products are the exclusive focus in these spaces. No novel or transformational value propositions are visible in these marketplaces.

Therefore, we contend that for the second-hand marketplaces to become a true alternative to the first-hand ones and establish new, de-centralized and localized consumer-consumer relationships, their practices and perceptions need to be challenged, and reframed, both conceptually and through the design of alternate service proposals, situated in a localized context.

Encapsulating the integrated design approach, Zygo is a service proposal based on localized practices of second-hand use and designed around place, people and possessions (see Figure 3), with a focus on the practices and perceptions of the local youth (between 16 to 27 years). It is framed as a scaffold to stages of life in which the youth are deeply invested in independently developing a sense of who they are and who they want to become in the future.

Data on consumption practices, lifestyles and social influences have been collected from sixteen participants, amounting to about 35 hours of recorded material. The main behavioral archetypes (Hartwell & Chen, 2012) that we identified through the analysis of our data were 1) *'nurtured dweller'* – a youth living at home, interested in first-hand purchases and part time income sources, contributing to the second-hand inventory, 2) *'busy frugal nomad'* – those managing shared and temporary living arrangements on a student budget and 3) *'steady independent mover'* - with steady jobs and the ability to replace need based goods with aspirational ones. Zygo has been designed to play a visible role in managing the connections and communication flows between these archetypes, by connecting complementary practices, lifestyle aspirations and needs, see the central part of Figure 3. It incorporates four supporting components: 1) Radius, as an interactive object that helps make decisions on what to sell and buy, 2) diverse print materials that help visualize Zygo as an existing service, 3) a high fidelity mobile prototype of the service and 4) a concept video, utilizing animation and storytelling to articulate possible ways of configuring the elements of consumption practice. Details regarding Zygo and its components, e.g., the functionality of the mobile app prototype, interface concerns related to Radius and other issues that would be addressed within interaction design or service design are outside the scope of this paper. Instead, alternative forms of current and future uses of Zygo and its potential to transform practices towards more sustainable ones, are of central concern. Zygo makes it clear that it aims to support dialogue between different archetypes engaged with the service, help them plan and manage a self-reliant life, assist by sharing relevant information for their transient situation and empower them to become engaged with local, driven and young community it serves.

The following three future narratives feature one of the archetypes each. Narratives are fictive but grounded in the interview data and on Zygo as a designed artifact.

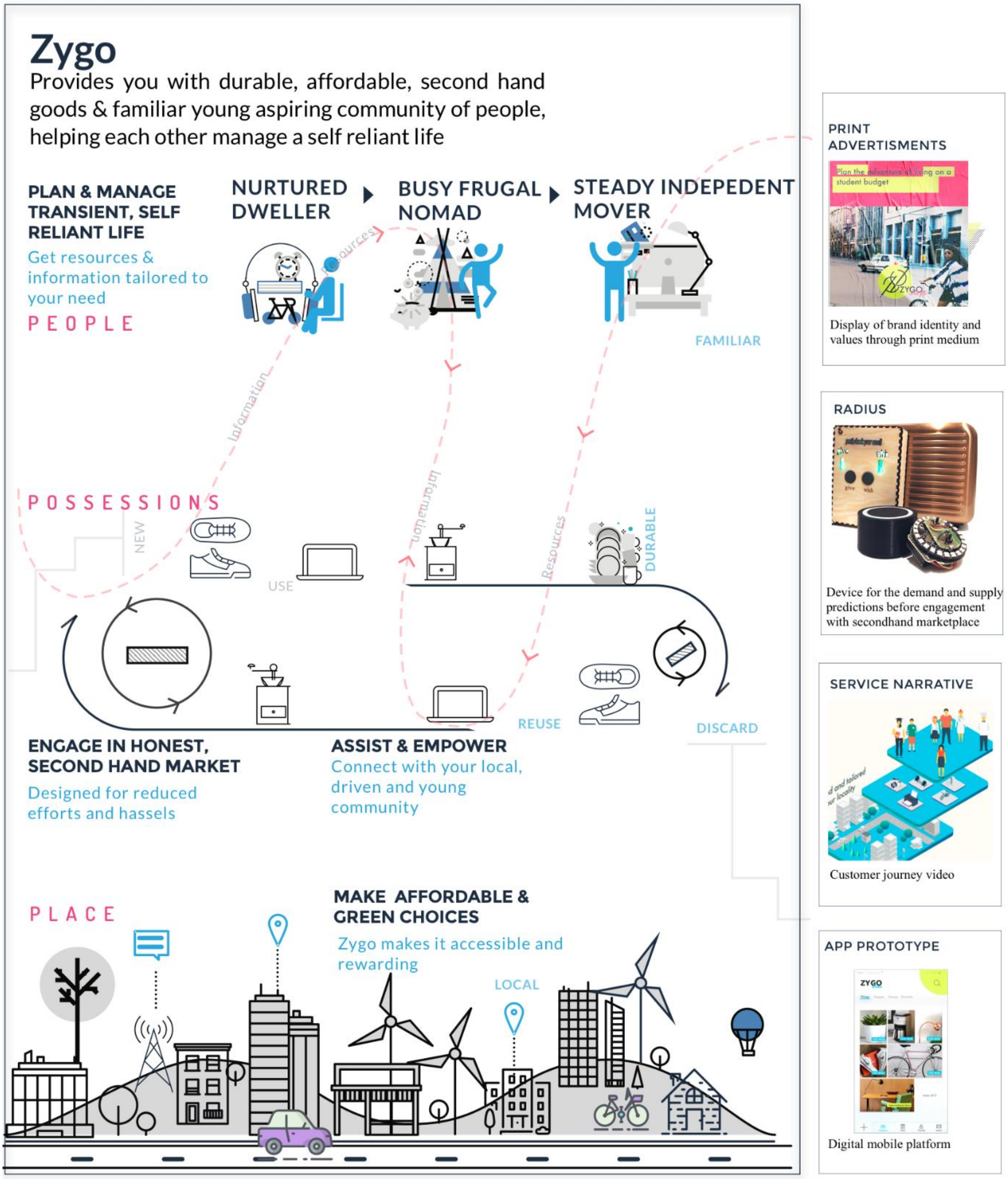

Figure 3 Service visualization, depicting the value landscape. The side images show the supporting elements of the service. These include a mobile app prototype, a video showing the service narrative, a device prototype that shows supply and demand and, finally, printed materials and branding elements

3.2 Zygo: Futuring narratives

3.2.1 Busy Frugal Nomads: Martine and Emma

Martine and Emma are roommates, and long-time friends. Martine is 23 today, but there is no time for a birthday celebration. She and Emma have spent the whole day packing and cleaning their rental apartment. It has been a long and tiring day, yet full of anticipation. The last year of college is over, the dream job is on the horizon. Taking a picture off the wall, Martine glanced at Emma and burst into laughter. Emma was hugging their purple reading chair hard, clearly unhappy about the prospect of parting *with it. A freshman girl was to come in 20 minutes and take the chair away. Emma knew that she cannot take it with her to the city she is moving to. Martine loved the chair too, but her heart was now set on a limited edition Hygge living room piece that she will get for her new place. For the past few months, she has been taking a longer route home, the route that led by Hygge's window display, showcasing what she considered to be the ultimate chair. Martine looked at the picture in her hand. She found herself staring at a photograph showing the party in their gorgeous living room, from two years ago. It evoked lots of memories of their arrival to this place. Martine had just a few books, a bicycle, some lamps and her favourite curtains. Even though the studies and the part time job took most of her energy, she and Emma still managed to create more than a decent interior, on a tight budget. Thanks to Zygo and its University Circle. Martine and Emma, as was traditional when graduating, put a bunch of things from their apartment on Zygo University Circle, the purple chair being one of them. Everyone bought as a freshman and sold when graduating. It was customary to take good care of things in use, in particular, of things for home that were solid and made with love. It was nice and convenient. The incoming students would always look for stuff at the University Circle first, because it was very local, and thus, even without a car, easy to pick things up. They called this "Zygoing" the place.*

It was the day when they got the much sought after coffee machine from a newly graduated girl that Martine famously declared that she and Emma were Zygo pros. Time really passed fast. For four years, this place was home and it reflected so much of who Martine was then, and who she wanted to be, too. Snapping back to the present, Martine turned to Emma: "You know, I will miss very much Zygoing my new place with you. Apart from Hygge's chair, I will Zygo everything. Do you really have to go live that far away?" Emma smiled and patted the back of the purple chair "I will never forget how we killed our backs carrying this chair for the entire four blocks, and then up to the third floor. We were just awesome."

The narrative shows Martine and Emma as part of the established social practice around acquiring home stuff from Zygo's University Circle. They bought from graduating students, they sold when they graduated. It was local, green and they felt good about it. This way of engaging with the service even got a name: Zygoing. The girls made an assembly of things from Zygo easily, as they appropriated things in a manner consistent with the vision of frugal, communal student life. They got nearly heirloom, lovable pieces of furniture that it was hard to part from. However, Martine was facing a possibly challenging situation. Buying the Hygge chair, she risked having to get everything much classier that intended, in order to match the superb design of Hygge chair. The matching, or Diderot effect (Ingram et al., 2007), and the social comparison mechanism during the transition from student to professional life were known to trigger overconsumption. Fortunately, Martine was a Zygoing pro, and was aware of this possible trap. The narrative offers opportunities for futuring and discussing practices related to the service, in conjunction with thinking about social practices and consumption mechanisms, both at the theoretical level and at the level of engagement with Zygo over time, tracing the evolving worldview, while transitioning towards the preferred future.

3.2.2 Nurtured Dweller: John

At 17, and from the age of 3, John has an immense passion for electronics. However, he is still in high school and does not have a job yet, so money is an issue and his parents are not very understanding. Earlier this morning, he asked mom if he could do chores to earn some money so that he could buy XyLens II, and her response was: "Did you not get that last month?" "That was just a XyLens, mom, not XyLens II". "Besides", mom said, "you need to see some friends and not live for this stuff only." John has been using Zygo since he discovered the service 2 years ago. He always sold components or other stuff that he did not need any more, in order to be able to support and develop this passion.

He would take up new technologies so fast that he would usually be done with them when others just discovered them. Thus, he never had problems selling his stuff. Fortunately, because he often needed extra money to pay for new things. Zygo had the best selection of specialized used items, sometimes even cutting-edge prototypes from the local tech companies that represented rejected research directions. He loved those the best, but they were quite rare. He managed to get only three so far.

Zygo noticed John's special interest, ability and passion for what he does (seeing how he tweaked some standard electronics and was selling way better stuff as second-hands). At this moment, the Zygo stuff was sitting around the table, their coffee pot heated on John's solar heating element, a tweak he sold recently and an employee happened to buy. They were discussing the possibility to use enthusiasts like John and offer him a part time work with their new and still very small research and development team that held totally radical ecological perspective in relation to digital technologies, including following of the principles of green informatics for Zygo's own development. The company held stance that design of their service is never really finished, they were open to exploration and understood that there is no such thing as infinite economic growth, but employees depended on their income and Zygo could not put them in jeopardy. Yes, John should be offered part time work at Zygo. He will no longer need to ask mom for money and mom will not have to worry about his social life.

Like some youth in our interviews, who still lived with their parents, John was interested in engaging with the first-hand market, in his case, a very specialized one. Only very special second-hands were of interest. John consumed a lot of technology, usually new, niche second-hands, and sold a lot. Using the newest technologies stimulated him immensely, and through this experience, he shaped his own identity as a that of a digital wizard and a nerd, i.e. The Creation of Self-identity and Mental Stimulation and Novelty from (Ingram et al., 2007) were the mechanisms that led him to consume. There are several lines of inquiry that open up through this narrative, we outline two. Firstly, how does John exactly use the Zygo app? Does he use any other products in his dealings with the service, e.g., Radius, or alternatives to it? Does he have any practices established in relation to how and when he uses Zygo? If so, how are they performed? Is there room for creating proto-practices? Do other "super users", like John, have different practices? Secondly, how could people like John, powered by skills, knowledge and passion, make Zygo's green aspirations more visible?

3.2.3 Steady Independent Mover: Edward

Edward loved his mornings. His 27 years old body was thriving on morning runs. He just returned from a run, and was tending to his breakfast making routine. He looked through the kitchen window, and found out that he was once more admiring the view. It had a bunch of qualities he appreciated. A scarce find these days. Waiting for the toast, he could not help but notice some Go-wheels in the area. "Well, at least they are bio-powered", he thought, avoiding conflicting emotions of guilt and pride. Guilt emerged every time he thought he had some responsibility for Go-wheels presence everywhere, and pride whenever he acknowledged that they actually do their job well. Go-wheels were driverless carts, used by the vast majority of delivery services these days. Zygo Inc., where Edward now works, is one of them. When businesses were looking for green alternatives, Zygo led by example. Edward appreciated the vision of the company. He accepted the job offer at Zygo because of its cutting edge, dynamic and global work profile. Also, because the company was familiar. He grew up using their services. His four star rating and all the badges he won as a youth prove his long lasting devotion to the service. Now, a part of Zygo, living the life he always wished for, he was working with a team introducing Zygo's hologram inventory displays to local stores. Interacting with holograms is fun, but he still likes the Radius that helped him earn many of the badges. Two days ago, he stepped into his favourite shoe store and found himself *scanning a pair of running shoes with Radius. The light on the Radius turned green. It meant that he could get a used pair on Zygo. He pressed the order button. Edward glanced at shoes sitting in the hallway. He ran in them today. He picked them up yesterday from a Go-wheel, just after he returned from work. The shoes came with a story of the previous owner, a local athlete. They were barely broken in, but still more comfy than a new pair.*

Edward's story illustrates how the products like Radius, made to fit the purpose of disposal, may promote buying second-hand and increase the loyalty to the brand, even passed student age. This narrative stretches further away in the future than the previous ones. It paints a longer time trajectory of Zygo's existence and use and can be used to speculate and critically reflect on artifacts in the narrative (holograms, Go-wheel carts, Radius, badges) and lifestyles that they co-create together with human actors.

4 Discussion

Everyday life is, potentially, a powerful transformative space**.** It is also a space that we are so used to that it makes it hard to scrutinize. It is easy, for designers in line with everyone else, to miss larger issues around consumption and consumption related everyday practices (Ingram et al., 2007), especially since traditional interests of designers are focused on new products and services opportunities, and not everyday life with designed objects and practices around use. Thus, drawing contextual boundaries around design spaces for transition towards decreased consumption of new goods by moving the second-hand marketplaces from their niche position mainstream, is not a simple matter. As with all complex, systemic design situations, there is an entanglement of things, people, social practices and environment, and there are no obvious ways to delineate what should be a part of a design context and what not. However, thinking within the framework of four orders of design (Buchanan, 2001), in increasing levels of complexity, is helpful, even though they differ in their strategy, intention, and outcomes. Buchanan (ibid.) suggests that the first order engages in communication, using symbols and graphical design as main vehicles of communication. The second order encompasses the traditional design and focuses on products, material things. The third one advances to interactions, experiences and services, while the fourth considers systems and environments. Each requires distinct skills, methods, and design practices.

In designing Zygo, all four orders of design were important and each is represented by one, or more, of its components. The first order of design enables Zygo to communicate about itself, through printed materials and video. It uses graphic design and visual symbols to communicate information about the service, and animation to show a typical day in lives of Zygo users. What printed and video material communicate is not arbitrary. The design of this material emerged by engaging with our research focus and maintaining a design workbook (Gaver, 2011), that helped create a visual account of '*reflection in practice'* (Schön, 1984) of *influences, rationales and assessment* of the work on Zygo, and allowed us to extract meaningful images, animated narratives and quality information about the service proposition.

Radius is an outcome of the second order of design, it is a designed object made to generate questions around practices related to acquisition, dispossession and reacquisition of consumer goods.

Zygo App is also a designed object, a research prototype and an outcome of the first iteration of service futuring. It belongs to the third order of design as it provides for interactions, experiences, planning and managing actions related to the second-hand market at Zygo. Lastly, Zygo enables creation of practices around the service. Introducing environmental and sustainability concerns, as well as an opportunity to design proto-practices and subsequently social practices, moves the entire project into the fourth order of design. This, as expected, leads to increased complexity and entanglement of issues. The narratives presented in the previous section, aim to highlight aspects of near and far future with Zygo, and draw a picture of how Zygo works and what are the potential issues with respect to the transition towards decreased consumption.

Service futuring for transition needs to establish a set of principles that would enable new, future forms of design and design practices to emerge. Ways of supporting deliberate conversations leading to collective action that enables transition are also needed. Narratives, as the ones presented here, open for such conversations today. They, however, need to be well crafted and rooted in data and data analysis (e.g., finding archetypes of consumption from interview data and identifying challenge points in today's practices), as well as how they support and provide theoretical insights, in order to communicate to others, for example, industrial partners, the relevance of futuring.

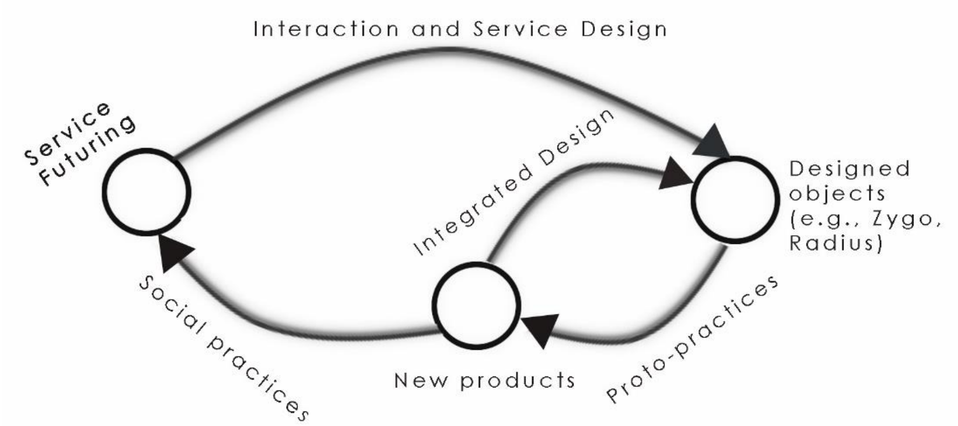

Figure 4 The model of Service Futuring based on Integrated Design approach, including social practices and design at all four orders, for transition towards a more sustainable consumption

We propose an approach to integrated design that draws on interaction and service design, social practice theory and practice-oriented design, see Figure 4. Starting from very concrete and practical concerns of industrial partners, we engaged in design studies and theoretical concerns around the underlying research inquiry and, using research through design, constructed designed objects, Radius and Zygo. Understanding that knowledge emerging from RtD *is provisional, contingent and aspirational* (Gaver, 2012, p. 937), making these objects provide a basis for practice studies and other queries. Knowing that there is a high demand for an unused toaster, would you sell it? Would new practices based on Zygo and Radius emerge? How would proto-practices be used? Such inquires lead to new product opportunities, or to re-design and new explorations with designed research objects, including making of new ones. The new products, however, should have the power to create and support new social practices, such as Zygo's University Circle, introduced in the first narrative. As mention earlier, the service futuring is dynamic and after each successful product and practices related to it, new futuring can take place.
In reference to the transition design framework from (Irwin et al., 2015, p. 7), in this work we have focused on the entanglement between new ways of designing and theories of change, as a way of creating a vision for transition, see Figure 5. Integrated design that includes all four orders of design and practice-oriented design for service futuring is a proposal that was hinted at in (Ingram et al., 2007), and developed here, starting from design of research products, and including then study of proto-practices and how they move towards practice as entity and social practices.

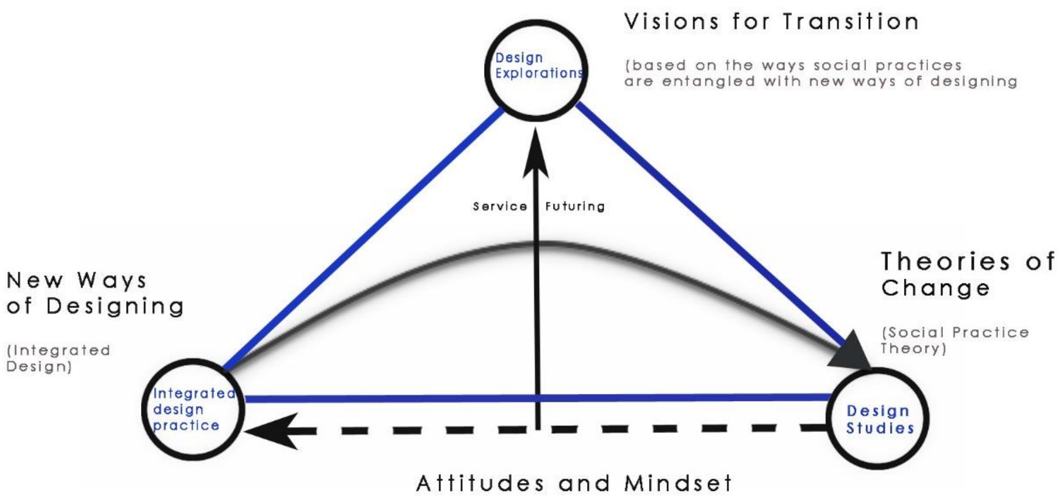

Figure 5 Transition Design Framework to gradually transform consumerist practices towards more sustainable ones

As mentioned in the introduction, the overarching methodology and, specifically, design research triangle were used throughout the work. The positioning of the triangle as shown in Figure 5, is delineating the dominant areas of RtD engagement (practice, studies and explorations) and elements that promote transition (Integrated design, social practice theory and futuring). This correspondence, just like drifting is in RtD, is fluid and does not prescribe. The reflective account of our engagement with RtD as the basis for our knowledge contributions, moves the focus back to design studies to create a final account of the knowledge generated from the explorations related to Zygo futuring.

In conclusion, we hope that the presented approach demonstrates possibilities of cross-fertilizing theories, diverse design practices within interaction, service and practice-oriented design. In our view, Zygo, and the presented narratives, exemplify a design concept that could be a viable alternative for the real world to transition towards more sustainable consumption practices.

Acknowledgements: This work was conducted as part of the research and innovation project Conserve and Consume, funded by the Norwegian Research Council (project number 235526/O30). Gratitude is due to our industrial and research project partners on fruitful discussions along the way.

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DRS 2018 Design Research Society 2018 Catalyst

University of Limerick
25th–28th June 2018

Exploring Lost and Found in Future Images of Energy Transitions: towards a bridging practice of provoking and affirming design

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doi: 10.21606/dma.2018.324

We need to transition our society in a more sustainable direction, for example through enormous cuts in carbon emissions. Yet this future is hard to envision and work towards. In this project, with a transition design posture, we have designed tools that we believe can be useful to initiate dialogues and reflections for the future. In particular we are interested in using the bridging between *provocative* and *affirmative* design as a way to explore and articulate what people see as the *lost and found* of such a transition. In this paper, we present a study where we used a practice lens to address one possible low carbon future through a provocation workshop. We present our methodology, the tentative tools we used during the workshop and the experiences as expressed by the workshop participants.

sustainability transitions; transition design posture; provocative and affirmative design; lost and found

1 Introduction

Every day, we are bombarded with news of extreme weather events, species extinction and land devastation. A search in the Swedish media archive shows that between 2014 and 2017 there was an average of 21 000 articles per year in Swedish newspapers on climate change related topics[1]. We know that several of the planetary boundaries have been overstepped (Steffen et al., 2015) and the scientific community is univocal in its agreement that climate change is real and with human origin (Stocker et al., 2013). We also know that a failure to keep global warming under 2 degrees Celsius, or, preferably, 1.5 degrees, most probably will lead to changes in climate systems with “severe, pervasive and irreversible impacts for people and ecosystems” (IPCC 2014, p.8). Yet, the transition to a more sustainable society with less carbon emissions is moving slowly. The UN emissions report of

[1] The articles were identified through searching for words including “klimat” (climate) in Swedish printed media published 2014-2017. Press releases and news agencies were excluded. The search was done 2017-11-05.

2017 shows that the gap between the reductions needed and the national pledges made in Paris is "alarmingly high" (UNEP, 2017).

This is not a new concern. Back in 2001, Norgaard (2011) did a one year ethnographic study in a Norwegian village and showed that despite the diminishing weeks of snow cover that affected the villagers' livelihood, based on ski tourism, her respondents still avoided talking or thinking about climate change. Norgaard's study showed that it is not lack of information that hindered action from the Norwegian villagers, but that people tend to shut out information that makes them uncomfortable. Through avoiding negative emotions and refraining from thinking about the future, climate change is actively (although not consciously) made into a "back-of-the-mind" issue. However, for a transition to happen, climate change needs to be transformed to a "front-of-the-mind" issue in politics (Giddens, 2011) as well as in everyday life. But how do we overcome the mechanisms of denial?

Studies on climate change communication have shown that too much alarmism depersonalizes the problem and makes it harder for individuals to engage and act (Ereaut & Segnit, 2006; Lowe, 2006). Moreover, while alarmist accounts could indeed induce emotions like fear, which could be a driver for pro-environmental behaviour, many people suffer from a perceived lack of agency and alternatives. Fear, rather than motivating people to act, thus lead to feelings of helplessness, hopelessness and inaction (Kollmuss & Agyeman, 2002).

Weber (2010) suggests that for individuals to become more engaged in climate change concretisation is needed, both by making climate change consequences more specific, as well as moving these closer in time and place. Schneider-Mayerson (2017) instead points to the lack of positive images of what low carbon futures might look like, making action hard to encourage. Furthermore, Randall (2009) describes the parallel narratives on climate change, where the problems lead to catastrophic losses, but where the solution narratives are often devoid of loss. Ignoring loss when working with climate change risk effects can hold back change efforts, or distract us from action, and result instead in rejection and avoidance, manic activity, idealization of lost things, or focusing on false solutions (ibid.).

In this paper, we seek to explore how transition design and futures studies could be used as empowering tools in relation to climate change mitigation. In particular we explore ways to identify and articulate what people see as *lost and found* in the transition to a low-carbon society, to investigate if there are ways to confront the *lost,* so this seems less threatening, and to mentally and emotionally invest in the *found*, to make the transition more appealing.

2 Framing our project as transition design

Sustainability transitions are extraordinarily complex, future oriented, abstract and global, as compared to less challenging problems that tend to be more immediate, visible and local (Geels, 2010). This implies that sustainability transitions need to be addressed by transdisciplinary approaches in which not only different scientific disciplines are involved but also other types of knowledge cultures such as practice based, tacit and lay knowledge (Miller et al., 2008; Robinson, 2004; 2008). Also Stirling (2011) urges for transdisciplinary approaches to open up for plural possibilities of transformations.

Transition design is an emerging design research field that aims at engaging design practice in exploring and enabling transitions towards more sustainable futures. It acknowledges that design can act as catalyst for change, even for complex systems, and suggests a role for designers as change agents (Irwin, Kossoff, & Tonkinwise, 2015). Irwin, Kossoff and Tonkinwise (2015) present four "building blocks" of transition design: 1) visions for transitions, 2) theories of change, 3) posture and mindset, and 4) new ways of designing. We elaborate on these building blocks in this paper, although in a different order. First, we explore what an interlinking of posture and mindset with theories of change brings us (focusing on socio-technical transition theories and social practice theories, respectively). Thereafter, we continue with exploring ways of designing and developing visions of transition.

2.1 Mindset and posture from within theories of change

Transition design advocates a mindset and posture that is *precautionary*, encouraging an explorative, reflexive and critical stance rather than aiming for optimized solutions (Tonkinwise, 2016). Transition design also advocates a mindset that is *participatory*, promoting collaborative efforts which acknowledge lay and tacit knowledge and know-how alongside professional and academic knowledge. A precautionary mindset and posture resonates well with socio-technical transition theories, such as transition management, as these promote reflexive learning for adaptive governance through visioning and experimentation (Kemp, Loorbach, & Rotmans, 2007). Transition management is also in line with a participatory mindset and posture but has traditionally focused on engaging people-as-professionals rather than as lay experts or experts on everyday life.

To understand the local, place-based and situated, and to engage people-as-people, a practice-oriented approach is useful. Practices are routinized activities carried out in everyday life (Reckwitz, 2002). Social practice theories focus on how people's everyday practices are shaped in the social context. Using social practice theories as a way to understand how to change "behaviours", is to acknowledge that the possibility of change lies in the emergence and maintenance of the practice itself (Warde, 2005). Social practice theories constitute one field of the transition theories and as such, is the one closest to people and their behaviour (Geels, 2010; Shove & Walker, 2010). They are particularly well-suited as a basis for transition design since the starting point for design has traditionally been in understanding (and influencing) the needs and wants of people (Forty, 1986). Also, the flatter ontology of social practice theories suits the design researcher, trained in messiness (Schön, 1983).

When aiming at supporting sustainability transitions, attention can be paid to vertical relations, as in the multi-level perspective (Geels, 2010), or to horizontal trajectories and interconnections of practices (Shove & Walker, 2010). Transition design could be used to mediate between socio-technical transition theories with their top-down hierarchical approaches and, and social practice theories with their bottom-up focus on everyday life and flat ontology. The capacity to iterate between concrete details of everyday life and more abstract concepts is a characteristic of most design practices (Nelson & Stolterman, 2003). However, what is specific in transition design is the connection to more macro-scaled societal structures and processes. Hence we believe that transition designers as change agents can thus operate at multiple levels of scale, including time and place.

2.2 Ways of designing and visions: Provoking and affirming design

To even further connect with people and their everyday practices, we believe co-design can be productive. Co-design, as a design research approach, is based in a participatory mindset where users are viewed as partners (Sanders, 2008). This partnership can be formed with different outsets (*for* or *with* the user) and different timescales in mind (near or far futures), forming a number of different design research approaches (Sanders & Stappers, 2014). In co-design, as ways to empower creativity amongst participants, bridging between *pasts, presents and futures* is often used, i.e. to discuss the present situation whilst referring to past experiences and then to envision future possibilities (Sanders & Stappers, 2012). Co-design can also be implemented, together with users, to explore the connection between the tangible, present and local (such as dinner practices) with the more abstract, future and global (such as climate change impacts). This is difficult, however, and we argue that there is a need for tools to further help participants in these different movements – in time, in place and in possibilities.

In the following we will use the concepts – *provoking* and *affirming*, respectively – to denote two design approaches we think are essential for transition design and which can be used in co-design workshops. We define provoking (or provocative) design approaches as those aiming at destabilizing and de-familiarizing (Bell, Blythe, & Sengers, 2005) the taken for granted, routinized and "back-of-the-mind" issues, in this way opening up for re-presenting and re-narrating processes. We define affirming (affirmative) design approaches as those aimed at supporting an exploration of the self, within ideas of present norms and practices, providing full preferential right of interpretation to the user. We acknowledge that there is tension between these concepts, but also see potential in using them for bridging purposes.

In this paper, we explore how such a bridging of provocative and affirmative design approaches could look in terms of concrete design tools, and how this can be used to explore more sustainable energy futures. We see design tools as *research devices*, which are links between objects and methods that can act as hinges between concepts and practices (Lury & Wakeford, 2012). To use them in practice-based design research is to design and use artefacts to initiate thinking processes. More specifically we explore how such bridging research devices can be helpful to empower users to explore and articulate their images of more sustainable energy futures, in particular as a way to explore personal and societal *lost and found* in relation to sustainability transitions. This also includes the bridging of the tangible-present-local to the abstract-future-global, as discussed above.

3 Using traces of practices

3.1 Introducing Empowering Energy Futures

The material presented in this paper was developed in the research project *Empowering Energy Futures* carried out in Stockholm, Sweden 2015-2017. The team was interdisciplinary, including researchers and practitioners with backgrounds in industrial design, interaction design, human-computer interaction, futures studies, systems analysis and graphic design. The overarching aim of the project was to explore people's images of the future from an energy transition perspective. In this paper, we focus on a subset of the activities in the project, where we sought to develop supportive tools for people to explore their own low carbon futures. Central to this effort was a 'provocation workshop' to which environmentally engaged participants were invited to explore the *lost and found* in such futures. Furthermore, the project developed an energy fiction, *Vitiden,* in the form of a manifesto and future archaeology with inspiration from design fiction. The energy fiction and its development will be presented in a separate forthcoming paper.

3.2 What future and which everyday life?

As a basis for the project we decided to use a scenario study by the Swedish Energy Agency called "Four Futures" [*Fyra framtider*] (Energimyndigheten, 2016). It explores and describes four possible futures in the years 2035 and 2050 with a focus on how the Swedish energy system could be developed. Each of the four scenarios – Forte, Vivace, Espressivo and Legato – is premised on a specific combination of driving forces: in Forte, economic growth and a strong export industry are the main priorities of Swedish society; Vivace builds on ecological modernization and export of Swedish green-tech; in Espressivo individual consumers and flexibility stand in focus; and for Legato ecological sustainability and global solidarity are the main concerns. These drivers influence not only the development of the energy system per se but also how industry, built environment, transport systems, and, to some extent, everyday life are organised. Each scenario is described in both qualitative and quantitative terms.

Since the aim of this project was to explore sustainable futures, and not just any futures, we decided to work solely with the scenario Legato, the only scenario in line with meeting the Paris agreement to keep global warming under 1.5 degrees. An initial analysis of Legato made it clear that while behavioural changes were mentioned, their descriptions were quite detached from everyday life, essentially making it difficult for people who were not energy systems experts to engage in this future and understand how it would affect them. Trawling for traces of practices in the text however resulted in a net list of eleven practices (or 'lifestyle changes'), including, for example, to bicycle more, to use car sharing, rental car or taxi instead of owning a car, and to work less or to work more locally. Looking closer at the list, it became clear that several of the practices focused on 'production' activities such as how and where to work, and that the rest mainly dealt with transport. Practices concerned with how we eat and reside were missing altogether, something that later found its explanation in the fact that Legato's impacts were mitigated through efficiency measures in production and infrastructure. Yet, reading between the lines, we could see that eating and residing as practices would also be affected by this particular future, if only indirectly, so we decided to add these to the list of practices. Another reason for this 'corruption' of data was that previous experience has shown that it is very difficult to engage people in discussions about everyday life while excluding large parts of it. Legato and its background data were also analysed to concretize what the changes in the energy system would imply in quantitative terms. This analysis showed that in Legato the carbon emission per person per year in 2050 would be 0.6 tonne of CO_2e, as compared to today's 10.8, i.e. emission cuts by 94 per cent[2].

To understand what the low carbon practices in Legato could be like we decided to interview 'early adopters' and forerunners of sustainable lifestyles. From the net list of practices, we extracted four that we wanted to explore in more depth: "work less", "increase the level of self-sufficiency", "refrain from longer trips" and "refrain from environmentally burdening consumption". Indeed, such practices are entangled and hard to separate, and in the end, we identified and conducted contextual in-depth interviews with five respondents (Table 1).

Table 1 The five forerunners and their four entangled practices.

	Work less	Refrain from consumption	Refrain from longer trips	Increased self-sufficiency
Downshifter	x	x	x	
Stopped flying			x	
Guerrilla-farmer/activist		x		x
Organic farmer			x	x
Simple living	x	x		

Interviews were semi-structured and carried out by three of the researchers in the homes of the respondents. Interviews were audio recorded and notes and photographs were taken (see Figure 1 for examples). The insights into the forerunners' practices formed a basis for the subsequent design work. Their already existing practices could be considered potential practices for the many in the future and as such gave us insights into the tangible-present-local as possible departing points for the abstract-future-global.

[2] These calculations were made in several steps, including converting the partial-territorial system definition used in the construction of Legato to a consumption-based system definition more in line with the societal values of Legato. A comprehensive account on these calculations is available upon request.

Figure 1 Examples from in-home-interviews with forerunners.

4 Reconceptualizing the future through trigger materials

When planning the workshop, we considered different kinds of materials that could be used to promote reflection and discussion amongst the participants. These were developed with emphasis on helping the participants to bridge the tangible-present-local to the abstract-future-global, and with particular emphasis on finding ways to balance the provocative with the affirmative. Another starting point was the wish to create a workshop process that meandered from the individual to the group and so on to more global issues. In the end, this resulted in the development of four different trigger materials used before and during the workshop.

4.1 Trigger material 1

The first trigger material was a homework assignment, where the invited participants were asked to make a climate footprint calculation before the workshop. For this purpose, the Swedish "Klimatkalkylatorn"[3] was chosen, which was suitable as it was readily available, fairly easy to use, included clear and simple result presentations with a coverage of the majority of the carbon emissions from everyday consumption, and was developed by trustworthy organizations. The idea with this trigger material was for it to function as a sensitizing material (Sanders & Stappers, 2012), making the participants reflect beforehand on their current and past activities in relation to climate impact. Once in the workshop, the participants were asked to present their own results and were then presented with a brief presentation of the future we were to explore where the average carbon footprint per person and year would be 0.6 tons CO_2e.

4.2 Trigger material 2

The second trigger material was developed as a set of cards and a 2x2 matrix, with one dimension spanning from "happy" to "sad", and the other from "more in the future" to "less of in the future". The cards were inspired by photo elicitation (Harper, 2002). The specific pictures were chosen to represent possible configurations of the practices identified in Legato, the reference research and the interviews. Another selection criteria was to have an equal or close to equal representation of gender, class and ethnicity across pictures. We also sought to include ambiguous pictures, as well as more 'dystopian' pictures. The 2x2 matrix was developed inspired by explorative futures studies in which similar matrices are used to examine uncertainties.

The cards depicted different activities, practices and things – concrete enough to support associations, but still open for interpretation (See Figure 2). The idea was that the participants

[3] https://www.klimatkalkylatorn.se/ developed by SEI and WWF.

should use the cards to explore what their hopes and fears were in relation to a more sustainable future, essentially helping them explore and articulate *lost and found*. As a primer, the participants had the individual carbon footprints from the first trigger material as well as the targeted carbon footprint of 0.6 CO_2e. After a period of self-reflection, the participants presented to the group some of their selected cards and placings, and described their feelings connected to these.

Figure 2 The cards used as the second trigger material.

4.3 Trigger material 3

The third trigger material comprised seven fictitious headline posters, representing possible configurations of Legato. The headlines were inspired by artistic explorations[4] of futures and presents. The headlines were designed to spur reactions, to confront the participants with possible futures as if they were already here. The main reason for giving the futures-as-present the shape of headlines was that we wanted to use a familiar form but avoid images. Through this the participants did not have to spend time making sense of the form before making sense of the content (to the extent that these two can be separated). The avoidance of images aimed to activate the participant's own imagination in the sense-making process, thus decreasing the risk that participants distanced themselves from the content because they did not like or believe in our way of visually representing it. During the workshop, the participants were first invited to individually place post-its with their immediate thoughts at the different posters. This was followed by a discussion, after which the participants were divided into smaller groups to discuss more in depth one of the headline posters and its implications.

4.4 Trigger material 4

The fourth trigger material consisted of "fill-in-the-blanks" posters, where the participants themselves filled in the missing words. The material was created to support reflections, but also as a playful and co-creative ending to the workshop, inviting the participants to 'check out' while creating decrees about the present and future.

[4] Examples include the project "Wish you were here? Postcards from the Future" by Robert Graves and Didier Madoc-Jones, and Barbara Kruger's collages.

4.5 Workshop participants

The workshop was arranged in May 2017, with 9 participants and conducted in Stockholm, Sweden. The participants were recruited by Kantar SIFO[5] from a database of people willing to be part of discussion groups and who had indicated they were interested in environmental issues. Five were women, four were men and the participants were between 27 and 70 years old. Besides their mutual environmental interest, the participants were recruited to have a spread in interests and values. The two-and-a-half hour workshop was arranged during the evening and followed a workshop schedule that was open for the participants' discussions and reflections as interests shifted.

5 Engaging with the trigger materials

In this section, we describe some examples of the discussions that took place and provocations that the trigger materials created, with a focus on our perception of how the participants expressed their thoughts on *lost and found*.

5.1 Trigger material 1

In the beginning of the workshop, when the participants presented themselves and talked about their climate footprints, most of them were uncomfortable or even distressed, since (all but one of them) had larger footprints than they had anticipated:

"I was surprised, I thought I would be much lower, I've always seen myself like a hero, and then I'm just average. I thought everyone else were much more environmental villains compared to me." Participant 5

The participants' results in the climate footprint calculation carried out prior to the workshop ranged from 7.2 to 19.2 CO_2e. All the participants had environmental concerns and tried to consume less or make more sustainable choices in their everyday lives. Furthermore, the climate footprint calculator results had surprised them, showing how large a portion of their footprints came from flying or housing, which they had previously not been aware of. There was a sensed tension when discussing their climate footprints and a subdued atmosphere around the table. When the goal of 0.6 CO_2e was presented there were exclamations of surprise and frustration.

5.2 Trigger material 2

When presented with the second trigger material (see Figure 3), the part focusing most clearly on *lost and found*, some of the participants moved between hope and despair as they navigated through different possibilities. Having previously expressed anger with their current footprints, some of the participants turned around and became positive as they realised that they would perhaps not miss so many of their current lifestyle choices. Instead, they expressed wishes for the non-material and the simple, as expressed in the following quote:

"An increase in non-material phenomena, experiences rather than buying things, things you do together, there was this picture with dancing people for example. Playing games, camping, things that do not require so much resources." Participant 2

Several participants also thought that we would live healthier in the future, as well as finding calmness and fulfilment in things closer to home. Some participants expressed hope in the development of new technologies including new types of foods. When it came to losses and fears, many expressed sadness over the loss of travelling, and fears for a more insecure and unstable future, with potentially more conflicts over resources, climate fugitives and irreversible waste from our current affluent society.

Some of the images, like those depicting for example military marching, were difficult for the participants to relate to and were interpreted differently. Some participants were confused with

[5] Kantar SIFO is a company working with opinion and social research, surveys and recruitment for different polls.

how the four fields of the matrix were to be interpreted as what they thought would happen or what they wanted to happen. Clearly, there was a tension between these two. Some participants had a need to also understand how the transition would happen, and even though they could envision alternative futures, they got stuck in not understanding how the necessary changes could possibly take place. Some participants expressed wishes regarding clear directions from governments and policy makers with new laws, regulations and even rationing of, for example, fossil fuels.

Figure 3 Participant reflecting and placing cards in the 2x2 matrix.

5.3 Trigger material 3

The third trigger material (see Figure 4) was the headline posters, and these also stirred up a fair amount of emotion, both negative and positive. When asked for first impressions, "Tonight the last airplane took off" was the headline poster that received the most attention. For some it was preposterous, a fable:

"It will never happen, [...] unless it is a world war. It is too black and white, there will always be exceptions. There will always be airplanes, even if it was decided that we ordinary people are not allowed to fly. There would be military or unquestionable transports of medicine." Participant 9

Many expressed sadness and loss of what the lack of travelling would lead to, but some also expressed positive feelings if flying were forbidden, potentially making train trips better and cheaper. One participant raised the question whether the reachable world would shrink whereby understandings of other cultures and customs might diminish. In the collective discussion around the headline posters, further topics were brought up, as if the posters had set in motion thinking about connected matters. One example was a discussion around self-sufficiency that prompted the participants to discuss working hours and a larger shift of time perception in society.

After a vote around the table, three of the headlines were chosen to be discussed in more depth in smaller groups ("Last airplane taking off tonight", "10 steps towards increased self-sufficiency", "Stockholm's major road will become a place for urban farming"). In the smaller groups, several tensions and problematic dilemmas were brought up. Regarding airplane transportation, the participants discussed the difference between necessary flying (for example medicines in emergency situations) and unnecessary flying (for example Thailand vacations). Other travel practices, such as train trips, were discussed as alternatives and the participants pointed out that appreciation of travel time could be an alternative value to promote. Also appreciating holiday time in your home town was pointed out as an alternative to unnecessary flying. Furthermore, the poster “Introducing meat tax” was discussed as a very realistic headline that actually could be implemented already this year. In order for a meat tax to have effect, the participants felt that the level of this tax would need to be very high. Furthermore, the participants also discussed the need for rationing fossil fuels and comparisons were made to how this took place in the 1970s and how well it worked at that time.

Figure 4 Participant writing down his first impressions of the headline poster stating: “Last airplane taking off tonight”.

5.4 Trigger material 4

In the last exercise, the participants created their own posters of possible future headlines from newspapers and magazines (see Figure 5). Several of the participants put the message: “For the sake of my children and grandchildren, I refrain from flying, car-driving and eating meat”.

Finally, there was an open discussion around the table where the participants were encouraged to talk about how they had experienced the workshop as a whole. Some described it as being intense and thought provoking, as expressed in the following quote:

“The uninhibited consumption our generation has experienced will never be relived. We are standing at a crossroad, we can’t continue like this. We have to end it. I almost feel like an old dinosaur. Soon the comet will come and then everything will be changed.” Participant 1

But many of the participants also expressed feelings of hope and positive outlooks for the future, even though some of them had come to the workshop with negative feelings about their own footprint and despair related to the seemingly impossible task of changing society into a more sustainable one. Some of the participants expressed gratefulness in being part of the workshop and claimed that they had learnt many new things and acquired interesting ideas. As a summary, the whole group, despite being diverse except for their engagement in environmental issues, seemed to gain a thirst for knowledge and a context to talk about climate change and the future.

Figure 5 Participants with the posters they made, from left to right: "Spiritual development/meditation circles is my new Friday family time, "Your sweat will create energy", "More plants give peace of mind" and "For the survival of my grandchildren I refrain from meat and flying".

6 Discussion: Balancing act

The trigger materials, i.e. research devices, used in this research project were designed to engage users in exploring and articulating *lost and found*, deliberately developed to be both provocative and affirmative. To start with, we used forerunners of practices identified as important for sustainability transitions. Meeting these forerunners in their homes to discuss their everyday lives enabled us to access their knowledge about how to solve everyday issues and to use this as design inspiration for the trigger materials. In these in-home-interviews, we focused on understanding the practices, including how they emerged and were maintained, i.e. how links were broken and established. As practices are dynamic and unstable, as well as bundled together, it is crucial to understand their interconnections (Shove and Walker, 2010). Even though practices can never be controlled, they can be orchestrated (ibid.) and since our intention in this project was to understand how to push sustainability transitions, we were specifically interested in understanding how the forerunners had made new practice bundles and how these changes came about.

From the interviews and analysis of *Four Futures* we could identify a large number of entry points to discuss energy futures with our workshop participants. As is often the case in a design process, the real challenge was not in finding material but in deciding how to conceptualise this into working categories. In this project, we deliberately designed to balance and bridge (see Sanders & Stappers, 2012) the affirmative, the mundane everyday here and now, with the provocative, imagining fundamentally different futures. However, it is as challenging to shift from understanding the present to construct possible futures as it is to think outside the current norms and values to develop future ideas.

The trigger material developed for the workshop included questioning norms as well as discussing established and well-known everyday practices. This balance between provoking current everyday life while still being affirmative to how it is actually conducted, is what we tested in the design of the trigger material, with the aim of engaging the participants in exploring *lost and found* in a sustainable future. For example, in trigger material 1, each workshop participant assessed their current CO_2e emissions. This sensitizing device worked well to create a space for reflection, even prior to the workshop, and most of the participants were provoked by their individual results. To use an audit can create a space for reflection that might contribute to more sustainable practices (Hargreaves, 2011). When faced with the need to decrease CO_2e emissions, from their individual results to the goal of 0.6, some of the participants felt frustrated as they did not know what they could possibly do to reach such a low level. However, as the workshop continued, it was clear that the individual assessment had caused reflection of possible futures, with new things found even whilst keeping links to current everyday lives.

With the second trigger material, it was clear that the co-design approach (which enabled the participants to first individually reflect and then tell the group about their card selections and placements) worked well as a bridge between participants' present practices (some which might be lost) and envisioned future possibilities (which in many cases were new found values). The images also worked to facilitate the transformation from concrete details to bigger and more abstract pictures. However, some of the images, for example those that caused reflection on war and totalitarian societies, were simply discarded by some as they were considered too provocative. When too provocative, the participants could not (or did not want to) connect to the material and no reflections were initiated. In this case, when the images were too provocative, the trigger material did not work so well, which is in line with research on climate communication (Kollmuss & Agyeman, 2002). Some participants got stuck in trying to figure out whether the matrix should depict what would happen, or what they wanted to happen in the future. Even though this ambiguity could be hampering, we believe that it is needed, since it can capture both fears and aspirations.

The third trigger material, the posters with deliberately strong headlines, spanned both the provocative and the affirmative. Some of the headlines pushed the participants quickly into future possibilities and they had no problems envisioning drastic changes of current regulations, laws and taxes to enable reaching targets, since this would ensure that they as individuals would not be the only ones breaking the norm. As many of the required changes are actually uncomfortable and inconvenient, provocations can be needed for this push. It was clear in the workshop that citizens desire that policy makers take actions and guide. The headlines also gave rise to many discussions and to some revelations of new things that might be found in a sustainable future - later displayed when the participants made their own headlines (trigger material 4). Here some of their concerned losses related to what they would abstain from in order to save the world for their children or grandchildren. However, many focused on newly found things, such as more time, more spirituality and new solutions. For some of the participants it was also difficult to understand how some suggested practices could possibly be implemented. The struggle to connect visions of desirable futures with change of existing everyday practices, and the need to understand the complete and complex implementation, is not uncommon for those who are not used to creative thinking and creative processes. We can also see that the trigger materials one by one might not help in bridging the tangible-present-local to the abstract-future-global, but in unison they helped the participants, in different ways, to make movements in time, place and possibilities.

7 Conclusions

In this project we have, through practice-based design research and with a transition design posture, designed tools that we believe can be useful to initiate dialogues and reflections on the future. We can see that the trigger materials worked well as research devices, and that they managed to, if not bridge, at least allow for a co-existence of provocative and affirmative approaches.

This research project has had its focus on Sweden and we have carried out just one workshop in Stockholm – we have had no ambition of painting a complete picture of all possible images of futures people might have. Moreover, we have developed only one set of trigger materials. We see great potential for developing different trigger materials that could be tested in different types of workshops, and to change the type of people participating. It could be interesting to conduct workshops with those in power positions, like politicians and authority leaders. We believe that a further development of the trigger material presented in this paper could be useful as workshop material in, for example, non-profit organisations or study circles, where there could be interest for creative explorations of *lost and found*.

It is clear that there is a discrepancy between the actions needed to reach the target for a sustainable energy system and the images people have of their existing and future energy use. Even so, people in Sweden are willing to engage in issues around transitions but many do not know what to do or where to start. We believe it is important to widen the horizon to help people understand that an energy system is not set in stone, and that many different futures are possible.

Acknowledgements: This project has been funded by the Swedish Energy Agency (P40238-1). We want to thank all the co-creators in the project that we met in interviews and in the provocation workshop. A special thanks Andrejs Ljunggren and Gabriel Kanulf.

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DRS 2018 Design Research Society 2018 Catalyst

University of Limerick
25th–28th June 2018

Recognizing and Overcoming the Myths of Modernity

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doi: 10.21606/dma.2018.468

This paper aims to contribute to the debate around the cultural dimension of the transitions by shedding a light on myths at the core of the modern civilizational project. The term *myths* is used to talk about stories that embody the values of the modern project, which became a certainty in people's minds. Transitioning to a sustainable civilization entails that we create and adopt new storylines. In order to do so, designers must be story-listeners and recognize the myths that are hindering the transformation of our ways of life. The modern world is, arguably, a world with only one storyline that separates the world in two (e.g., developed and developing). I argue that designing new societal projects demands the collaboration between multiple cultures. In the modern world, however, we do not have an epistemology that enables such collaborations. Therefore, several myths of modernity need to be recognized and dispelled to allow for new epistemologies to emerge, so that we can purposefully create new stories for a new civilization.

design for transitions; sustainability; modernity; southern epistemologies

1 Introduction

The starting point of this paper is the recognition that humanity is living through a deep transition, which was triggered by the awareness of the enormous crises we all are enmeshed in – "such as climate change, loss of biodiversity, depletion of natural resources, and the widening gap between rich and poor" (Irwin 2015: 229). For several decades designers have tried to address the crises by treating the symptoms, solving problems or trying to reduce the damages. Transition design, on the other hand, takes as its central premise the need for societal transition and advocates the reconception of entire lifestyles (Irwin, Kossoff & Tonkinwise, 2015).

Arguably, the "reconception of entire lifestyles" is another expression for cultural change. In the last decades, several design researchers (Ehrenfeld, 2008; Fry, 2009; Orr, 2002; Vezzoli & Manzini, 2008; Walker, 2010) have advocated for a change in the cultural model as the main path to address the current crises. Those authors have argued, using different words, that the colossal environmental and social crises are consequences of the Western/Modern lifestyles. For instance, Ehrenfeld (2008) argued that "unstainability springs from the cultural structure of modernity itself: the way we hold reality and ourselves as human beings"(p.7).

Nonetheless, discussions about culture and the cultural dimension in design are almost absent. This absence, for Manzini (2016), critically limits our possibilities to design for a societal transition. And so, the term 'cultural change' is often used as a meaningless buzzword. Perhaps, as stated by Asino, Giacumo & Chen (2017), since culture is a concept hard to explain or grasp. And yet, it is at the core of what we do, what we value, who we believe we are and what we believe we do, how we act, and how we make sense of our experiences. As Manzini (2015) argues

> *If what must emerge is a new civilization, the issue is not only one of solving problems; a civilization is also, and primarily, made up of values, of qualities, and, in more general terms, of sense systems. (p. 3)*

This paper aims to contribute to the debate around the cultural dimension of the transitions by shedding light on stories and myths at the core of the modern civilizational project. In their DESIS[1] book *The Pearl Diver: the designer as storyteller*, Bertolotti, Daam, Piredda and Tassinari (2016) suggest that, in designing for social innovation and radical change, "it is becoming increasingly urgent to think about the implications of the stories we tell and the ways in which we tell them" (p. 9). Arguably, story-telling is one of the main tools of a design for transition – as designing a fair and sustainable society entails creating and adopting new stories (Ehrenfeld, 2008). But, in order to do so, Berlotti et al. argue that designers must be story-listeners:

> *The storyteller is thus, first and foremost, a story-listener. He is someone who has the ability to look at things other people do not pay attention to, because they regard them as too small or insignificant: the fragments of the mainstream narrative. (Berlotti et al. 2016, p.20)*

I use the term myths to talk about stories that embody the values of the modern project, which became a certainty in people's minds. In a similar vein, Arturo Escobar (2012) affirms that certain representations have become dominant in the Western social imagery, shaping the ways in which reality is imagined and acted upon. Even when reality starkly contradicts those representations, he suggests that "it seems impossible to conceptualize social reality in other terms" (Escobar, 2012, p. 5). I argue that, in order to design for transition, we (design experts) need to recognize the myths spun out of the modern project – i.e., being story-listeners – so that we can purposefully create new stories.

2 Culture and worldview

The paper describing Transition Design – written by Irwin, Kossoff, Tonkinwise and Scupelli (2015) – opens with a quote from Buckminster Fuller:

> *You never change things by fighting the existing reality. To change something, build a new model that makes the existing model obsolete.*

What is the cultural model in need of changing? It is the cultural paradigm of Europe and North America, which has been shaped since the Enlightenment in the pursuit of the Modern project – that which has been conceptualized as modernity. The problem is that this model is not external to ourselves. It is also internal, shaping our cognitive framework and worldview. As Leroy Little Bear explains:

> *Different ways of interpreting the world are manifest through different cultures. (…) Culture comprises a society's philosophy about the nature of reality, the values that flow*

[1] DESIS is a network of design labs with the purpose to promote design for social innovation in higher education institutions so as to generate useful design knowledge and to create meaningful social changes in collaboration with other stakeholders (http://www.desisnetwork.org/about)

from this philosophy, and the social customs that embody these values. Any individual within a culture is going to have his or her own personal interpretation of the collective cultural code; however, the individual's worldview has its roots in the culture - that is, in the society's shared philosophy, values, and customs. (Little Bear, 2000, p. 77)

And, since culture shapes how we think and interpret reality, it is so embedded in us that we take it for granted. Clifford Geertz (1973) argued that “man is an animal suspended in webs of significance he himself has spun” (p. 5). He defined culture as those “webs of significance”, which serve to generate and maintain meaning. Through the webs of significance, we interpret and make sense of the world. We can compare them with lenses that change that which we see, for better or for worse (Huesemann & Huesemann, 2011). If we are not aware that our lenses are distorting our vision, we take the distortion as the real and true image. Our actions upon the world will reflect and perpetuate the distortion, unless we make a conscious effort to examine our lenses – by bringing our beliefs and the stories we tell into awareness.

Most modern beliefs have already been criticized by numerous studies[2]. Nonetheless, modern stories and myths still shape the way laypeople think about the world. And, most importantly, they shape the discourses of numerous designers who aim to address the environmental and social crises. What motivated me to write this paper was remarking that many myths of modernity are prevalent in design initiatives that aim to address complex social and environmental problems.

There is no doubt that my personal cultural background (Brazilian-Canadian) and professional identity (design practitioner and researcher) influence my perceptions, the stories I hear and the stories I am able to tell. I am a Brazilian whose parents have distinct ethnic backgrounds. Since my childhood, in moving from one side of my family to the other, I understood that people can hold and embody disparate worldviews. This skill has been useful since I moved to Canada, over a decade ago, and in seven years of participatory action research in collaboration with Indigenous peoples. In my research activities, my partners are often Indigenous (Canada's First Nations) while my academic colleagues are North American (settlers) and European, therefore, I had to be aware of the different worldviews at play.

3 Myths of modernity

Myths of modernity have been crafted since the Scientific Revolution of the 16th and 17th centuries, in which the work of Enlightenment philosophers and scientists – notably Rene Descartes, Francis Bacon, Thomas Hobbes and Isaac Newton – laid the foundation for modern scientific, technological and social progress (Merchant, 1980). Enlightenment can be seen as the creation of a new framework of ideas about man, society and nature, which challenged the conceptions of the feudalistic worldview (Hamilton, 1992). The conception of reality that emerged has been named as modernity. Briefly,

modernity is a particular ontology that in the last centuries determined the division between nature and society, a colonial distinction between modern and non-modern indigenous peoples, the myth of progress as a unidirectional linear path, and a strong confidence on Cartesian science. (Gudynas, 2011, p. 447)

Although the foundations of modern thinking were established in the 16th and 17th centuries, the project of modernity achieved its most effective expression with the onset of industrialization in the 19th century (Hall, 1992; Hamilton, 1992). Meanwhile, design was established as a profession and a recognized expertise with the advent of the Industrial Revolution (Kaine & Dubuc, 2010). As a result, the foundations of our field are interwoven with the project of modernity and its worldview.

[2] A few books cited in this paper: The Formations of Modernity (Hall & Gieben, 1992); Decolonizing Methodologies (Smith, 1999); Encountering Development (Escobar, 2012) and Epistemologies of the South (Santos, 2014)

Below, I outline the synopses, characters and props of a few stories forged out of the beliefs of the modern project and the myths related to them. I chose the following seven myths because I believe they are particularly relevant to the field of a design for transitions. Before discussing each myth and their implications, I introduce a specific character and the plot of their story (in italics). Those plots combine many stories that I have listened to over the years. And, since we are dealing with myths, I exaggerate the elements of those stories.

3.1 Leading Character – The hero and his weapons: reason and technology

The modern Western man is the hero of our stories[3]. Originally, however, he was not born modern, nor a hero. Until the 17th century, prior to Enlightenment, most Europeans lived in close interaction with the land and nature. Our European man became modern because he wished so. Modernity was created as an ideal to be pursued, as a project of eternal progress.

Why is he a hero? As king Arthur found Excalibur, our hero discovered the ultimate weapons of his time: reason and technology. Those weapons allowed him to break away from his obscure past. And since then, he has been sworn to use his weapons to free humanity from all ills.

3.2 MYTH 1. Our hero solves problems that have plagued humanity since the beginning of times.

Arguably, this is the great myth of the modern project. There is a true heroism and idealism behind modernity. The modern project was created out of a great dream: to promote an improvement in all the conditions of life. Finally, man had reason. Finally, man could understand the universe, the laws of nature, and control his environment.

In the 17th and 18th centuries, the optimism generated with the Scientific Revolution gave rise to the belief that reason would soon solve all of the problems facing society and promote an ever-increasing level of well-being. Huesemann and Huesemann explain that “the early successes in science and technology encouraged the belief that human reason was capable of generating not only scientific progress but also social and moral progress” (2011, p. 149). Another aspect of this myth is the concept of universalism: as science understands the general laws which govern the entire universe, science and reason could be applied to any and every situation (Hamilton, 1992).

Designers have been profoundly influenced by this myth of solving all the major universal problems – using “techno-solutions” – since the birth of our profession. This myth is still present in the discourse of contemporary designers. For instance: in 2017, ‘EDIT – Expo for Design, Innovation & Technology’ took place in Toronto, as a festival of the future and world-changing ideas[4]. Its main exhibition, curated by Bruce Mau, was named “Prosperity for All”. On its first wall, we could read:

> *Around the world, people are collaborating to design solutions to challenges that have vexed society since the beginning of human history. Our collective project to understand the universe and the complex dynamic world we live in, and design tools for the challenges we face, has been profoundly successful. Never in human history have more people escaped the bonds of poverty, disease, and ignorance to explore their potential and participate in the bounty, beauty, and opportunity of modern life.*

In 2017, it is troubling to see a design festival about the creation of the future presenting the ideas and beliefs created in the 17th and 18th centuries – seemingly ignoring all the criticism these ideas have received in the last two centuries. Nonetheless, several design researchers[5] have presented critical perspectives to the fallacy that modern solutions can improve the human condition and solve

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[3] No, modern myths do not pass the Bechdel test, since female characters do not have independent well-developed storylines (Bechdel, 1986).

[4] It was self-described as “an immersive expo-meets-festival designed to celebrate the innovative work that is making the world a better place for all people” (http://editdx.org/)

[5] Among them, Ehrenfeld, 2008; Fry, 2009; Orr, 2002; Vezzoli & Manzini, 2008.

all problems. In designing for transition, we should work to make those critical perspectives mainstream.

As Banerjee (2003) argues, after more than 200 years of Industrialization, "the benefits delivered by the grand design of progress and modernity are, at best, equivocal" (p. 143). Today we have an increasing awareness that the current social and environmental crises we face are linked to the Western ways of life and to the consequences of colonialism (e.g., slavery, dispossession of lands and forced assimilation). Framing our current problems as problems that have been plaguing us since the beginning of times does not help us to solve the numerous problems generated by pursuing the modern project for over 300 years.

3.3 Character #2 – The dragon: the hero's enemy

Once we have our hero and his sword, he needs enemies out there to combat. The ultimate enemy of the modern project is nature and its irrationality – that which cannot be predicted or controlled. Dragons are irrational unpredictable creatures, and are out there to be slain.

Please note that the key expression here is "out there". "In the Cartesian form of objective reality, action and reality are independent. Reality is simply out there" (Ehrenfeld, 2008, p.26).

3.4 MYTH 2. Problems are external to ourselves

Cartesian rationality can be understood as a separation between man and nature, mind from body, intellect from emotions, observer from observed (Dussel, 2008; Merchant, 1983). This separation paved the way "for a mechanistic reductionist science, which, in turn, yielded powerful knowledge on how to dominate, control and exploit the environment (Huesemann & Huesemann, 2011, p. 4).

The Cartesian separation impacts the way designers understand and frame the problems facing society – as reality is out there, problems are conceived as being out there as well. Certainly, humanity faces numerous external problems that need external solutions. Our enormous crises, however, stem "from the models through which we imagine the world to be a certain way and construct it accordingly" (Escobar, 2015, p. 15).

This second myth explains why social designers dedicate so little thought to cultural aspects – i.e., worldviews. As a result, designers tend to search for external solutions to problems that we see as separate from ourselves. I name those seemingly external problems as "dragons" – and searching for external solutions as the activity of dragon-slaying.

An example of such "dragons" is poverty. Because it manifests as a lack of material resources, it is tempting to slay that dragon by providing resources to the poor. Nonetheless, poverty is a systemic problem. The destitution prevalent among certain groups of people is a consequence of how modern societies are structured (Appadurai, 2004; Escobar, 2012; Viveiros de Castro, 2017). Therefore, poverty is not a problem out there to be solved with material resources only (Sen, 1999), since social structures comprise values, norms, beliefs, meaning systems, and so on. It is telling that, in Western culture, the modern conception of happiness and well-being is also external, attached to the possession of material goods (Vezzoli & Manzini, 2008; Walker, 2010). The problem of human suffering, something intrinsic to the human condition, has been framed in the modern world as an external problem that could be solved with material resources (mostly goods and, if that fails, medication).

> *Because many social problems manifest themselves in the form of symptoms that appear to be treatable by science and technology, it has been tempting to redefine these complex social problems as simple technical challenges. (Huesemann & Huesemann 2011, p. 75)*

As an example of external fixes, Huesemann and Huesemann (2011) cite the use of medicine or surgery to address diseases that are the result of lifestyle choices. Vezzoli and Manzini (2008) use another example: it is easier to design "light products" and to promote the development of clean technologies than to drastically rethink our conception of well-being and our consumption patterns – which is cultural.

External fixes attempt to ameliorate the symptoms instead of recognizing them as warning signs of deeper cultural problems (Huesemann & Huesemann, 2011). Ehrenfeld (2008) suggests that designing those external fixes diverts our attention from striving to create sustainability – which will be an outcome of new ways of life and worldviews.

3.5 Character #3 – the magician and his techno-elixir

Even though our hero believes that technology is the panacea, dragons are multiplying and threatening to destroy the planet. After each dragon is slain, three others appear. In these desperate times, our hero needs the help of a magician who can conceive a more powerful sword.

After six months, his second sword is not effective enough to slay all the new dragons. Consequently, the magician keeps conceiving new and improved swords. At some point, he realizes that instead of a sword he could create a rifle or a bazooka. He could improve the hero as well, creating elixirs to enhance his strength.

Clearly, the work of the magician is highly specialized; it is reserved for the best brains. The destiny of the human race is at the hands of those brilliant few. And so, the population has hope that one day the magicians will create the perfect techno-solution to save the world.

3.6 MYTH 3. The search for the magical solution to save the world.

The third myth can be encapsulated in Buckminster Fuller's definition of design science:

> *The function of what I call design science is to solve problems by introducing into the environment new artifacts, the availability of which will induce their spontaneous employment by humans and thus, coincidentally, cause humans to abandon their previous problem-producing behaviors and devices.*[6]

Even if many contemporary problems were created by applications of technology, there is still a remarkable confidence that more science and technology will be the solution (Huesemann & Huesemann, 2011). Transition design entails that we define 'design science' and its purposes in different terms.

Furthermore, the belief that a few brilliant people (e.g., design experts) will conceive the magic solutions is disempowering and disabling to the overall population. Manzini (2015) suggests that such an approach creates passive, "not to say lazy and incapable, subjects" (p. 95). Inspired by the work of Sen and Nussbaum, Manzini proposes that we move away from the idea of users and consumers as passive figures, and start to consider people as active and capable subjects. He argues that in "a world in rapid and profound transformation, we are all designers" (Manzini, 2015, p. 1).

At issue now is understanding who can be included in the "we all."

3.7 Background characters – The exotic Other

In the 15th and 16th century, Europeans "discovered" new worlds and new peoples. Since then, those Others have played background roles in our hero's storyline – most often in nonspeaking capacity. Those extras do not have independent storylines – as we know, history starts when Western men arrive. The Others are only represented in the tales of intrepid explorers. Today, they are in the background of selfies taken by travelers who visit 40 countries in 3 months.

3.8 MYTH 4. A planet with only one storyline: becoming modern

Since the beginning of the European expansion, the Others were treated as history-less peoples and their territories as terra-nullius (Sahlins, 1999; Smith, 1999). The leading role of the modern man entails that we live in a planet with only one storyline: the heroic story of the modern man. John Law

[6] Retrieved from https://www.bfi.org/about-fuller/big-ideas/design-science

(2011) named this myth as the “One-World world”. This one and only storyline is “conceived from the perspective of the Euro-American historical experience and exported to many world regions over the past few hundred years” (Escobar, 2015, p. 14).

The overall plot can be summarized as such: humanity is moving, in a linear and evolutionary process, from a primitive or traditional level to an advanced and modern level. The ‘primitive’ ways of life were close to nature – as the pre-modern European ways of life – therefore the savages need to be ‘evolved’ (or civilized or developed). Consequently, modern culture delivers the benefits of civilization to the backward (or developing) ones (Dussel, 2008). Spreading the benefits of civilization was a noble undertaking in the European’s – and subsequently in North-American’s – perception (Viriri & Mungwini, 2010). In the One-World world storyline, we are all here to become modern (or developed, in more recent wording).

An interesting feature of the myths of modernity is that buzzwords and terms keep changing, but the plot remains the same. After the Second World War, terms such as *to civilize*, *savage* and *primitive* went out of fashion, and were replaced by *to develop*, *underdeveloped* and *developing* (Banerjee, 2003). The desirability or the need for development was never questioned, even when the conditions of life of millions of people deteriorated since the 1950’s (Escobar, 2012; Sen, 1999).

As the project of modernity created a separation between humans and nature, the myth of the single storyline entails another separation: the ones who live the single storyline under the One-World world (the West), and the ones who do not <u>yet</u> (the rest) (Escobar, 2015; Hall, 1992). For Boaventura de Sousa Santos, modern western thinking creates some invisible and radical lines

> *that divide social reality into two realms, the realm of "this side of the line" and the realm of “the other side of the line.” The division is such that "the other side of the line" vanishes as reality (Santos, 2007, p. 45).*
>
> *On the other side of the line there is no real knowledge; there are beliefs, opinions, intuitive or subjective understandings, which, at the most, may become the raw material for scientific inquiry (Santos, 2007, p. 47).*

Not only the line divides the world in two, but Stuart Hall (1992) argues that the concept of the West allows people to: (a) classify societies into different categories (e.g., western and non-western); (b) condense a number of different characteristics of different societies, cultures, peoples into one picture; (c) compare to what extent different societies resemble, or differ from, one another (and so, non-western societies can be said to be ‘close to’ or ‘catching up with’ the West); (d) evaluate and rank other societies against certain criteria. “For example, ‘the West’ = developed= *good*= desirable; or the ‘non-West’ = under-developed = *bad* = undesirable” (Hall, 1992, p. 277).

Hall’s and Santo’s arguments are easily verifiable: how many Western design schools teach the ways of designing and producing material culture of different societies as something of value to the contemporary world, not as history or curiosity? How many indigenous designers teach western designers? How many designers go to other continents to learn with other cultures (and not to study them or to help them)? Few, as the knowledge of the Others – produced on the other side of the line – is most often seen as an inferior knowledge (Swadener & Mutua, 2008).

From the point of view of a western transition designer, what is the problem in the fact that the Others play non-speaking roles and we live in a world of a single storyline? We develop awareness about ourselves – and of our own cultural patterns, worldviews and assumptions – through contrast with that which we are not (me and not-me). In other words, we can only become aware of the features and flaws of our worldview in contrast with other storylines. However, the encounter between different cultures is usually framed inside the storyline of *becoming modern* – the Others are simply *catching up* with that story and need a little “help” from the western heroes to do so. Thus, the flawed myths remain (mostly) undisputed. As Sousa Santos points out:

> *The problem is that after five centuries of 'teaching' the world, the global North seems to have lost the capacity to learn from the experiences of the world. In other words, it looks as if colonialism has disabled the global North from learning in non-colonial terms, that is, in terms that allow for the existence of histories other than the 'universal' history of the West. (Santos, 2016, p. 19)*

3.9 Character #5 – The penitent hero

Some modern men realize that all their weapons and all the magic used to slay the dragons have deeply damaged their environment. They see the consequences of their actions – and of their fellow heroes and magicians – and cry. How could humans do so much harm? It seemed that humanity had no way out, as our nature was inherently destructive – that is simply the way we live on this planet. Then, the heroes and magicians come to the conclusion that they have to clean the damages themselves, because they are the only ones with the power, knowledge and technological advancement to do so.

Let's remember that this is a planet with only one storyline – the story of the modern hero. It does not matter whether he is confident or penitent.

3.10 MYTH 5. Humanity is a virus: nature must be protected from human hands to be preserved

Science-fiction created in the 20th century became increasingly dystopic. We became immersed in tales of a barren future – taking place either in an artificial world or in an arid and violent environment. And since the damages were unavoidable, because they are byproducts of human ways of life, we should strive to minimize them – consuming less, producing less, discarding less, and so on. Tony Fry (2009) refers to this approach as "sustaining the unsustainable".

> *Almost everything being done in the name of sustainable development addresses and attempts to reduce unsustainability. But reducing unsustainability, although critical, does not and will not create sustainability. (Ehrenfeld, 2008, p. 7)*

This myth shows a deep lack of imagination that there can be other ways of shaping our presence on this planet. What we need in order to design sustainability is not less damage, but different worldviews. "No matter how dominant a worldview is, there are always other ways of interpreting the world" (Little Bear, 2000, p.77). For instance, if we visualize progress as a linear evolution, our model of production/consumption/discard will be also conceived in a linear fashion. Products are designed within this frame of mind, which keeps feeding unsustainable lifestyles. Therefore, creating sustainability entails breaking away from linear thinking, and adopting new ways of understanding evolution, production and consumption.

Another way of (seemingly) minimizing the damages caused by modern ways of life is to protect nature from human hands. Inspired by the work of John Muir, several national parks and natural reserves have been created throughout the globe (Edwards, 2005; Novaes, 2007). This way of "saving the environment" from us, is directly linked to the myth of separation between humans and nature. "The obvious truth regarding humans as part of nature escaped the philosophers of the Enlightenment" (Huesemann & Huesemann, 2011, p. 4).

In the modern worldview, two forms of representation of nature coexist: (a) as untouched nature or wilderness and (b) as natural resources that can be transformed into commodities (Diegues, 1998). "In both of these cases, paradoxically, the forest should be uninhabited, which denies the existence of innumerable cultures and societies that live in the forest" (Diegues, 1998, p. 26). Most often, the untouched nature is a myth, as Victor Margolin (2010) argues: "in fact, humans have intervened in nature throughout history and what appears to us as the natural world today is a world that has absorbed these interventions" (p. 71).

The actions to protect nature from human hands have been controversial at best. I faced that issue in 2010, when I studied an indigenous population in Brazil (Leitão, 2011). Caiçaras live in one of the most precious and biologically diverse ecosystem on the planet. Since 1985, environmental regulations established by the government – with the support of international organizations for environmental conservation – imposed severe restrictions to the traditional subsistence practices, without proposing alternatives to sustain the local communities (Novaes, 2007; Pedroso-Júnior & Sato, 2005). The result was a social tragedy, as many villagers lost their livelihoods[7].

This kind of conflict is happening not only in Brazil. Dowie (2005) argues that there are millions of native people in similar situations all over the world:

> *It's no secret that millions of native peoples around the world have been pushed off their land to make room for big oil, big metal, big timber, and big agriculture. But few people realize that the same thing has happened for a much nobler cause: land and wildlife conservation. (Dowie, 2005)*

On a similar note, but from a different point of view, María Mies and Vandana Shiva argue:

> *In the early phases of colonization, the white man's burden consisted of the need to "civilize" the non-white peoples of the world — this meant above all depriving them of their resources and rights. In the latter phase of colonization, the white man's burden consisted of the need to "develop" the Third World, and this again involved depriving local communities of their resources and rights. We are now on the threshold of the third phase of colonization, in which the white man's burden is to protect the environment — and this too, involves taking control of rights and resources.*
> *(Mies & Shiva 1993, in Banerjee, 2003, p. 143)*

No, designing the transition towards sustainable ways of life cannot be white man's burden, as the way of thinking that brought us here cannot get us out of here. I believe, as Escobar (2011; 2015), that the transition to a sustainable civilization should be embraced as a collaboration between multiple cultures, from the two sides of the line – overcoming the dualism that marked the last four centuries. A dualism created by the myth of the single storyline, in which the numerous storylines of different cultures have been labeled as opposite from the heroic tale of the modern man. In other words, the numerous storylines available on this planet are not <u>opposite</u> to the modern story, but <u>alternative</u> – other possibilities.

There are numerous cultures in the world whose knowledge could be mobilized in order to remake the relationships between humans and nature and to create new conceptions of productivity, consumption and evolution.

> *Alternatives are not lacking in the world. What is indeed missing is an alternative thinking of alternatives. (…) This immensity of alternatives of life, conviviality and interaction with the world is largely wasted because the theories and concepts developed in the global North and employed in the entire academic world do not identify such alternatives. When they do, they do not valorize them as being valid contributions towards constructing a better society. (Santos, 2016, p. 20)*

For Santos (2009), at issue here is that we do not have an epistemology that enables the dialogue and cooperation between the vast diversity of worldviews. I argue that, in order to establish a true dialogue between different knowledges, many myths of modernity need to be recognized and dispelled, allowing for new cognitive frameworks and new epistemologies to emerge.

Inside the modern myths, most often the modern hero will continue talking to inferior or mythic beings (as our next character).

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[7] My study documented the community's initiatives to improve their living conditions through craftsmanship (Leitão 2011).

3.11 Character #6 – Children of the forest: the guardians of the Garden of Eden

Many modern stories present the idealized guardians of the forest who reconnect the hero with nature. From Game of Thrones *to* Avatar*, those peoples symbolize the mythic ecological innocence that was lost in the modern world. Nonetheless, the children of the forest are vanishing. Our hero runs into the last survivors of those noble cultures.*

3.12 Myth 6. Indigenous peoples as guardians of the pre-industrial mythic past

In the Western worldview, indigenous cultures are inevitably vanishing because of the contact with the modern life (Hunter, 2011; Sahlins, 1999). The survivors are guardians of 'traditional' knowledge – linked to the past and pre-industrial – as a counterpoint to modern (scientific) knowledge.

I spent the last seven years collaborating with Indigenous artists and cultural stewards. My partners frequently said to me: *we don't want to be seen as folkloric characters*. Indigenous peoples are contemporary people – who have been affected by globalization and industrialization – and fight for decolonization and self-determination at this present time. Nevertheless, considering them as relics from the past is a way of invalidating contemporary indigenous knowledge – that which they are doing and making right now in order to create a better society.

Why is contemporary Indigenous knowledge particularly relevant to the design for transitions? The idea that a transition to a new civilization is needed arises from the recognition that Western civilization reached a breaking point. We recognize that modern ways of life are unsustainable and a societal change is needed. Otherwise, we will most likely see the destruction of our world. Therefore, transition entails a dialogue about survival and resilience to a (forced and mandatory) deep change in the way we shape our presence on Earth.

The term "indigenous peoples" refers to numerous distinct populations, who live in different contexts, with distinct cultures and experiences. In common they share the legacy of the colonization of their lands and cultures, and the denial of their sovereignty (Smith, 1999). Therefore, they have already experienced the destruction of their World and have a lot to say in terms of resilience and adaptation to drastic changes.

Santos (2009) uses the concept "South" to describe this place of human suffering, struggle, resistance to the project of Modernity, as well as resilience. This South is not a geographic concept, since it also exists in the geographic North in the form of excluded and marginalized populations (Santos 2016). Santos argues that southern knowledges are modern in the way that they have interacted with and resisted the hegemonic worldview for five centuries. Therefore, they consist in "alternative modernities" (Santos, 2009) or "alternatives to development" (Escobar, 2015). One example of an alternative societal project created in the South is the *Buen Vivir* in Ecuador and Bolivia (Gudynas, 2011).

3.13 Myth 7. The active ingredient: eliminating irrational aspects of indigenous knowledge

As pharmaceutical companies extract the active substance of plants to create drugs, sometimes westerners tend to study southern wisdom to extract its active (universal) principle. In other words, in looking for the active principle, there is a tendency to eliminate many aspects of indigenous knowledge that are incompatible with modern beliefs. Nevertheless, in order to create new lifestyles, the specific ways people conceive life – their epistemologies – matter.

For instance, Meyer (2008) explains that for Hawaiian people, knowledge that endures is spirit driven, in the sense that it is a life force connected to all life force. Spirituality here refers to life's intelligence and not to religion. Likewise, Dillard (2008) states that spirituality is the essence of African people. "It is a kind of cosmological spirituality that holds central the notion that all life is sacred" (Dillard 2008: 3). Martin-Mirraboopa argues that, for Aboriginal people, "country is not only the Land and People, but is also the Entities of Waterways, Animals, Plants, Climate, Skies and

Spirits" (2003: 2017). People are no more or less important than the other entities, therefore all things are respected for their place in the overall system (Martin-Mirraboopa 2003).

Moreover, for several epistemologies, the body is involved in the process of knowing. Meyer explains that in Hawaiian worldview, the body is the central space in which knowing is embedded. "Our body holds truth, our body invigorates knowing, our body helps us become who we are." (Meyer 2008: 10). He argues that the *feeling mind* is not conceived as separate from the *thinking body*.

I believe that, in order to know other epistemologies, only intellectual understanding is not enough – they need to be embodied. For example, we can understand that other cultures have a cyclic conception of evolution and time, instead of linear, but cyclic time is something lived and experienced. Thus, the challenge of creating new epistemologies involves embodying the multiple forms of understanding the world and being present in the world. A challenge of the education for the transition.

4 Conclusion

This paper argued that the transition towards sustainable societies is a work that should involve the collaboration of the multitude of cultures and knowledge systems available on Earth. This paper aimed to identify a few myths that embody the beliefs of the modern project and limit our possibilities of collaborating and creating new worldviews. In this sense, recognizing the pillars of modernity that are hindering deep transformations in the Western ways of life.

Creating a new civilization, however, it is not only a task of story-listening – be that listening to the myths of modernity, or the southern cosmologies. The task ahead is the task of creating stories that were never imagined before, but will enable us to achieve our long-standing dream of human flourishing.

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DRS 2018 Design Research Society 2018 Catalyst

University of Limerick
25th – 28th June 2018

The Emerging Transition Design Approach

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doi: 10.21606/dma.2018.210

This paper outlines an emerging Transition Design approach for addressing "wicked" problems (such as climate change, loss of biodiversity, crime, poverty, pollution, etc.) and catalysing societal transitions toward more sustainable and desirable futures. Wicked problems are "systems problems" that exist within large, socio-technical systems and therefore require new problem-solving approaches. The Transition Design Framework brings together an evolving body of practices that can be used to: **1.** visualize and "map" complex problems and their interconnections and interdependencies; **2.** situate them within large, spatio-temporal contexts; **3.** identify and bridge stakeholder conflicts and leverage alignments; **4.** facilitate stakeholders in the co-creation of visions of desirable futures; **5.** identify leverage points in the large problem system in which to situate design interventions. Rather than a fixed, templatised process, the Transition Design Framework provides a logic for bringing together an evolving set of practices relevant to designing for systems level change. This paper reports on how this approach is being tested on a community-based project that was informed by classroom-based coursework.

transition design; wicked problems; socio-technical transitions; sustainable design

1 The Need for a New Design-Led Approach

A new, design-led approach is needed to address the complex, wicked problems confronting societies in the 21st century (Hughes & Steffen, 2013; Jensen, 2017) and to seed and catalyse societal transitions toward more sustainable and desirable long-term futures (Porritt, 2013, pp 274-276). Problems such as climate change, water security, poverty, crime, forced migration, and loss of biodiversity are "systems problems" and challenging for several reasons: 1) they involve multiple stakeholders with conflicting agendas (Dentoni & Bitzer, 2015, p 68); 2) straddle disciplinary boundaries; 3) are ill defined and stakeholders rarely share an understanding of the problem; 4) the problem is continually changing and evolving; 5) problems exist at multiple levels of scale and are interdependent and interconnected; 6) any intervention (attempted solution) in one part of the system, ramifies elsewhere in unpredictable ways; 7) interventions take a long time to evaluate, and problems, a long time to resolve (Rittel & Webber, 1973, Buchanan, 1995; Coyne 2005; Irwin, 2011a, 2011b, 2015).

Traditional design approaches (that were characterized by linear processes and de-contextualized problem frames, whose objective was the swift realization of predictable and profitable solutions) were inadequate for addressing this class of problem (Irwin, 2011b, p 235; Sanders & Stappers, 2008, p 10; Norman & Stappers, 2016). Areas of design focus such service design, experience design, design for social innovation, deep design, metadesign and various ecological and sustainable design processes take a more systematic approach in addressing complex problems. However, they still tend to frame problems within relatively narrow spatio-temporal contexts and do not offer a comprehensive approach for identifying *all* stakeholders and addressing their conflicts. A more holistic approach is needed to address problems that will take dozens of years or even decades to resolve.

A new, design-led approach should:

- Enable stakeholders to arrive at a shared definition of the problem and an understanding of its complexities and interdependencies
- Identify stakeholder concerns, relations, expectations and beliefs and factor them into both problem frames and designed interventions in order to leverage collective stakeholder intelligence (Forrester, Swartling & Lonsdale, 2008; GPPAC, 2015, p 4)
- Provide a process for stakeholders to transcend their differences in the present by co-creating visions of a shared and desirable long-term future (visioning)
- Frame wicked problems within radically large spatio-temporal contexts
- Provide stakeholders and interdisciplinary teams with a palette of tools and methodologies useful in resolving wicked problems and seeding/catalysing systems-level change
- Provide a rationale for "intervening" in complex systems and "solutioning" over long periods of time (dozens of years or even decades) vs. creating short-term, one-off solutions

2 The Importance of Stakeholder Involvement in Wicked Problem Resolution and Systems Transitions

Wicked problems and socio-technical systems transitions are challenging because of the high degrees of social complexity which permeate them. Social issues form the roots of many wicked problems, yet often go unseen and unaddressed by traditional problem-solving approaches. Identifying these social roots and involving *all* affected stakeholders (Carlsson-Kanyama, Drebord, Moll, & Padovan, 2008; Baur, Elteren, Nierse & Abma, 2010; Simon & Rychard, 2005) is crucial in resolving wicked problems and designing for systems-level change. User- and human-centred design approaches seldom have the objective to identify *all* affected stakeholder groups and surface their concerns. Rather, these processes identify "key" groups and privilege the concerns of some over others (for example the concerns of the group commissioning a project, perceived target audiences or those of higher socio-economic rank).

Because the distribution of power among stakeholders is almost always unequal (Bauer et. al, 2010, p 233; Lawhon & Murphy, 2011), if one or two groups are in the position to frame (define) the problem, their needs and concerns will be privileged over those of others. Although traditional design-led approaches consider user preferences and motivations, they seldom examine the individual and collective stakeholder beliefs, assumptions and cultural norms that have contributed to the problem. Social factors such as practices and behaviours are underpinned by beliefs, assumptions (Niedderer, Cain, Lockton, Ludden, Marckrill & Morris, 2014; Ajzen, 1985; 1991) and cultural norms, and *must* be taken into consideration when framing the problem and designing "systems interventions" (solutions) aimed at its resolution (Incropera, 2016, p 15).

Transition Design draws on approaches from the social sciences to understand the social roots of wicked problems and places stakeholder concerns and co-design/collaboration at the heart of the problem-solving process. We use the term "stakeholder" to refer to anyone who has a stake or interest in a specific issue or is affected by a particular problem. The importance of engaging stakeholders in the problem-solving process is well known, particularly in the areas of policy and governance, environmental issues, backcasting and conflict resolution (Grimble & Wellard, 1997, p 173; Bohling, 2011, p 4; Quist & Vergragt, 2006, p 1028; Carlsson-Kanyama, et. al, 2008, pp 34-35; Global Partnership for the Prevention of Armed Conflict, 2015, p 4), but it has yet to be integrated into most traditional design-led approaches.

An Australian Public Service policy report noted that "a key conclusion of much of the literature about wicked policy problems is that effectively engaging the full range of stakeholders in the search for solutions is crucial" (2007, p. 27). There are many well established methods for engaging stakeholders in relation to complex problem solving, for example: Multi-stakeholder Governance (Helmerich & Malets, 2011), Multi-Stakeholder Processes (MSPs) (Global Partnership for the Prevention of Armed Conflict, 2015) and Stakeholder Analysis (SA) (Grimble & Wellard, 1997).

Participatory Action Research (PAR) (Cornwall & Jewkes 1995; Chatterton, Fuller and Routledge, 2007), focuses upon knowledge for action (p. 1667), and is "aimed at social transformation rather than to use a set of tools aimed at the 'production of knowledge' and the 'solving' of 'local' problems" (Chatterton, Fuller and Routledge, 2007, p. 218). The Global Partnership for the Prevention of Armed Conflict list the following benefits of multi-stakeholder engagement (MSP) (2015, p. 23):

1. The involvement of more actors provides a broader range of expertise and perspectives. This means problems can be **analyzed better**, based upon several different viewpoints.
2. Such analyses can lead to a more **comprehensive strategy** to address complex conflict situations.
3. MSPs provide the opportunity for greater understanding of different stakeholders' capacities, roles and limitations, thus contributing to **better coordination** of interventions.
4. MSPs can help organizations **pool and share resources**, including skills, funding, staff time, and logistical or administrative resources.
5. The involvement of multiple stakeholders can be conducive to public outreach and awareness raising at different levels simultaneously, increasing the reach from grassroots to policy mobilization. In this way, they have potential for **multiplier effect** when the key messages of the process are communicated to the participants respective constituencies.
6. MSP can contribute to building **trust** among diverse stakeholders, and enable relationships that can outlast the process itself.
7. They can provide a platform for much needed **capacity building** among practitioners at different levels.
8. Sharing skills and knowledge can enable participants to see problems in a new way, which is also conducive to **innovation**.

Transition Design argues that stakeholder relations can be seen as the "connective tissue" within a wicked problem, and failure to address these concerns and complex relations, are barriers to problem resolution. Conversely, because stakeholder relations permeate the problem (system), they also have the potential to be leveraged in designing interventions aimed at its resolution (Reed, Graves, Dandy, Stringer, 2009).

3 The Transition Design Framework and Phased Approach

A Transition Design approach for addressing wicked problems and catalysing systems-level change is emerging. We call it an “approach” rather than a “process” because this work will require a variety of tools and methodologies, used in different ways—no single, prescribed process would be effective in all circumstances. The approach described in this paper emerged out of workshops conducted with the city of Ojai, California to frame their water shortage as a Transition Design problem (Irwin, 2017) and was informed by coursework in the design program at Carnegie Mellon University and short courses taught in 2016, 2017 in the UK and Spain. Two key components have emerged: A framework that provides logic for bringing together knowledge and practices outside the design disciplines, and a three-phased approach for applying them to design interventions. It should be stressed that this approach is still in nascent form and is offered here as an invitation to other researchers and practitioners to provide feedback, critique and engagement with the objective of co-constituting a new area of design focus aimed at systems-level change.

3.1 The Transition Design Framework

Figure 1. The Transition Design Framework brings together a body of practices in four key areas useful in designing for systems-level change. Source: T. Irwin.

The Transition Design Framework provides a logic for bringing together a variety of practices (knowledge and skillsets outside the design disciplines), situated within four mutually-influencing, co-evolving areas that are relevant to seeding and catalysing systems-level change: Vision (because we need to have clear visions of what we want to transition toward), Theories of Change (because we need a variety of theories and methodologies that explain the dynamics of change within complex systems), Mindset and Posture (because we will need to develop postures of open, collaboration and self-reflection in order to undertake this work), and New Ways of Designing (which will arise out of the previous three areas). Each of these four areas contains a variety of practices that can evolve and change, and which together, form a "palette" from which practitioners and researchers can configure situation-appropriate designed interventions.

3.2 The Transition Design Phased Approach

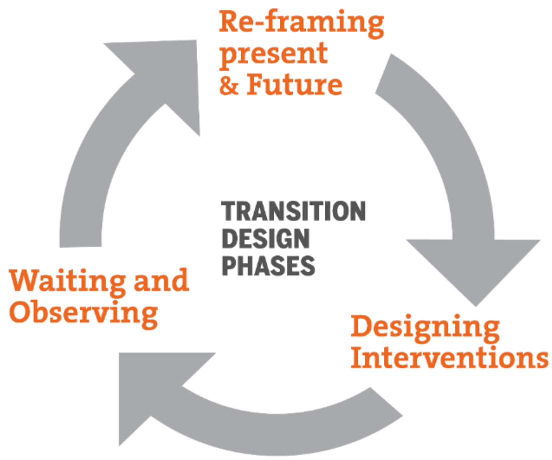


Figure 2. The emerging Transition Design approach suggests three phases comprised of reframing the problem and its context in the present and future, designing interventions, then observing how the system responds. These broad phases accommodate a variety of practices and processes tailored to specific problems and contexts. Source: T. Irwin.

Practices from the framework can be applied within three phases: Re-Framing the Present and Future; Designing Interventions; Waiting and Observing. Rather than a process, these phases suggest the types of action (or inaction) that should be considered when designing for systems-level change.

4 Reframing: The Present and Future

In this phase, stakeholders "reframe" the problem in the present and envision a long-term future in which it has been resolved. Whether it is acknowledged or not each stakeholder affected by a wicked problem has an implicit or explicit vision of the future associated with it (Rawolle, Schultheiss, Strasser, & Kehr 2016, p 1). Sociologist George Lakoff describes frames as "mental structures that shape the way we see the world" (2004, p xi-xii). These structures and cognitive models are influenced by metaphors, norms, mass media, political movements, personal history, etc. and each stakeholder group brings with them, their limited understanding of the problem (the problem frame) as well as their fears, expectations and beliefs with them, all of which are influenced by individual and collective "frames".

4.1 Mapping the Problem in the Present

In this step, stakeholder groups collaborate to visually map the wicked problem, identifying as many relationships within it as possible. This process is intended to: 1. Enable stakeholders to achieve a shared definition of the problem; 2. Provide stakeholders with an understanding and appreciation of the complexities of the problem; 3. Develop an appreciation of the limited perspective and knowledge base of each stakeholder group (i.e. no single stakeholder group can solve the problem); 4. Enable stakeholders to adopt collaborative (as opposed to confrontational) postures which aid in transcending differences; 5. Position stakeholder workshop participants as representatives (within their wider community group) of a diversity of stakeholder perspectives; 6. Create a visual artefact (problem map) that can be continually updated and validated through qualitative research and informal feedback, to serve as a rallying point for community education, action and awareness.

The 2007 report by the The Australian Public Service Commission stressed the importance of achieving a shared understanding of the problem among stakeholders: "it can be extremely difficult to make any headway on an acceptable solution to the wicked problem if stakeholders cannot agree on what the problem is. Achieving a shared understanding of the dimensions of the problem and different perspectives among external stakeholders who can contribute to a full understanding and comprehensive response to the issue is crucial (p. 27).” How problems are framed determines how they will be understood and acted upon. Bardwell (1991, pp 604-605) argues that people solve problems based upon mental models (cognitive maps) assembled over the course of their lives and draw on these subconsciously when encountering new situations. Therefore, people frame new problems in old ways reflecting existing values, assumptions “profoundly impacting upon the quality of solutions.” Because addressing wicked problems will be a new experience for most people, it is imperative that old frames and cognitive models are set aside, in order to reframe the problem using the group intelligence of stakeholders themselves.

An important part of the Ojai problem mapping process involved identifying as many inter-connections and lines of relationship as possible between factors/causes. The types of relationships found within a wicked problem such as a water shortage include: **interdependencies** (between the social issue of residents’ lack of awareness/ignorance of the water shortage and the political issue of a lack of support for developing new policies restricting water use), **causal relationships** (the economic issue of businesses promoting tourism and development is causally related to the environmental issue of the depletion of local water reserves and the environmental issue of the decline of ecosystem health due to the increased demand for water), **conflictual relationships** (the economic issue of increased tourism is at odds with the social issue of residents facing a water shortage while tourists in the hotels are not compelled to conserve) **or affinities** (between the political issue of the need to pass new laws limiting water use and alignment with the environmental issue of conservationists’ desire to protect the integrity of local water sources) and relationships that **feedback** on each other (the economic issue of marketing to increase tourism increases the popularity of Ojai as a destination, which results in more people, using more water, which exacerbates the water shortage—a positive feedback loop). These relationships comprise *the dynamics within wicked problems* often go unaddressed by traditional design approaches.

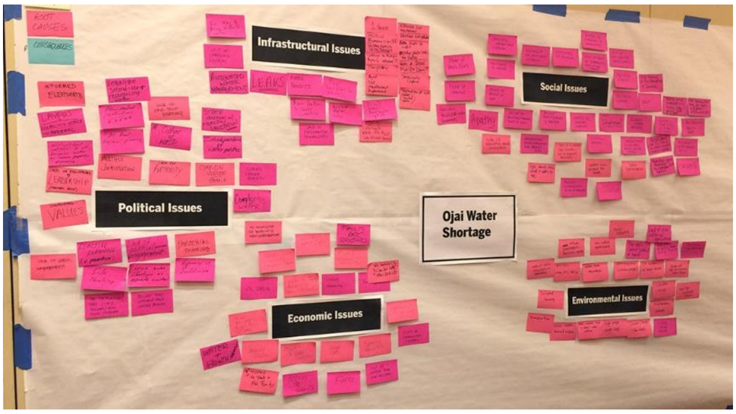


Figure 3. In the Ojai workshops, stakeholder groups mapped contributing factors to the problem in 5 areas: policitcal issues, economic issues, infrastructural issues, social issues and environmental issues. This was accomplished in a ½ day session using post-it notes. A discussion among participants about the interconnections and causal relationships within the problem map informed the creation by workshop facilitators of a higher fidelity map (figure 4). Source: T. Irwin

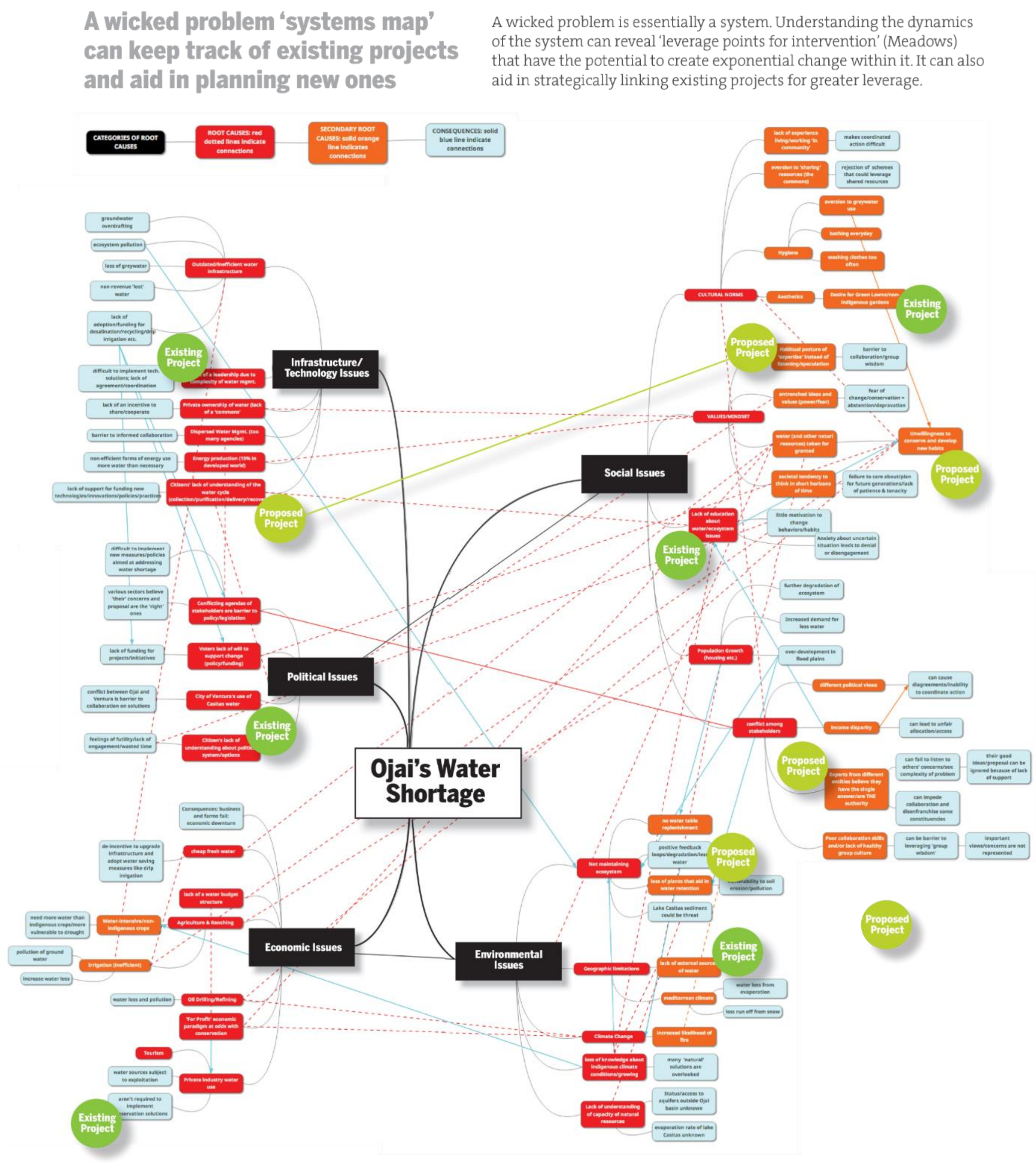


Figure 4. Based upon the problem mapping conducted by workshop participants and subsequent discussions, organizers developed this visualization, adding lines of connection and relationship. Green circles demonstrated to the community how new and existing projects and initiatives can act as strategically placed "interventions" aimed at transitioning the system (problem) toward a future of water security. This map is intended as an early "sketch" to guide qualitative stakeholder research aimed at validating or refuting nodes and relationships. In this way the map becomes a visual representation of a community's collective understanding of the problem of water security. Source: T. Irwin

Asking stakeholder groups to map the problem together accomplished several things: 1. Participants discovered facets of the problem they were unaware of, which challenged what they believed to be "true"; 2. The process fostered empathy for the way the water shortage affected other stakeholder groups; 3. Transformed a potentially "confrontational" meeting among opposing stakeholder groups into a co-creation process with elements of discovery and "play". And, it prepared them for the following step which looks more closely at the relations between groups.

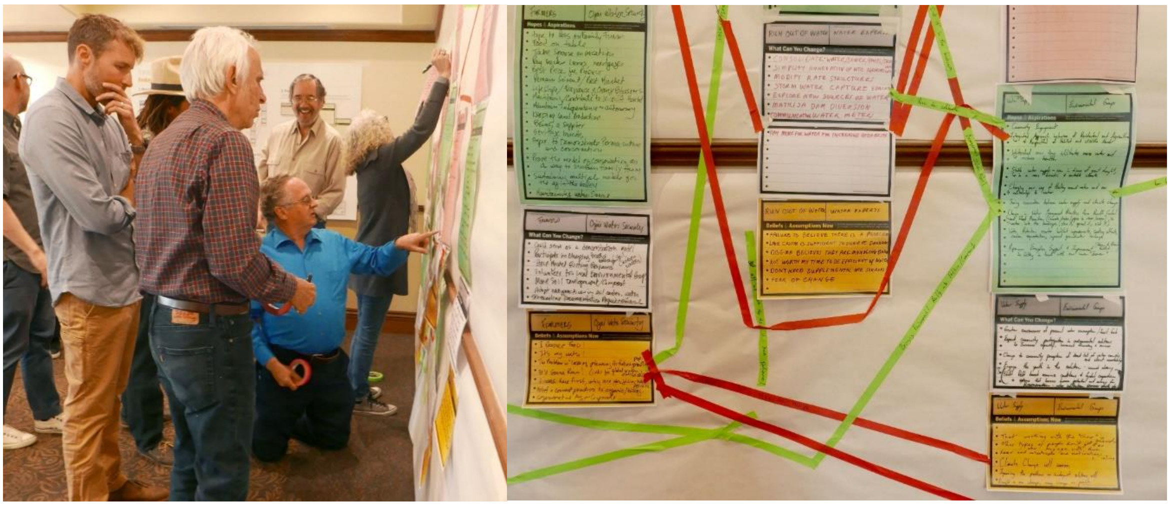
4.2 *Mapping Stakeholder Concerns & Relations*

Failure to consider stakeholder concerns, fears, hopes and desires related to the problem can be a barrier to problem resolution. As yet, there is no design-led process aimed at identifying these concerns and integrating them into problem frames and designed interventions. However, in other fields there are many well documented approaches, including Needs-Fears Mapping (Wageningen University, 2017), Conflict Analysis Tools (Mason & Rychard, 2005), and Multi-Stakeholder Processes (Hemmati, 2002), to name a few. These delve more deeply into understanding stakeholder differences, mindsets and relations than traditional design processes (such as actor and stakeholder mapping which often privilege the consultant/expert designer's or client's point of view), and offer collaborative processes for resolving conflicts and facilitating more meaningful collaboration and understanding.

What these approaches lack is a design-led component leading to tangible action and material results. For example, designed interactions, communications and artefacts can educate, clarify and facilitate new behaviours and outcomes and permeate socio-technical systems. Transition Design aspires to integrate these stakeholder conflict resolution methods as a strategy for addressing wicked problems.

In the Ojai workshops, stakeholder groups listed both their fears/concerns and hopes/desires related to the regional water shortage and were asked to identify and label relations among groups. Tape was used to connect points of opposition (red) and points of affinity and alignment (green) (figures 5 & 6) to which they added notes explaining the nature of the connection. This informal and rather "boisterous" process interjected an element of discovery, surprise and "play" into what would ordinarily have been a tense and potentially confrontational debate among diverse stakeholder groups about how to solve the problem. The results showed several red lines of stark oppositions (instances in which one stakeholder group's greatest fear is another's fondest wish) but these were identified in a spirit of discovery and friendly competition to see how many connections could be identified. Dialog between opposing groups was collegial, even light hearted and stakeholders were surprised at the number of lines of affinity among groups, which became points of positive speculation and discussion.

A final discussion around the large, sprawling map of concerns, fears, hopes and desires focused on how red lines of opposition could be resolved, and lines of affinity leveraged. This shifted the focus from debating differences to conversations about how to resolve them. More research to validate this approach is planned; however early signs show it has the potential to spark dialog among stakeholders with opposing agendas and move them toward collaboration in areas of common interests and objectives. In a final, self-reflective exercise, groups examined the cultural norms, beliefs and assumptions (held by their stakeholder group) that may have contributed to the water shortage. This is challenging work, because few of us are skilled in examining our own worldviews and mind-sets (Lent, 2017; Clarke, 2002; Woodhouse, 1996; Kearney, 1984; Kuhn, 1962) as the roots of a wicked problem. Once stakeholder groups identified their cultural norms, beliefs and assumptions connected to the problem, they were asked: "if by 2050, the problem has been resolved, how would cultural norms, beliefs and assumptions have changed?"



Figures 5 & 6. Stakeholder groups listed their fears/concerns, hopes/desires and the 2017 "beliefs" about water that might have contributed to the problem (pink and green sheets). Beliefs and assumptions about the problem were listed on the yellow sheets. All of these were hung on the wall and the entire group looked for lines of opposition (red tape) and alignment (green tape) in order to identify conflicts (barriers) as well as alignments that could be leveraged in formulating design interventions. Source: T. Irwin.

At the conclusion of the exercise, each stakeholder group had two sets of contrasting beliefs, assumptions and norms: one set for 2017 (that had contributed to the problem) and a second "future" set from 2050 (that would inform its resolution via the re-conception of lifestyles and place-based solutions). As an example, one group articulated their 2017 beliefs as "we believe that water is something to be bought and sold, because there will always be enough of it." This contrasted with their set of 2050 beliefs: "water is precious and sacred—it is part of 'the commons' and everyone has a right to enough. To waste it is seen as a criminal offense." This exercise, while challenging, marked a distinct change in tone in the workshop. Participants appeared to slow down and became more speculative, even contemplative. Encouraging participants to adopt this new posture (which relates to the Mindset & Posture area of the Transition Design Framework) prepared participants for the following step:

4.3 Future Visioning

Transition Design aspires to draw on a range of foresighting techniques that enable stakeholders to co-create compelling visions of long-term, lifestyle-based futures in which the problem has been resolved and many stakeholder fears/concerns addressed and hopes/desires fulfilled. These visions help stakeholders transcend present-day differences and they act as both a "magnet" that pulls communities toward co-envisioned, desirable futures, and a compass which guides the design of systems interventions in the present.

The intersection of foresight studies and design has given rise to several new areas of theory, research and practice including Design Fiction (Lindley & Coulton, 2016; Sterling, 2005), Speculative/ Critical Design (Dunne & Raby, 2013) and Experiential Futures (Candy & Dunagan, 2017; Candy & Kornet, 2017) that are concerned with envisioning and prototyping both *possible* and *preferable* futures. Candy and Dunagan (2017, p 3) note that "experiential futures [are able to] catalyse high quality engagement, insight, and action to shape change, using whatever means fits the situation" and seek to provide individuals and groups with glimpses of a future that resonates more deeply than other modalities.

New tools and approaches for enabling stakeholders to co-create compelling visions of long-term, desirable futures are needed. Stakeholder groups in the Ojai workshops undertook an exercise called "Snapshots from 2050" to develop lifestyle-based narratives of Ojai in 2050, in which the water shortage had been resolved. Groups were provided with relevant examples of "day-in-the-life" narratives to ensure they remained focused on *the holistic process of envisioning/ reconceiving* *entire lifestyles*, vs. the dominant, reductionist approach of *envisioning discipline-based solutions*. Groups were provided with narrative word/image “templates” and prompted with questions such as: “what would the resolution of the problem make possible for your stakeholder group?”; “what might you be able to do/accomplish that you currently cannot?”; “in what ways would your everyday life (practices, surroundings, profession, home life) look different or be better if the water shortage were resolved?”

Groups used their previously articulated 2050 beliefs, assumptions and cultural norms as the springboard for the futuring exercise. They were asked to consider how their 2050 “worldview” might inform new practices, behaviours and designed interactions, and how artefacts would be part of their narrative. Participants also referenced their earlier lists of fears/concerns and hopes/desires, and speculate about how they would have been resolved or fulfilled in the future, and as a way to develop more concrete examples for the day-in-the-life narratives. In a final group critique, groups reprised the exercise of drawing green lines of affinity and red lines of opposition between the different narratives. The results showed many green lines due to the striking similarities among the visions, and few red lines of opposition. Our hypothesis (which can only be borne out through additional, extensive research with more groups) is that the “space” participants enter into when envisioning a desired, common future, enables them to transcend opposition and conflict in the present and focus on affinities and similarities in a commonly envisioned, hypothetical future.

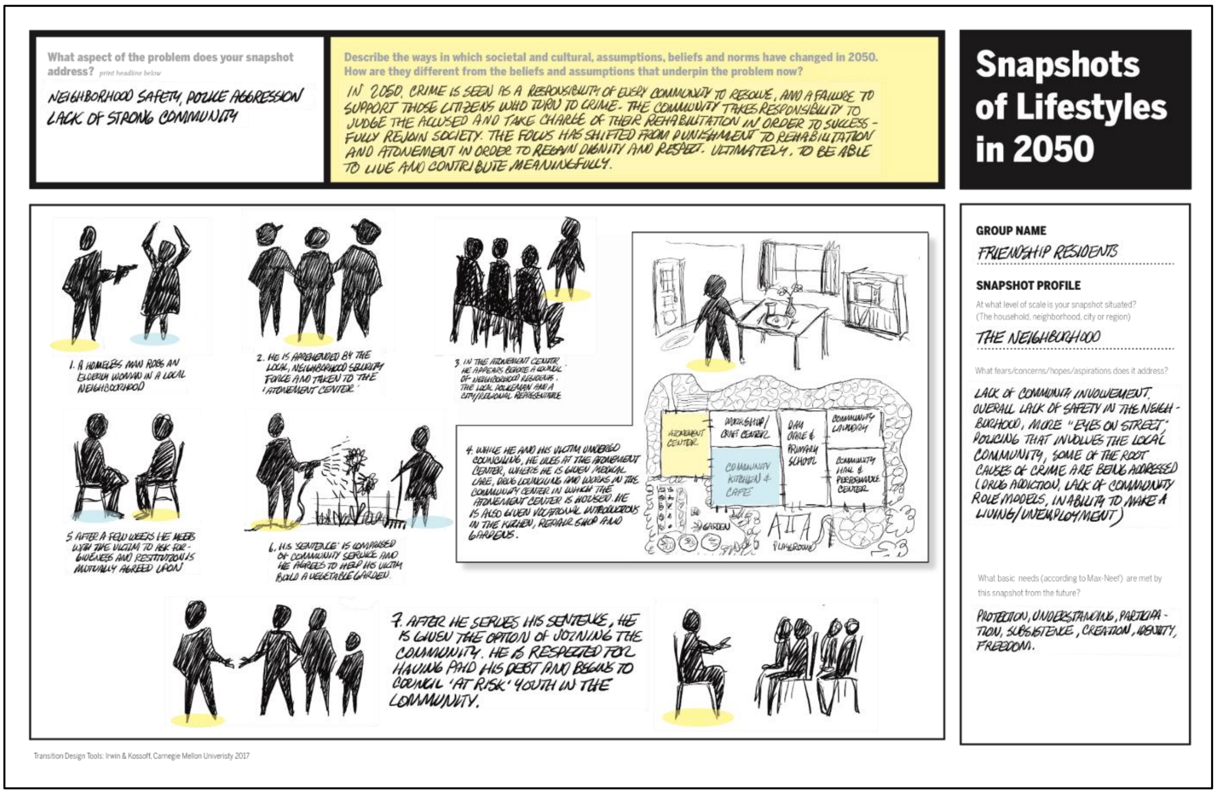


Figure 7. Workshop stakeholder groups were provided with templates and examples of how to develop future, lifestyle-based narratives that incorporate solutions “holistically” in a narrative. This template provided participants with an example of a future snapshot in which neighborhood crime had been resolved. Source: T.Irwin.

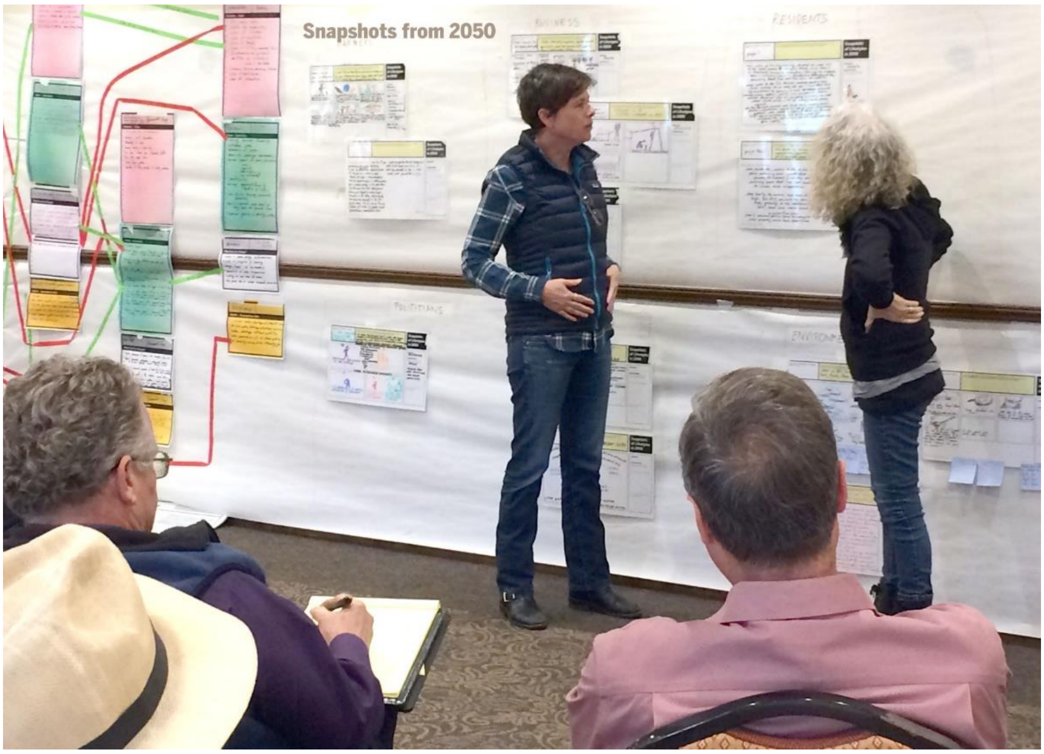


Figure 8. Each stakeholder group presented their future narrative in a studio-based critique style. Source:T. Irwin.

4.4 Backcasting

Backcasting (Robinson, 1982; Dreborg, 1996) has been successfully used to address long-term, complex societal issues that involve multiple stakeholder groups (Carlesson-Kanyama, et. al., 2008; Quist & Vergragt, 2006). It begins with defining a desirable future then "backcasting" to the present to create a "transition pathway" along which projects, initiatives and programs are positioned as initial "steps" in a longer transition. It differs from forecasting in approach. Forecasting extrapolates current trends (based in dominant paradigms out of which the problem arose) into the future, whereas backcasting attempts to define preferable futures, analyse their consequences, and determine the conditions necessary for them to materialize. Robinson (1982) notes "the major distinguishing characteristic of backcasting analysis is a concern, not with what futures are likely to happen, but with how desirable futures can be attained. It is thus normative, involving working backwards from a particular desirable future end-point to the present, in order to determine the physical feasibility of that future and what policy measures would be required to reach that point (p. 337)." Transition Design proposes backcasting as a collaborative activity in which stakeholder groups leverage their visions of desirable futures to inform tangible, consensus-based action in the present. Due to time limitations, Ojai workshop participants did not delve deeply into this process. Groups were asked to create a transition pathway from the present to their 2050 vision and use post-it notes to speculate on what projects, initiatives, and milestones would be necessary (between the present and 2050) to achieve the vision. This technique draws on the approaches used by Porritt (2013), Carlesson-Kanyama et. al. (2008), and Sharpe (2013) in using backcasting to envision a process of societal transition.

Workshop organizers observed that participants were highly challenged when asked to think in long horizons of time and struggled with the exercise. Further research must be undertaken to evolve the backcasting process for Transition Design, and it is likely that a variety of approaches can be employed and combined in different ways (including the STEEP and Three Horizons tools).

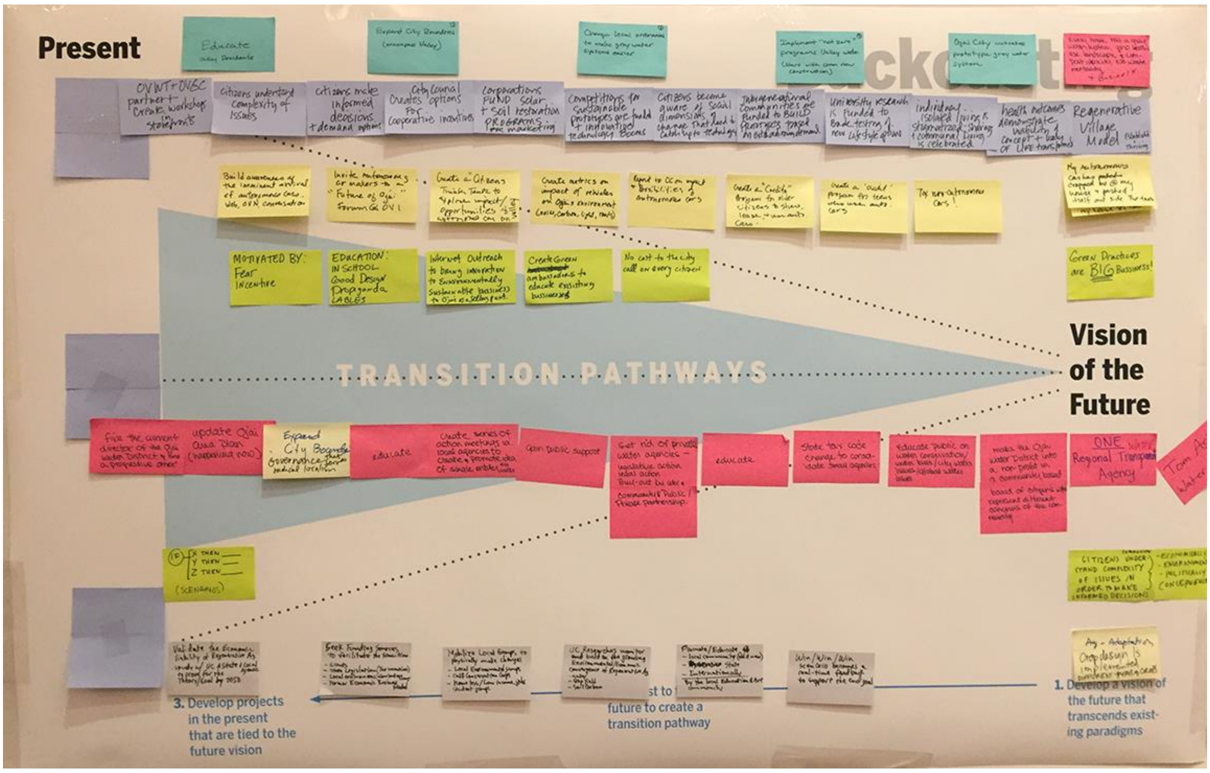


Figure 9. Stakeholder groups mapped a speculative transition pathway from their desired future to the present, with each post-it representing a tangible project/initiative or milestone. Large plotter "canvases" provides participants with a visual structure within which to work. Source: T. Irwin

Irwin, Tonkinwise, and Kossoff (2015) have proposed an iterative and cyclical process, shown in figure 10, for backcasting and visioning as the slow process of problem resolution and societal transitions unfold. This process ensures that long-term thinking becomes common and that future visions do not become "fixed" and static, but rather, are in a continual process of evolution and change, based upon feedback and outputs from present and near-term projects (steps in the transition).

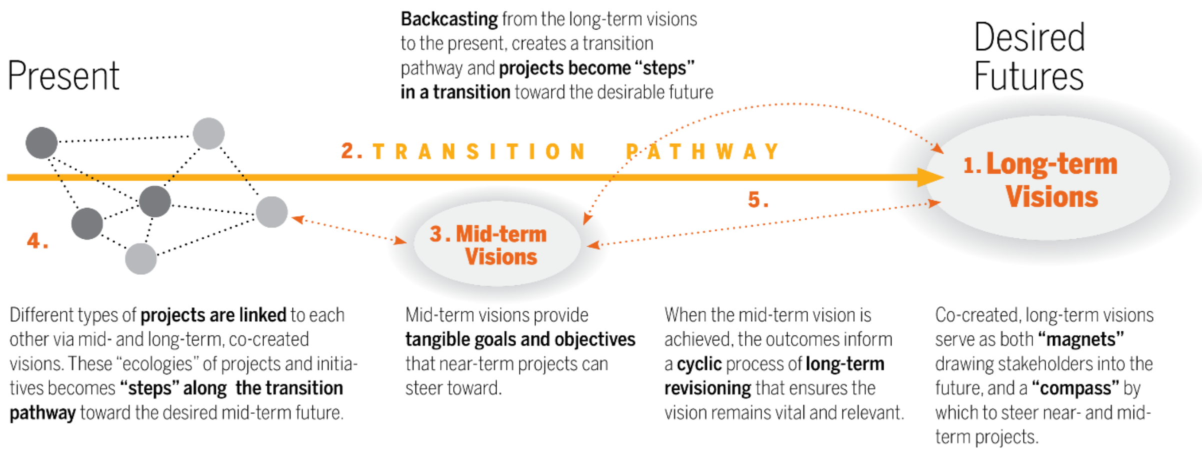


Figure 10. Backcasting from a co-created future vision creates a "transition pathway" along which new and existing projects can be connected and situated as "steps" in a long transition toward the desired future. Source: T. Irwin, G. Kossoff, C.Tonkinwise.

5 Designing Interventions

Phase 2 situates both the problem map and the future vision within a large, spatio-temporal context (figure 11). It also draws on tools and approaches from the Transition Design Framework to develop interventions for problem resolution and systems transition. Most design-led approaches situate problems within small, manageable problem frames and contexts in order to arrive at swift, profitable solutions. We argue that wicked problem resolution requires myriad interventions at multiple levels within extremely large spatio-temporal contexts (over long periods of time). Wicked problems exist at multiple levels of scale and *always* have their roots in the past because it takes years, decades, or even longer for problems to become wicked. It is necessary to look at both higher *and* lower systems levels to understand the problem's ramifications and consequences in the present, and look to the past in order to understand the problem's root causes and evolution.

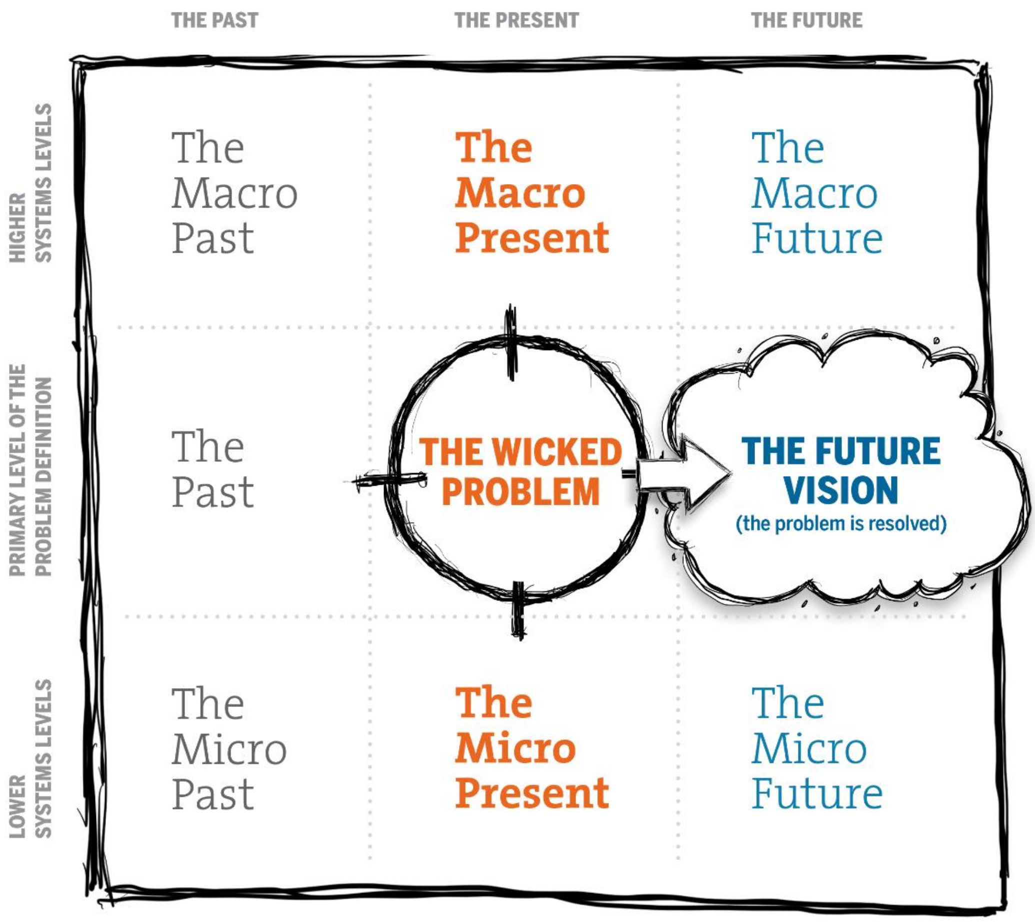


Figure 11. Transition Design draws upon the concept of the Multi-Level Perspective (Geels 2006) to situate both the wicked problem and a future, lifestyle-based vision in a large, spatio-temporal context. This large context is explored in order to identify the most promising points of "intervention" lie within this large context. Source: T. Irwin.

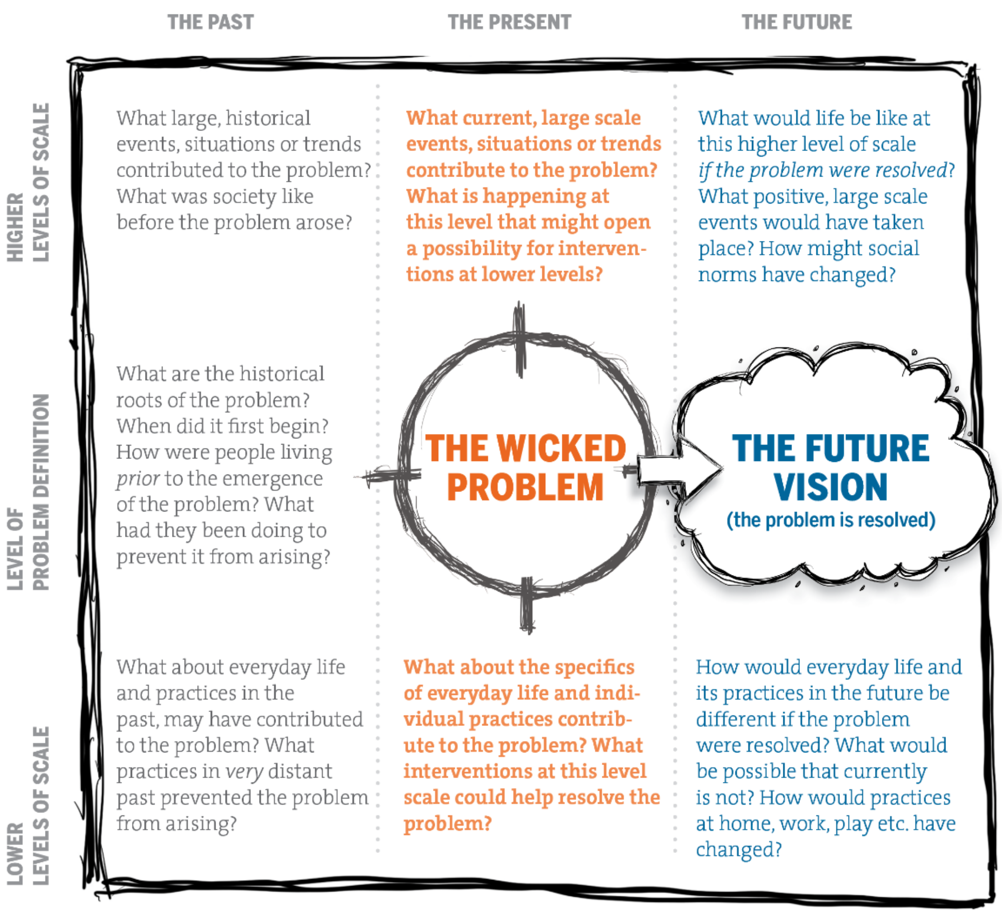


Figure 12. Specific questions can be asked at each level in the past, present and future in order to guide research and bring a higher level of fidelity to the future vision. Source: T. Irwin.

In essence, phase two of the transition design process involves *looking up and down systems levels in space, and backward and forward in time* in order to contextualize and address wicked problems—both dimensions play a role in devising interventions (figures 11 & 12). Exploring this large context helps us: **1.** understand the **present**-day ramifications and consequences of wicked problems (looking up and down systems levels); **2.** Understand how wicked problems evolved and identify their root causes (in the **past**); **3.** Know where to situate interventions aimed at transitioning the system (problem and context) toward the preferred **future**.

Many of the practices listed in the Transition Design Framework (Figure 1) will prove useful in the design of systems interventions (both in wicked problem resolution and initiating systems transitions). Due to the limited length of this paper, only six have been listed in Figure 13 on the following page, with an overview of the practice, its relevance to Transition Design and references where more information can be found.

5.1 Linking and Amplifying Projects

Many one-off projects and initiatives are often developed to address wicked problems like a water shortage; however, Transition Design argues that these are unlikely to resolve the problem, or catalyse systems-level change. A new design-led approach must provide a rationale for linking efforts together, over time, for greater traction and 'leverage; (Meadows, 1999). Linking new *and* existing projects (from multiple sectors, including service design and social innovation) to each other *and* long-term visions of co-created, desirable futures is a key Transition Design strategy (Figure 10).

Tools & Practices for Designing Systems Interventions

PRACTICE	WHAT IT IS	WHAT IT IS USEFUL FOR	REFERENCES
MLP The Muli-Level Perspective	Conceptual framework used to investigate **how large socio-technical systems transition** over long periods of time. Describes 3 distinct systems levels in which events unfold, infrastructure and artifacts arise, and webs of interaction occur.	Useful in exploring large, spatio-temporal contexts; identifying the **historical roots** of complex problem(s) and "entrenched"/intractable areas within a large system; **reveals opportunities for disruptions** (designed interventions); provides large enough context to reveal connections between multiple wicked problems.	**Geels**, 2006 **Irwin, Tonkinwise & Kossoff**, 2015 **Gaziulusoy & Breze**t, 2015 **Grin, Rotmans & Schot**, 2010 **Rotmans & Kemp**, 2003 **Trist & Murray**, 1993
Max-Neef's Theory of Needs	Proposes that **needs are ontological, non-hierarchical, finite and universal,** but how they are satisfied is limitless and specific to culture, place, gender, age, and era. **"Poverties" of unmet needs are the root of many problems.**	Can be **integrated into problem frames** to ascertain if the proposed solution is meeting genuine needs (in sustainable ways) or whether it might be undermining the ability to meet other needs. Can be used as an approach to **socially and environmentally responsible design**. Useful in designing systems interventions at mezzo and micro levels.	**Max-Neef**, 1991 **Irwin**, 2011 a, p 50 **Kossoff**, 2011, p 130
Social Practice Theory	Considers the entire **ecology** of elements that are involved in practices: **materials, competencies and meanings**. Used as a strategy for sustainability, it looks particularly at how practices arise and then become inertial.	Can be used at the **micro-systems level** to understand how people's practices contribute to wicked problems and systems entrenchment. Because **practices are so ubiquitous**, they can be used as a **leverage point for change** within complex systems like wicked problems and socio-technical systems.	**Shove & Walker**, 2010 **Shove et. al.**, 2012 **Kossoff, Tonkinwise & Irwin**, 2015 **Scott et al.**, 2011 **Kuijer & De Jong**, 2011 **Bourdieu**, 1997 **Giddens**, 1984
Design for Behavior Change	Focuses on **people's attitudes, behaviors, motivations** and understandings to leverage psychological principles in the design of products and services that can **influence users' behavior for social benefit**.	Understanding how individuals' and groups' beliefs, attitudes and **behaviors contribute to both wicked problems** and systems intertia or entrenchment can become a strategy for systems-level change. Useful in combination with social practice theory in examing the social interactions and interdependencies found within large, socio-technical systems and wicked problems.	**Lockton et. al**, 2013 **Jana**, 2010 **Abraham & Michie**, 2008
Domains of Everyday Life & Lifestyles	Everyday life and lifestyles refer to the way in which individuals, communities and societies meet their needs. The Domains Framework proposes that **everyday life is comprised of nested systems levels** in which particular types of needs are best satisfied: The household, the neighborhood, the city, the region, the planet.	Can be used as **a more appropriate context** within which to conceive sustainable solutions and design interventions and catalyze systems-level change. Solutions can be intentionally situated in a particular domain of everyday life to become **more effective systems interventions**. Long-term visions are more powerful when developed within the context of everyday life and lifestyles.	**Lefebvre**, 1991 **Debord**, 2002 **SPREAD**, 2012 a, b, c **Kossoff**, 2011 **de Certeau**, 1984
Social Pathways Matrix The Winterhouse Institute	A model developed by design educators to **map the territories in which designers now work**. The matrix shows the **scale of engagement and the range of expertise** required of types of projects and their impact.	Can be used as a **guide in designing interventions in large, spatio-temporal systems**. The tool can inventory existing and proposed interventions in order to ensure that interventions are situated at multiple levels in the system (wicked problem) and over multiple time horizons.	**Winterhouse**, 2017 **Irwin**, 2015 **Amatullo**, 2016

Figure 13. The practices above are listed in the Transition Framework and can be especially useful in designing systems interventions within large, spatio-temporal contexts. Source: T. Irwin.

Amplifying projects (Manzini, 2015, pp 123-124; Penin, 2010; Amplifying Creative Communities, 2010) refers to the need to look for what is already working at the grassroots level in order to support and "amplify" these efforts. This will call for decidedly different mindsets and postures—that of the non-expert, who approaches a new situation in a posture of empathy and sensitivity to "emergent solutions". The expert designer mindset that aims to "fix what is wrong" through superior specialist knowledge, whereas the transition designer "looks for what is right" within local, indigenous efforts already underway.

6 Waiting and Observing (Mindset & Posture)

In order to seed and catalyse change in complex systems and resolve wicked problems, multiple interventions, at multiple levels of scale over multiple time horizons will be required. Working with and *within* large, slow moving systems will involve periods of activity and intervention counter-balanced by intervals of observation and reflection in *order to understand how the system has responded to the perturbation*. This contrasts with traditional, design-led approaches, characterized by fast-paced, linear processes whose objective is clear, predictable, conclusive results (solutions).
Complex systems with large social components (lots of people interacting with each other) display properties of self-organization, including "the spontaneous emergence of new structures and new forms of behaviour" (Capra, 1996, p 85). Because these systems are self-organizing, the ways in which they react to perturbations from their environment (designed interventions) are internal and self-determined; i.e. their response cannot be predicted. This is an extremely important principle that, if properly understood, should radically transform traditional design process. The context for these interventions—socio-technical systems and social organizations—will rarely respond to an intervention the way we think it will, and the more complex the system, the more unpredictable its response. This principle of self-organization is why so many meticulously designed solutions fail. Instead of thinking in terms of "designing solutions", transition designers must think in terms of "solutioning" at multiple levels of scale, over long periods of time. Or, as Wheatley and Kellner-Rogers have said, we must learn to "tinker" things into existence (1996, p. 10).
This extremely important part of the Transition Design approach will be highly controversial because it challenges the dominant socio-technical, economic and political paradigms out of which most wicked problems have arisen. These paradigms are based upon a style of thinking that has been widely critiqued and described in turn as "mechanistic", "reductionist" and "de-contextualized" (Author 2011b, p 254; Capra 1996; Capra & Luisi, 2014; Scott, 1998; Toulmin,1990; Mumford, 1971; Berman, 1981). Sociologist George Ritzer argues that this style of thinking dominates 21st century society via business models characterized by efficiency, calculability, predictability and control (Ritzer, 2004, pp 12-15). Transition Design argues that these same characteristics are found in traditional problem-solving processes and are—ironically—one of the root causes of wicked problems (Irwin 2011b, p 235).
Designing for systems-level change will require fundamentally different mindsets and postures (Irwin 2015, p 236) and will be slow, patient work with "emergent outcomes." It will also challenge dominant paradigms that demand fast, concrete, predictable and profitable results. Orr (2002) makes an important distinction between fast and slow knowledge, arguing that "the twentieth century is the age of fast knowledge driven by rapid technological change and the rise of the global economy. This has undermined communities, cultures, and religions that once slowed the rate of change and filtered the appropriate knowledge from the cacophony of new information" (p 36). The aim of slow knowledge is resilience, harmony and the preservation of patterns that connect (p. 39) and will challenge transition designers to adopt a slower pace and the ability to think in longer horizons of time. Stewart Brand of the Long Now Foundation asks "how do we make long-term thinking automatic and common instead of difficult and rare?" (Brand, 1999, p 2). Similarly, the "seventh generation" principle from the Great Law of Iroquois Confederacy required its citizens to make crucial decisions with the welfare and preservation of the 7th future generation in mind (Loew, 2014). This type of long-term thinking, along with an understanding of the longer, slower cycles that govern the natural world, *must* underpin a Transition Design approach.
The Transition Design approach can be compared with Chinese acupuncture. An acupuncturist will closely observe the patient for a period of time in order to understand the imbalances or blocks in the system (body) and then place needles along specific meridians in order to shift energy (this is similar to a practitioner designing systems interventions). After placing the needles, he/she will *always* wait and observe how the body (system) responds. Sometimes several weeks might go by before another treatment is recommended. The practitioner places needles based upon his/her experience and a "working hypothesis" that a certain response is *probable*, however a good

practitioner will wait to see how a specific individual responds (based upon their own physiology, psychology, lifestyle, etc.) before intervening again. Designing interventions for socio-technical systems will require a similar approach in which periods of action and intervention are punctuated by periods of observation and reflection *in order to understand how the system is responding*. This process will be at odds with 21st century expectations for quick, conclusive, profitable and quantifiable results. For this reason, the transition designer will also need to develop compelling arguments and narratives about the (long-term) value and benefits of the process itself.

7 Conclusion

This paper has outlined an emerging, design-led approach for addressing complex, wicked problems and catalysing societal transitions toward more sustainable futures (figure 14). It emphasizes the need to engage *all* stakeholders (human and non-human) affected by the problem in order to create a shared problem definition and understanding of the oppositions and alignments among them. A framework or “guide” for situating problems within large, spatio-temporal contexts is proposed. This framework can be used to understand root causes and consequences and identify leverage points for interventions aimed at transitioning the system along a transition pathway toward a co-envisioned future.

Transition Design aspires to become a flexible, integrated approach that makes design-led tools and approaches available to transdisciplinary teams working on transition-related projects and initiatives. Still in its nascent phase, it will require researchers and practitioners from many disciplines and a diversity of cultural perspectives working together to constitute a broadly applicable, transdisciplinary process. This paper is presented as an invitation for critique, speculation and a roadmap for further research.

PHASE ONE | **PRACTICES USED IN OJAI**

Reframing: Past and Present

Reframing the present in order to arrive at a shared understanding of the problem.

Reframing the future through the co-creation of visions of where we want to go.

1

1. **Mapping the Problem**
   Stakeholders collaborate to create a shared understanding of the problem, its complexity and interconnections and inter-dependencies.
2. **Mapping stakeholder concerns and relations**
   Stakeholders identify their fears/concerns, hopes/desires and their beliefs, assumptions and cultural norms that have contributed to the problem.
3. **Developing visions of the future**
   Stakeholders co-create lifestyle-based visions of a shared, desirable future in which the problem has been resolved and their needs met.
4. **Backcasting to create transition pathways**
   Stakeholders backcast from the vision to create a transition pathway to the present. Projects and initiatives will become steps toward the desired future.

PHASE TWO | **USEFUL APPROACHES**

Designing Interventions

Situating the problem map and future vision within a large, spatio-temporal context. Identifying consequences and root causes at multiple levels of scale in order to design interventions aimed at resolving the problem, and catalyzing system transition.

2

- **Multi-Level Perspective**
  The problem is situated within its socio-technical context in order to identify its historic roots and opportunities for interventions at multiple levels of spatio-temporal scale.
- **The Domains of Everyday Life/Lifestyles**
  Interventions are developed within the context of re-conceived lifestyles and everyday life.
- **Max-Neef's Theory of Needs**
  The satisfaction of genuine needs (as opposed to wants/desires) is a strategy for designing more effective interventions.
- **Social Practice Theory & Design for Behavior Change**
  Individual and collective practices and behavior are seen as both causes of wicked problems as well as leverage point for change.
- **Winterhouse Social Pathways Matrix**
  A useful tool for planning interventions at mutiple levels of scale over multiple horizons of time.
- **Linking and Amplifying**
  Existing and new projects/initiatives (many of which arise at the grassroots level) are linked together and amplified to catalyze systems-level change.

PHASE THREE | **USEFUL APPROACHES**

Waiting & Observing

Periods of activity and intervention are counterbalanced by periods of observations and contemplation which requires new mindsets and postures.

3

- **Patience and restraint**
  Instead of rushing to completion with the expectation of clear, measurable results, the designer takes up a posture of patient observation and waiting. The designer resists the pressure of coming to quick conclusions about the results of interventions.
- **Slow knowlege/long time horizons**
  The designer understands the slower cycles that characterize ecosystems and design with these slower cycles in mind. They frame interventions within long time horizons and know that outcomes may take dozens of years or decades.
- **Design with living systems principles**
  Designers have a deep appreciation of living systems principles such as self-organization, emergence, sensitivity to initial conditions and feedback and integrate this understanding into their process.
- **Speculation vs. certainty**
  The designer understands that the outcomes of interventions cannot be predicted, and therefore postures of certainty must be replaced by speculation and spontaneity.

Figure 14. An overview of the emerging Transition Design approach is presented using several of the practices included in the Framework. These can be configured differently and appropriately for different problems and situations. Source: T. Irwin.

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DRS 2018 Design Research Society 2018 Catalyst

University of Limerick
25th – 28th June 2018

Transition Design: teaching and learning

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doi: 10.21606/dma.2018.282

Central to the development of transition design is its foundation in higher education. The theoretical basis that informs the practice of transition design develops from an emergent process comprised of hypotheses, theory, and testing in educational settings. These approaches—which focus on tackling specific, complex, placed-based challenges—must be tailored to address the nature of specific contexts and the varied learning of student cohorts and their respective needs. This paper investigates the value and thoughtful integration of transition design practices into design education and proposes curricula for undergraduate design students. It outlines methods and tools that are utilized in our teaching, describes successes, identifies challenges, presents ideas for improvement, and proposes opportunities for development.

transition design, education, curricula, teaching

1 Introduction

The thorny problems that transition design can address are all around us. They fall under the category of "wicked problems" that appear insurmountable because of their scale. Wicked problems can't be formulated because each one is a symptom of another problem. For example, a succession of hurricanes recently hit several areas of the southern United States and Puerto Rico. Climate change is a contributing factor to the strength of these storms. Nonetheless, geographical, global, local, and political factors also play a role in the intensification of storms. Where do we begin to tackle the problem? On a local level, low high school completion rates, child poverty, incarceration, and the lack of affordable housing are all interconnected issues in an African-American neighbourhood. Where we attempt to intervene at the outset will have an impact on every other part of the equation. Indeed, the way that a wicked problem is defined "determines the nature of the problem's resolution" (Rittel & Webber, 1973, p.166).

Identifying appropriate places and ways to intervene in systems is not a small feat, but an important one to tackle and teach. This paper addresses the question: How can transition design be taught effectively in undergraduate education? It details a course sequence and the rationale for specific approaches, outlines observations and discoveries gleaned, and defines areas that warrant improvement. It also emphasizes the teaching of transition design as a learning process, in which its curricular development and delivery furthers inquiry and discovery.

2 Overview of Course Structure, Methods, and Tools

We witnessed the merits of integrating transition design into the graduate and doctoral programs at Carnegie Mellon University through the teaching of seminar courses over the past two years. Consequently, we decided to explore teaching undergraduate students transition design concepts because we believe they are essential for all design students to learn. We used core content, activities, and sequencing from our prior experiences teaching transition design to inform the curriculum of a senior design research studio that was taught in fall 2017. We integrated into the course a range of readings seminal to the study of transition design that originate in other disciplines, and leveraged the futures and foresight expertise of a new faculty member. The course also built on the students' prior knowledge and skills gained in the design studies courses that they had previously taken that focused on futures, systems, and cultures.

Our goal was to introduce students to the necessity of societal, systems-level change in addressing complex problems, the value of imagining and realizing sustainable futures, and the roles of designers in these processes. Through a series of choreographed lectures, discussions, and activities, the course sought to help students: 1. Adopt expert and non-expert postures when investigating and working through complex, wicked problems; 2. Gain insight into approaches and methods that aid the study of factors affecting the harmony between people and their environment; and 3. Apply insights that were framed as a toolkit, to the design of speculative services and socially minded interventions that help transition societies to sustainable futures. We implemented this approach because our experience and research indicates that students gain a deep understanding of concepts when they follow reflective processing of information with active practice of concepts.

In the context of a three-hour studio course that convened twice a week over a 15-week period, Professors Stacie Rohrbach, Stuart Candy, and Terry Irwin taught 48 undergraduate design seniors. We identified "cosmopolitan localism" (Manzini, 2005), which situates itself in place-based practice but global in its exchange of information, as important to the study and practice of transition design. We positioned our teaching of transition design in contexts that are familiar to our students while encouraging them to consider the global ramifications of their actions. At the onset of the course, we introduced students to wicked problems that exist throughout Pittsburgh. Randomly configured into eight teams of six students, each group spent several weeks investigating issues that contribute to: (1) the lack of affordable housing or (2) public transportation, (3) gentrification, (4) poor access to quality education or (5) food, (6) crime, or (7) poor air or (8) water quality in the region. In an attempt to move students through steps that we identified as critical to the understanding of transition design, we utilized a range of methods and tools as outlined below.

2.1 Framing Wicked Problems

Diagramming Root Causes and Consequences to Place-Based Issues

We began the course by focusing on wicked problems that warrant systems-level change. Students viewed familiar and foreign examples of problems that related to each of their topics to aid the breadth and depth of their thinking at various levels of scale. The introductory lecture and discussion sought to help students gain insight into the contexts, characteristics, and interconnectedness of wicked problems within the context of large systems.

We asked the students to conduct secondary research on their topic and then visualize the existing problems and outcomes they discovered. We provided each team with the STEEP (social, technological, economical, environmental, and political) framework printed on a panel, which they used to categorize their findings. The students were also tasked with identifying the root causes of issues and the consequences of current actions. To aid their thinking, the students learned about leverage points, which Donella Meadows describes as "places within a complex system (a corporation, an economy, a living body, a city, an ecosystem) where a small shift in one thing can produce big changes in everything” (1999). (Figure 1)

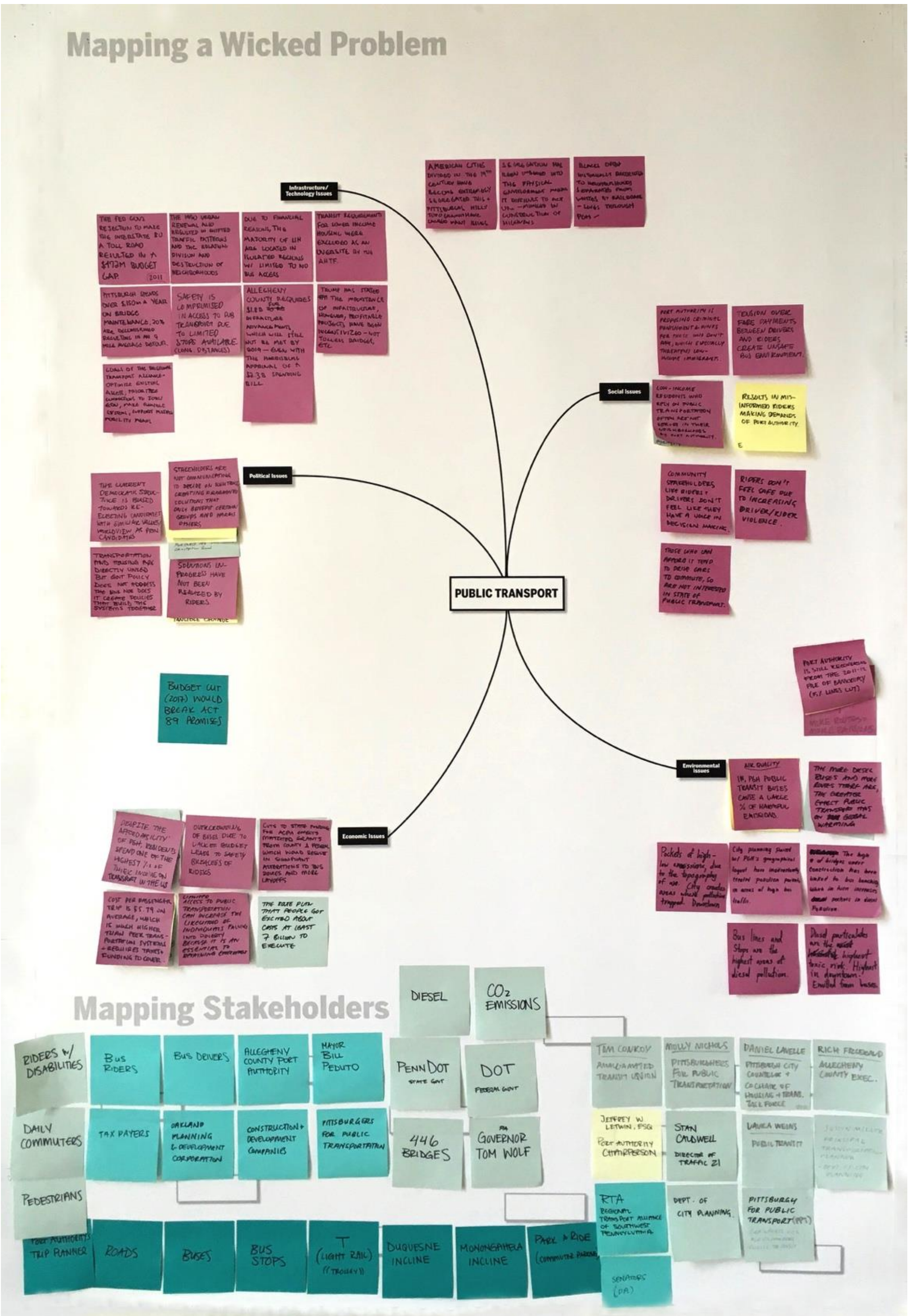


Figure 1. Students used social, technological, economical, environmental, and political categories to delineate the root causes of transportation problems in Pittsburgh.

2.2 Mapping Stakeholder Relations

Uncovering fears and concerns, hopes and aspirations, and connectedness of stakeholders

The second stage of the course focused on worldview; the understanding of reality based on the interpretation of prior experiences (Capra, 1983). Worldviews describe and predict reality, shaping how we perceive and engage in the world. Any worldview causes people to believe what they see rather than identify their perceptions as elements of reality. As a result, worldviews typically reinforce existing beliefs and expectations.

Instead of perpetuating a mechanistic worldview that exacerbates capitalistic tendencies, the studio course instead supported a holistic worldview—one that considers the interconnectedness of facets that comprise sociotechnical systems challenges (Capra, 1997). A few characteristics of this shift in perspective include relating instead of dominating, cooperating rather than competing, co-learning and re-skilling, and designing for long-time horizons (Woodhouse, 1996). Holistic thinking encourages a speculative posture where students are curious, pose questions, and emphasize relationships rather than simply aiming to solve problems and focusing on objects. A mind-set that values waiting and observing is a critical component of this approach.

In this unit of the course, students defined and investigated stakeholders related to their topics. Although the students didn't have immediate access to specific stakeholders at that time, we asked them to use the information they gathered to speculate the fears and concerns, and hopes and aspirations of those groups to familiarize themselves with the step and recognize its importance to transition design. (Figure 2) Each team chose three stakeholder groups related to their topic that represented a diverse set. They then performed triad mapping, which revealed points of affinity and opposition among the groups, and the nature of their relationships. (Figure 3)

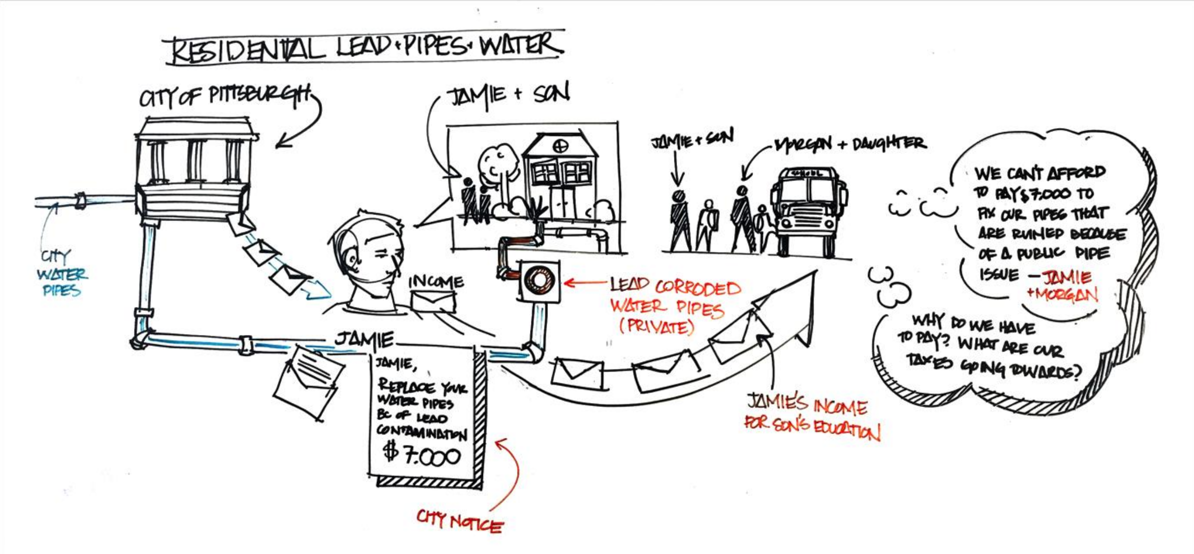


Figure 2. Students described the fears/concerns and hope/aspirations of air quality stakeholders in Pittsburgh.

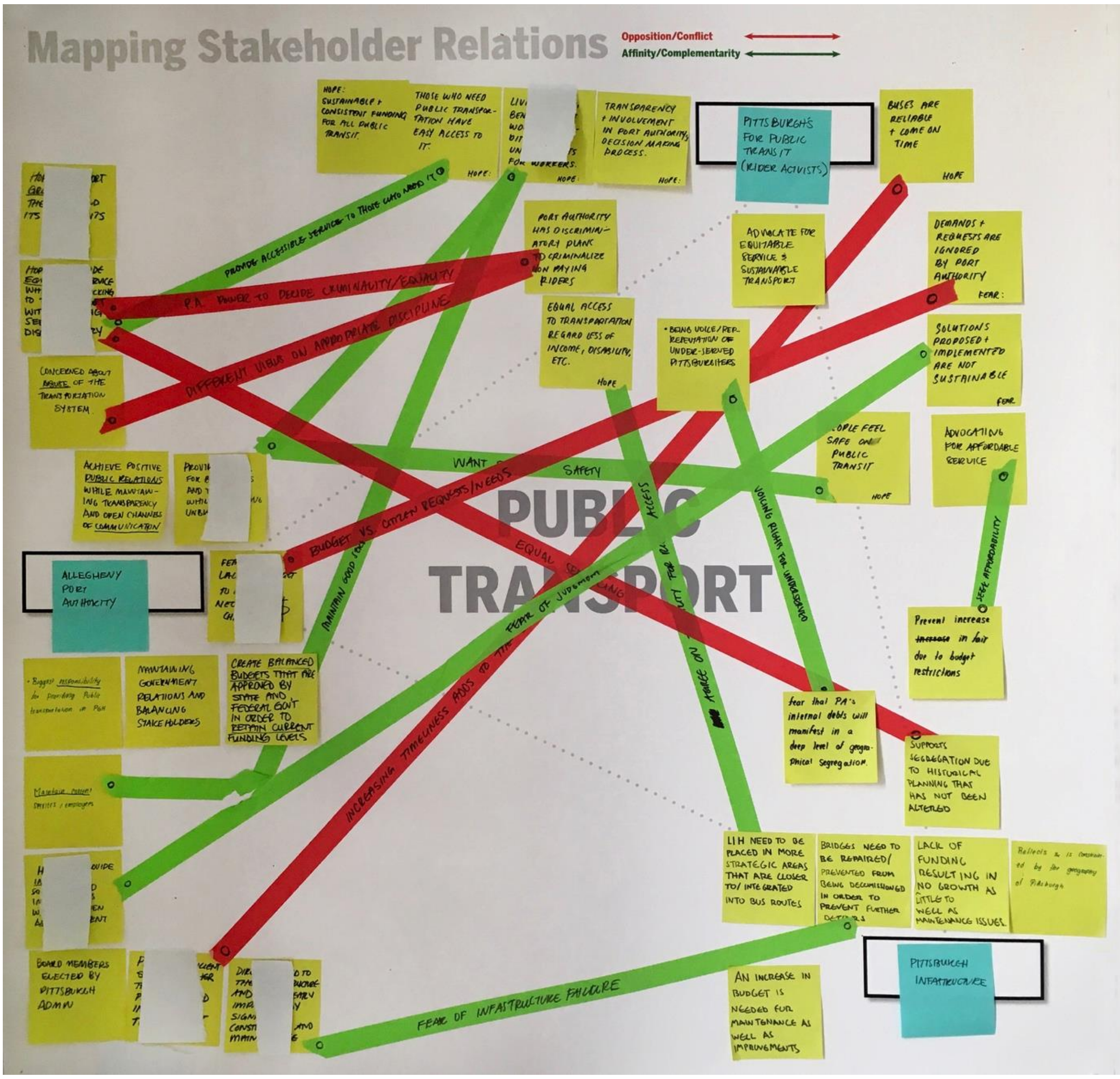


Figure 3. Students performed triad mapping, which revealed points of affinity and opposition among stakeholder groups, and the nature of their relationships.

2.3 Developing Visions

Defining short-, medium-, and long-term futures

In the next unit, the studio shifted attention to speculating futures as a means of exploring diverse ways of sense making. (Note that "futures" is plural because, in contrast to the singularly-defined past, futures do not yet exist and thus can take many different paths.) Informed by a method from course instructor Stuart Candy's dissertation (2010), students brainstormed the development of possible, probable, and preferable futures for Pittsburgh in 2050. We gave the students a template to help them frame the visions of futures in relation to the STEEP framework [social (S), technological (T), economical (Ec), environmental (En), and political (P)]. The eight teams were then grouped in four pairs and provided one of four lenses by which to view their futures; growth (progress continues), collapse (society comes apart), discipline (order is coordinated or imposed), and transform (a profound historical evolution occurs). The students then developed written scenarios that served as hypothetical histories. (Figure 4)

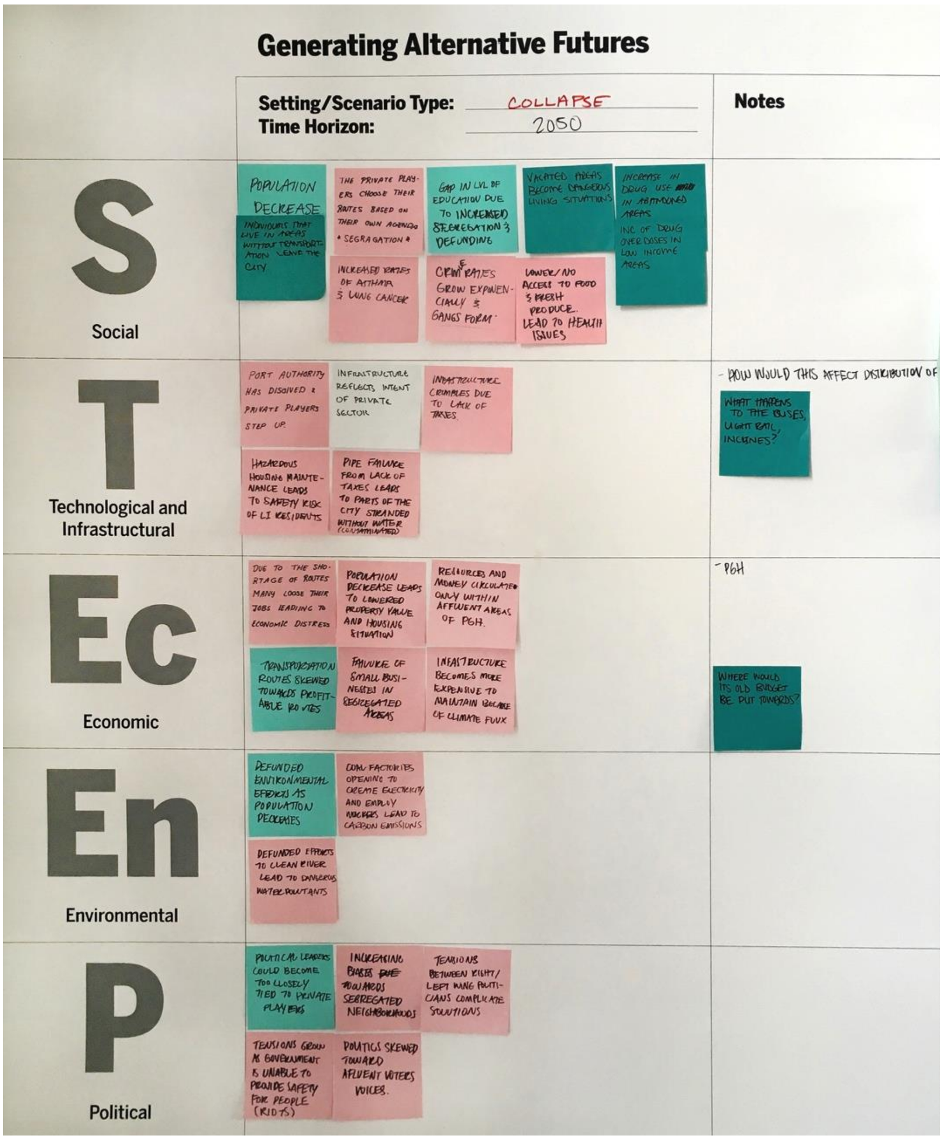


Figure 4. Students explored alternative futures by mapping social, technological, economical, environmental, and political issues through grow, collapse, discipline, and transform lenses.

In subsequent class sessions, students drilled down levels of scale to explore their futures in greater granularity and think more deeply about the scenarios they developed. Focusing specifically on their topics, the student teams collaboratively created a vision for the year 2050 in which the current problem they had been studying no longer exists. In this exercise, students were urged to consider granular aspects of the situation. The students again developed a written story to convey their ideas, with some teams designing objects and services in 2050 in support of their histories. (Figure 5) Next, we introduced students to “Seeing in Multiple Horizons: Connecting Futures to Strategy” (Curry & Hodgson, 2008) to shape their thinking of short-, medium-, and long-term change. The framework also strives to facilitate “cultural transformation and aid innovative exploration and wise action in the face of uncertainty and not-knowing” (Wahl, 2017). The framework presents three horizon lines that show the status quo, disruption to system possibilities, and a transformation toward regenerative culture. Wahl (2017) explains, “Three Horizons thinking offers a methodology and practice of seeing things from multiple perspectives and valuing the contribution that each perspective makes to the way we bring forth the world together.” The students applied the three horizons to define milestones along a timeline that lead to the vision they defined over a thirty-year period. Their textual/visual speculations served as the first steps in defining design opportunities situated within larger systems. (Figures 6 & 7)

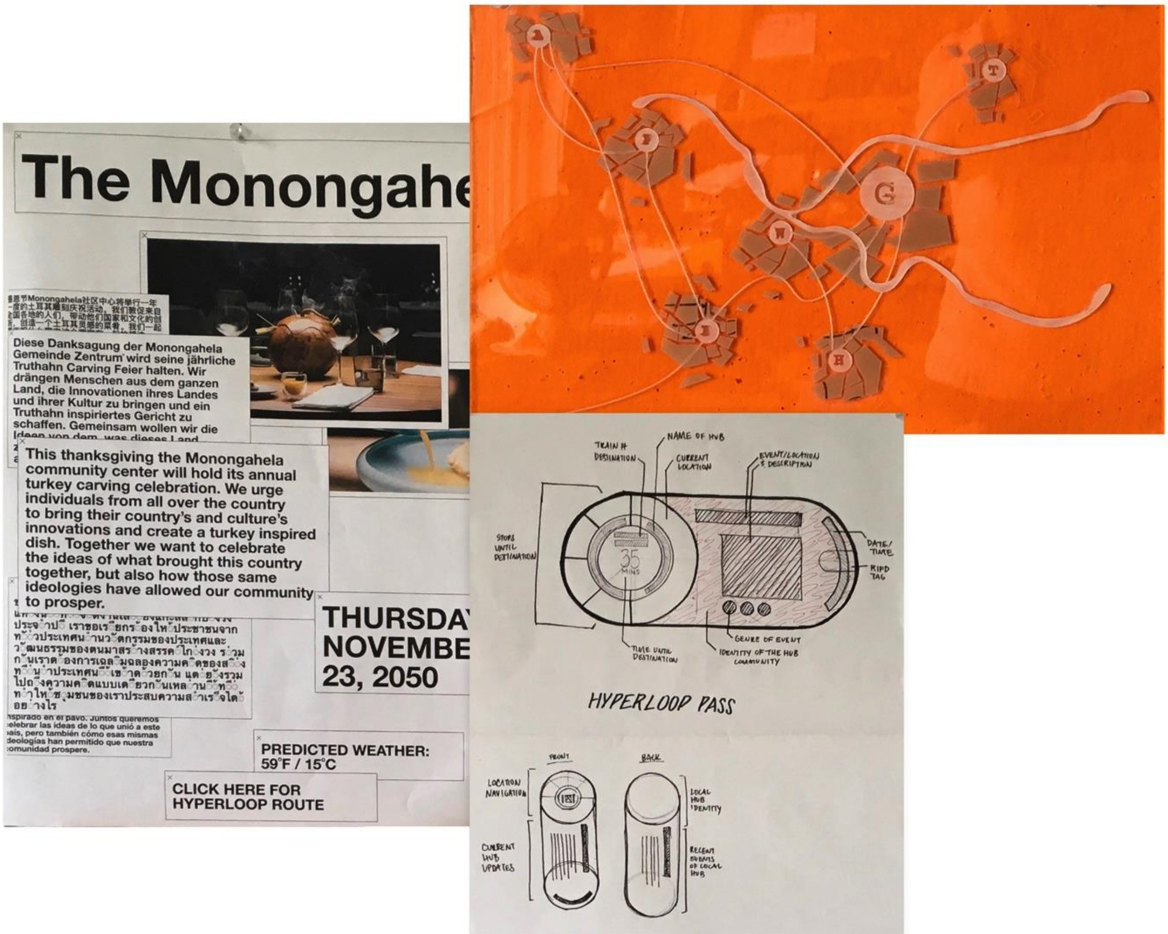


Figure 5. Students visualized designed objects and services that existed in their vision of 2050 as a means of clarifying their ideas and aiding their writing.

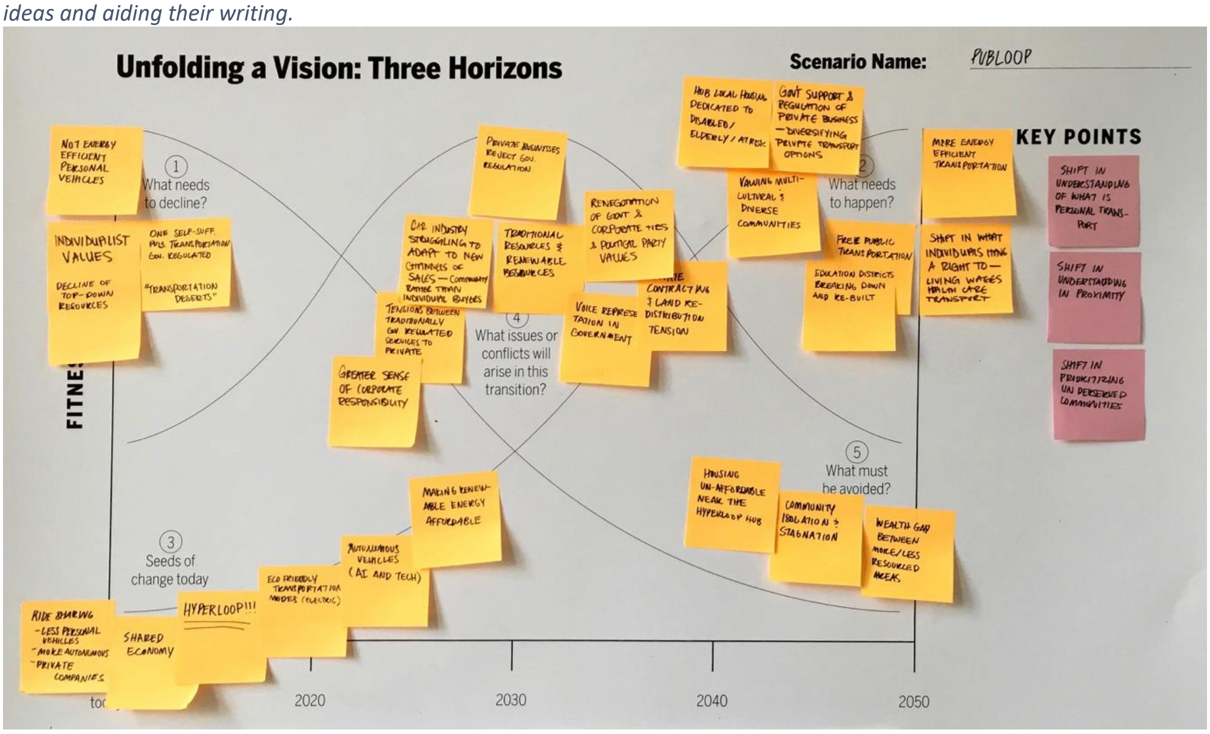


Figure 6. Students used the Three Horizons framework to see their ideas from multiple perspectives and identify the value of

each contribution.

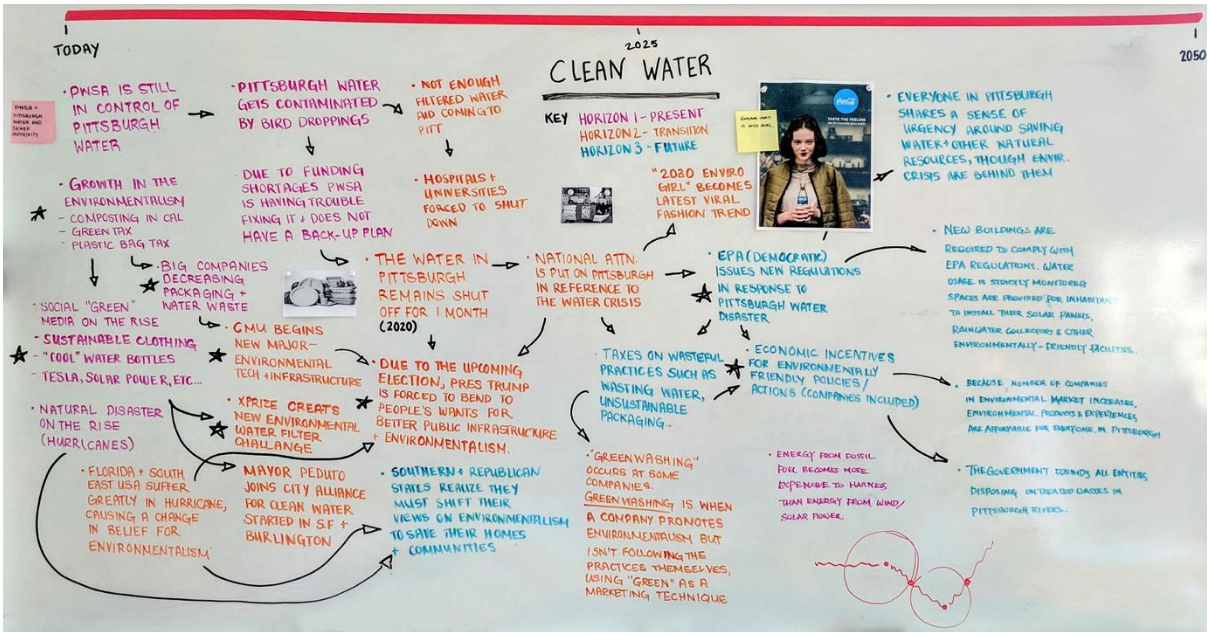
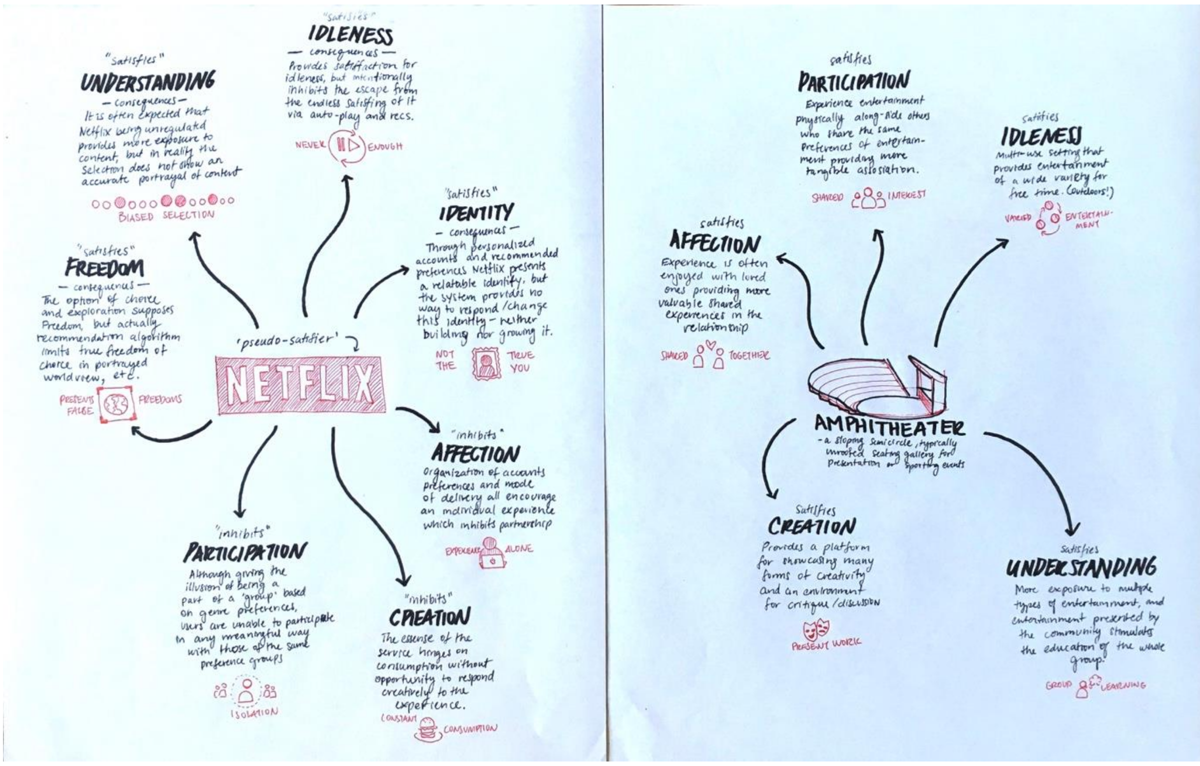


Figure 7. Students used the three horizons to define milestones along a timeline that lead to the vision they defined.

2.4 Exploring Theories of Change

Describing the Satisfaction of Human Needs through Design

In order to encourage the thoughtful design of products, communications, and environments, we used Chilean development economist Manfred Max-Neef's taxonomy of the classification of human needs (1991) to guide the students' progress. He argues that circumstances cause people to take action in response to a fundamental need, and that people are motivated by the same set of nine needs—subsistence, protection, affection, understanding, participation, idleness, creation, identity, and freedom—but the ways that they satisfy them are unique and infinite. It is important to note that not all satisfiers address needs in a sustainable manner. Some satisfiers address a single need, stimulate a false sense of satisfying, and/or inhibit satisfaction or destroy the possibility of satisfaction. Students used Max-Neef's taxonomy to study how the design of existing products, communications, environments and services satisfy or inhibit human needs. They defined and explored an object, environment, or service that they interact with often and another that they believed had few or no inhibiting satisfiers. (Figures 8, 9, & 10) In the class discussion that followed, students concluded that most examples designed by humans were void of inhibiting satisfiers.



Figures 8 & 9. Students investigated designed communications, products, environments, and services, learning how they satisfy or inhibit the satisfaction of human needs.

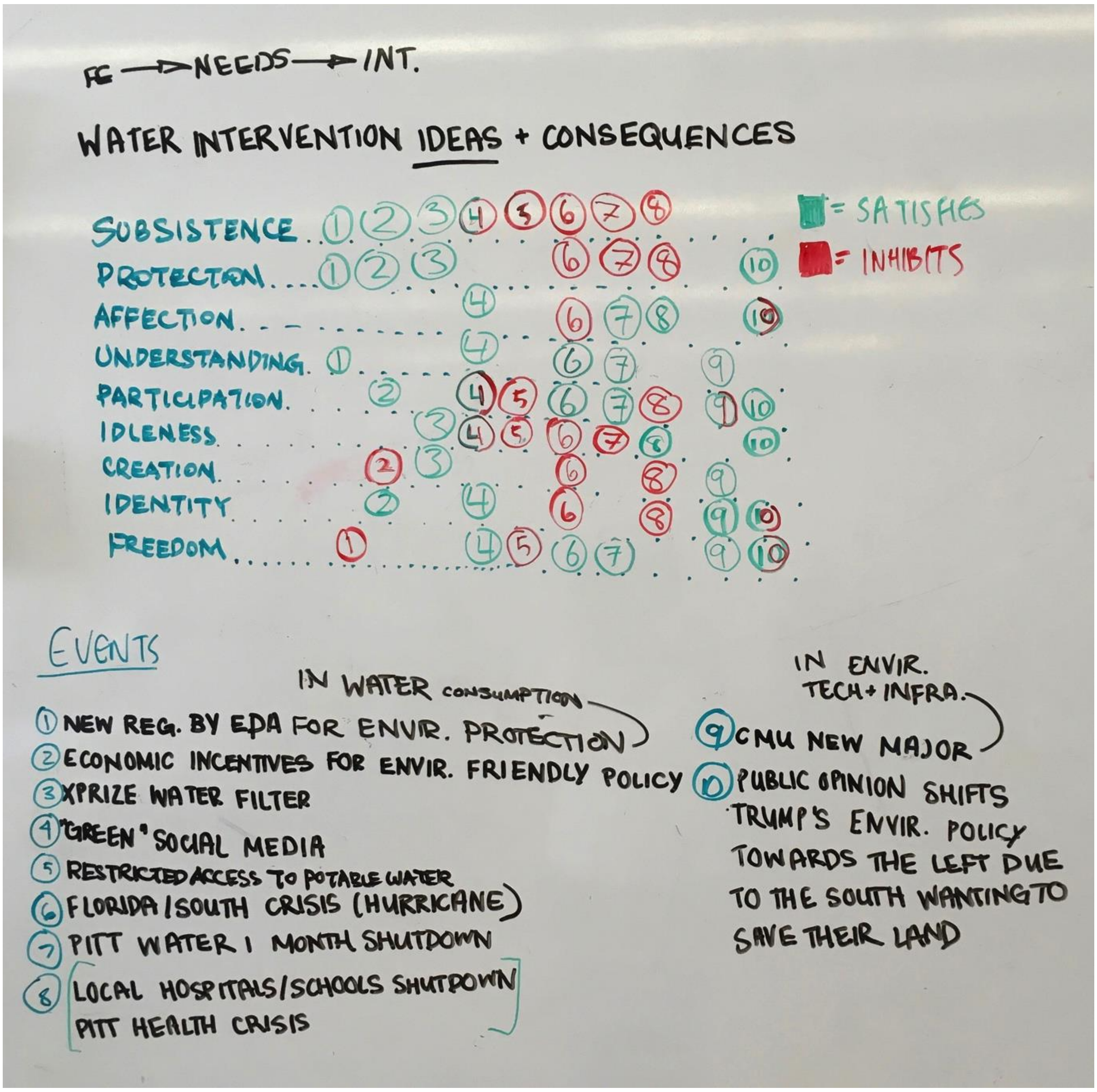


Figure 10. Students reviewed their ideas for possible design interventions, identifying how they satisfy or inhibit the satisfaction of human needs.

Once they had speculated futures and the human needs of relevant stakeholders and positioned them along a timeline, the students were poised to consider the role that lifestyles play in setting the context for an exploration of design interventions. Transition design posits that the examination of people's actions provides insight into how they satisfy their fundamental human needs. Students were asked to study the level of control that communities retain in satisfying their needs in the past and present day, examining possible tensions between centralized institutions and localized experience; as Kossoff, Tonkinwise, and Irwin argue, such transfers of control may have ecological, social, economic, and political effects (2015). Students were encouraged to consider the benefits of cosmopolitan localism, where communities are human-scaled and place-based in their activities, yet exchange information globally (Irwin, 2015). Students examined everyday life at various levels of scale as a means of understanding the relationships of community challenges, which helped them envision what sustainable communities in Pittsburgh might look like.

2.5 Defining Design Interventions

Proposing Opportunities for Design to Seed and Catalyse Systems-Level Change

We introduced students to service design and design for social innovation concepts in order to build on the transition design research that they conducted earlier in the semester and to aid their realization of design interventions in Pittsburgh. The students gained an understanding of the characteristics that define these areas of design focus and learned fundamental approaches that enable their practice.

Students explored the value of fostering relationships between customers and service providers to improve the quality of their interactions and the service that is rendered. Professor Molly Steenson, introduced service design concepts through a microscopic version of the Global Service Jam, in which students quickly brainstormed service scenarios and prototyped concepts for presentation to the class. (Figure 11)

Figure 11. Students quickly brainstormed service scenarios and prototyped concepts for presentation to the class.

The following week, students explored design for social innovation with Cheryl Dahle, a distinguished adjunct of professional practice with the School of Design. As Phills, Jr., Deiglmeier, & Miller write in an article Dahle introduced to the class, “A novel solution to a social problem that is more effective, efficient, sustainable, or just than existing solutions and for which the value created accrues primarily to society as a whole rather than private individuals” (2008). Dahle presented a range of relevant businesses, services, and products, such as fair trade and a human-powered washing machine, as well as a social innovation case study that focused on the fisheries in Indonesia.

In the studio, we frame such social innovation interventions as components of transition design because collectively, they can lead to longer-term systems change. To that end, Dahle provided students with a four-quadrant framework aimed at helping them define the projected outcomes of intervention proposals. One axis focused on the scale of impact, while the other mapped the complexity of the concept. The students then used the Social Design Pathways to "see that broad terrain; to identify the skills required for action; to identify the kinds of partners needed for success; to preview the scales of engagement; and to foresee the possible impacts of social design projects" (2017). In this framework, one axis focused on the scale of engagement, while the other asked students to consider the range of expertise of parties involved. (Figure 12)

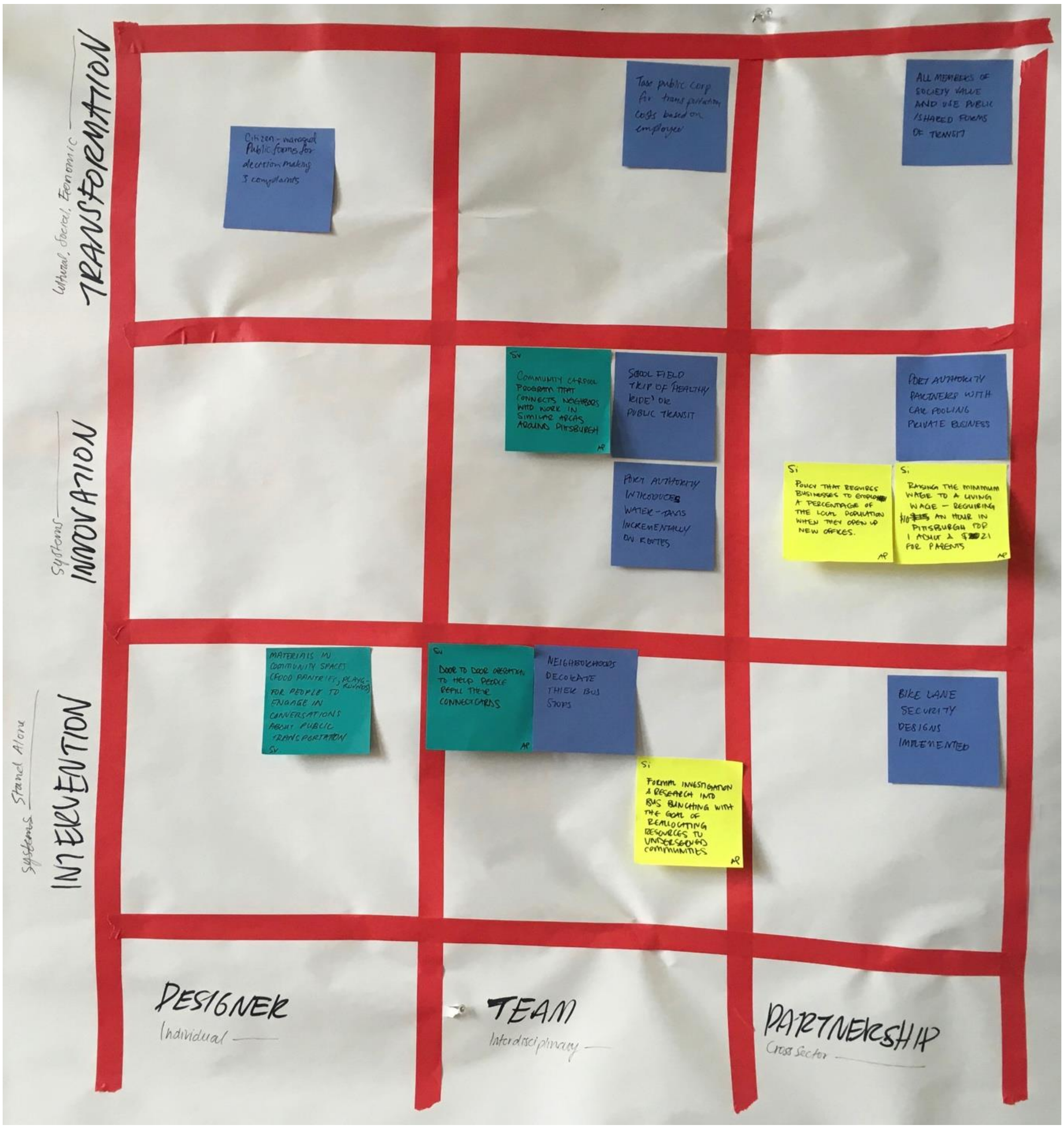


Figure 12. Students used the Social Design Pathways framework to foresee the possible impacts of their intervention ideas, identify scales of engagement, and propose partners.

Once the topic-based student teams had brainstormed design interventions through service design and design for social innovation lenses (Figure 13) that aligned to the futures timelines they created, we prompted them bring their ideas to fruition. Each team developed six intervention ideas that they believed had merit. Next, every student noted a few of the concepts that they wanted to explore for the remainder of the term. The entire class then perused the ideas and interests of their peers and mapped possible connections between them. This step illuminated inherent relationships and opened doors for collaboration among the students. We then prompted the class cohort to engage in conversations that led them to reconfigure themselves into new teams of three to five students. The newly formed groups proposed ways of addressing obstacles they identified by using existing resources and leveraging the collective knowledge and skills they gained the first half of the term. Throughout the next six weeks, each student team selected and developed one intervention as a hypothesis that they used to receive school-wide feedback at the close of the semester. (Figure 14)

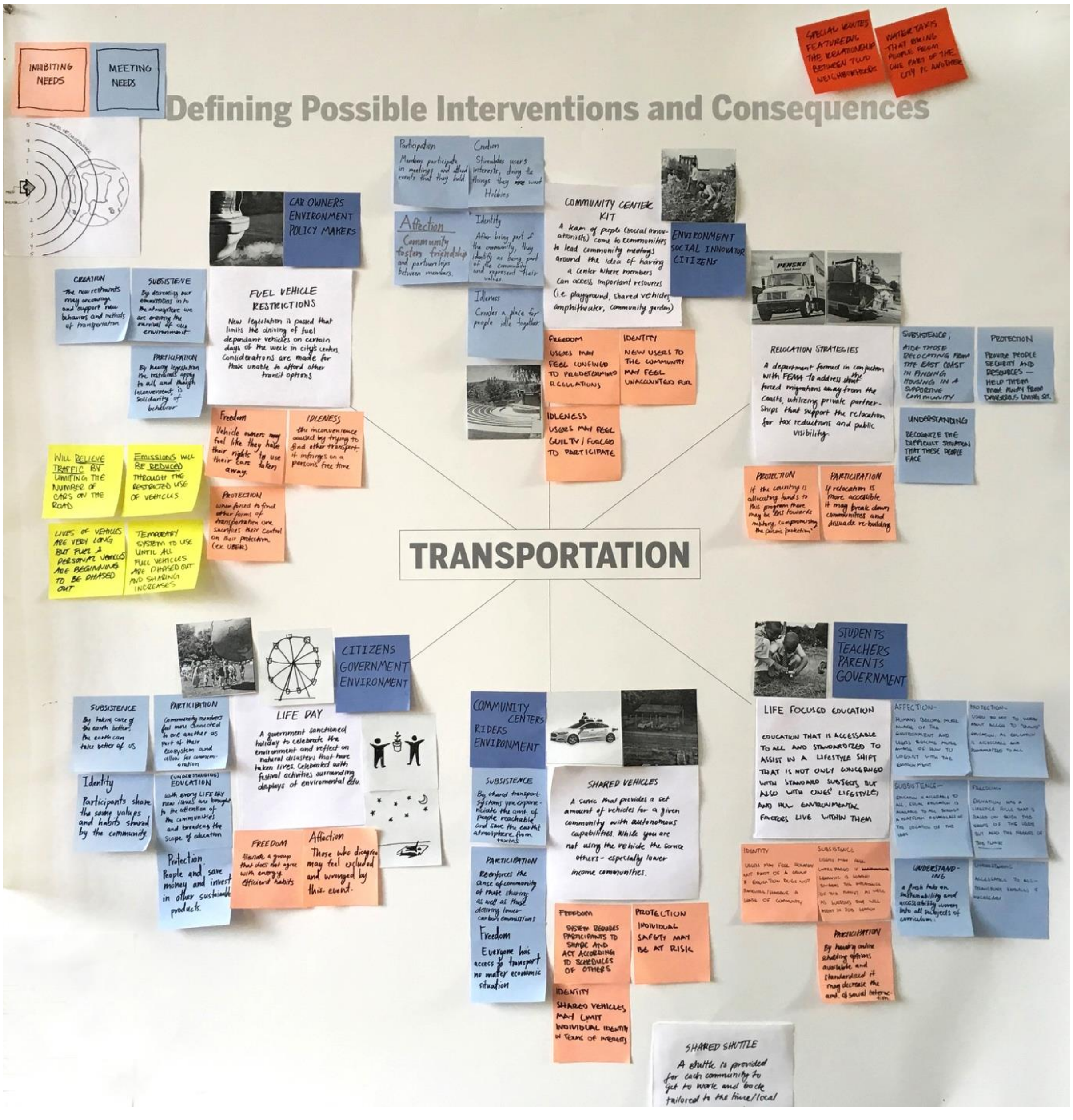


Figure 13. Students map their service design and design for social innovation intervention ideas that they believe have significant merit, in concert.

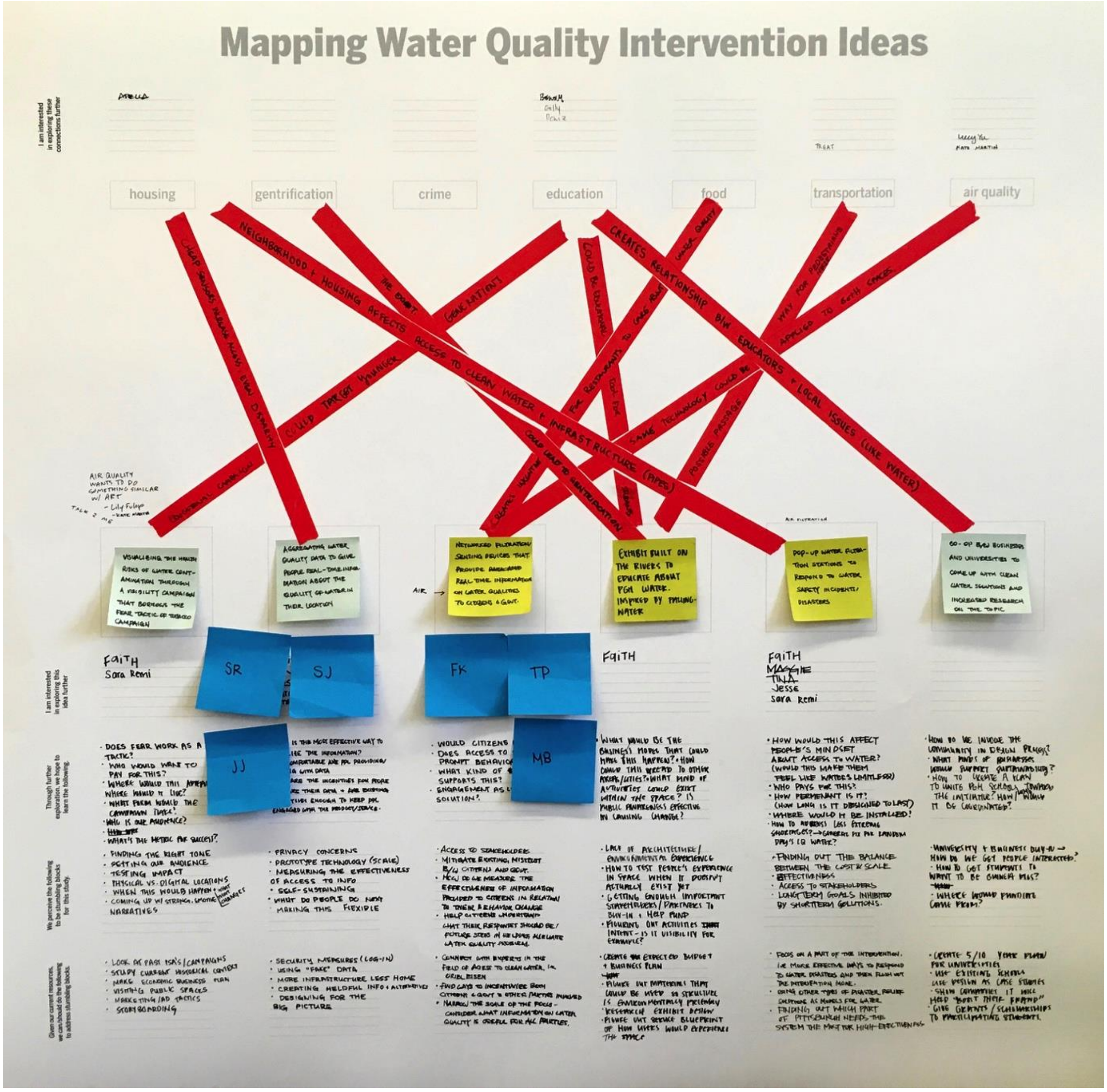


Figure 14. Student teams mapped possible connections between their intervention ideas and the other topics being investigated by their classmates, articulated research questions, and proposed plans for working through known obstacles.

3 Evaluation

As a means of evaluating the effectiveness of our approach, we observed students as they worked, paid close attention to their team conversations and working processes, and reviewed the outcomes of their efforts. We noted our findings and compared them to the learning goals we established at the start of the course. The successes and challenges we identified are based on this assessment. Although some of our discoveries may be evidenced in design education at large, we believe the set we present is particularly important to the teaching of transition design. These sections are followed by opportunities for improvement, which reflect the lessons we learned by teaching the course.

4 Successes

Transition design requires students to consider the broad ramifications that result from their actions. Few students were prepared to explore the vast impact design can hold or immerse themselves in a process where outcomes are unknown at the onset. Nonetheless, the students demonstrated significant growth in these areas throughout the term. Our interactions with them highlighted successes in our approach to teaching transition design in the context of the Design Research Studio.

4.1 Students grasped the facets of wicked problems and explored how to enter them

When students started to understand that wicked problems are systems problems residing within other systems, they began to shift their thinking from solving small-scale, immediate problems to seeing relationships among their topics at various levels of scale. Through mapping and diagramming exercises, students demonstrated confidence in defining and tackling manageable facets of wicked problems rather than simply becoming overwhelmed and paralyzed by their magnitude. They also learned to distinguish consequences of wicked problems by tracing their root causes through deeper levels of the systems. By starting the course with systems-thinking discussions and activities, we were able to lead students to alter their views of local challenges and propose appropriate ways of intervening. A quote popularly attributed to Albert Einstein states, "No problem can be solved by the same kind of thinking that created it." Given that systems are so ubiquitous that they often go unnoticed, the curriculum helped students identify nested systems—a capability critical to the study and practice of transition design.

4.2 Students recognized the importance of stakeholders in the transition design process

Although this task proved to be difficult, the students began to indicate awareness for the connectedness of their topics and stakeholders, an appreciation for the complexity of the challenges they studied, and a cognizance of how little they knew about their stakeholder groups. Course activities caused the students to recognize pitfalls in stereotyping stakeholders and the importance of working directly with stakeholder groups. (See the Opportunities for Improvements section for further discussion.)

4.3 Students created visions of futures that informed their design actions in the present

After participating in several sessions that focused on envisioning futures, the students exhibited strength in working in a state of uncertainty. Course activities taught them how to toggle between short- and long-term thinking and the longstanding consequences of what they design. As a result, students showed mindfulness for futures when intervening in the present. They also noted that the design studies courses that they had taken in the past, which focused on cultures, systems, and futures, prepared them for speculative design and aided their learning of transition design.

4.4 Students learned the value of satisfying the needs of all living things through design

Given that class activities and discussions included mindfulness for all living things, students intuitively adopted a living-centered, rather than human-centered approach for design. In fact, when introduced to Manfred Max-Neef's categorization of human needs (1991), students promptly pushed back, explaining the framework's lack of inclusiveness relative to all living things. Nonetheless, his theory served as a tool that helped students understand how design satisfies or inhibits a range of human needs. Through their analysis and proposal of designed products, communications, environments, and services, students also illustrated a realization of the value of helping communities control the satisfaction of their human needs at a local level.

4.5 Students assembled a toolkit that aids their own proposals for design interventions

In order to move beyond theoretical discussions of large, long-term systems change, we prompted students to take the methods and approaches that they learned throughout the course and apply them to contemporary design interventions. Instead of seeing such design challenges as insurmountable, which is what many students expressed at the start of the semester, they demonstrated that they could articulate the characteristics of specific situations and suggest appropriate methods and tools to investigate known problems. They exhibited confidence and agility in tackling ambiguous challenges rooted in service design and design for social innovation that reside within the larger umbrella of transition design. Early evidence shows that some groups are applying this knowledge to projects that they're currently conducting in the subsequent semester.

4.6 Students developed a mindfulness for their actions and experienced a mindset shift

After several weeks of intense work sessions with their group of peers, students described, practiced, and advocated collaboration as a critical component of transition design. Although the process was vastly different than what they experienced in the past, the students indicated an understanding of the value of designing a series of "interventions" over a long period of time instead of "solutions" that existed solely in the present. Their approaches often took a "less is more" approach to design, illustrating a soft hand in intervening. By the middle of the term, students were able to describe the potential impact design could have in seeding and catalysing positive change in the world and accepted important responsibilities in leading these efforts.

5 Challenges

Given that Fall 2017 marked the first delivery of the Design Research Studio, the instructors had spent several months prior to the term carefully planning the course. Nonetheless, its curriculum was based on lessons learned through the development of transition design theories, workshops, and a graduate seminar course. The differences in the course structure, its duration, and the nature of the cohort caused new challenges to arise for us to address.

5.1 Deciding not to work with stakeholders in context revealed significant challenges

Working with stakeholders and users is a means to question the designer's own bias and cultivate an understanding of others' concerns and aspirations, something that students recognized early in the course. At the same time, we believe as instructors that we have an ethical responsibility to do no harm. In design education, information is often gathered from stakeholders in local communities for short-term studies that are often devoid of symbiotic exchange—a situation that we did not want to support. This approach to research runs the risk of causing participants to become disenfranchised with the process as their engagement fails to lead to improvements in their communities due to the short duration of projects. However, this decision led to challenges in the classroom. Although some students observed stakeholders in context and took the initiative to meet with experts on their topics, several of them struggled to work within what they identified as a hypothetical context. They expressed a discomfort in basing design proposals on the limited information they gathered about stakeholders and sought to validate or negate their design interventions in realistic settings.

5.2 The course sometimes failed to situate students' learning within a broad and critical design context

Although students stated an appreciation for the content of the course, they explained the difficulty in it covering a range of approaches and methods. The students gained exposure to an array of topics that are critical to the study and practice of transition design. However, the course lacked ample time to frequently engage students in conversations that aided their deep understanding of the topics covered. As a result, the students expressed a frustration in not fully grasping the relevance of the course content to their immediate practice of design.

Many class sessions consisted of short lectures and discussions, followed by exercises that aimed to solidify students' learning of course concepts. Although the fast-paced nature of the format enabled us to cover a lot of information and sustain student engagement, it also caused them to sometimes lose sight of the big picture because we did not continually situate their incremental knowledge and skill acquisition in a larger context grounded in transition design. This is a challenge that designers and educators of service design face when moving between large contexts and small details.

The students also noted an appreciation for specific approaches introduced in the course but questioned how opposing theories may function. They sought comparisons that would prevent them from making ill-informed design decisions. Given the short duration of the course and the amount of information we aimed to cover, we chose to narrow the amount of content that we provided the students in order to avoid overwhelming them. However, in future deliveries of the course, we will find ways to include additional source material to address this concern.

5.3 Students struggled to adopt behaviours that did not align with their prior experiences

The senior cohort had participated in courses that encouraged them to learn and apply specific design approaches to clearly defined design problems. In contrast, the Design Research Studio asked students to consider a range of design theories and develop hypotheses for effective courses of action. Although common at the graduate level, this form of inquiry was foreign to the senior cohort. The inability to align current and prior design education experiences caused the students to have difficulty grasping the relevance of course activities.

Similarly, students spent most of the first half of the term working in teams of six on mapping and diagramming tasks that aimed to aid their understanding and practice of transition design. Several students expressed a frustration in the lack of making that took place in the course, which negatively impacted their motivation to fully engage in activities. This observation indicated students' narrow definition of making in design, as we had believed that all of the activities that they performed were a form of making common in design practice.

Lastly, although the students were able to grasp the fundamentals of service design and design for social innovation relatively easily, applying the methods that we practiced in class using small-scale challenges to their transition design work that focused on wicked problems situated in Pittsburgh, proved to be difficult. The students seemed conflicted in maintaining the mind-set that their work should solve an immediate problem versus shifting their view of design to planting seeds that catalyse systems-level change over a long period of time. We continually discussed their stumbling blocks and referred to their work as interventions to help them adopt a design posture and mind-set that facilitates effective work in transition design.

6 Opportunities for Improvement

As we taught the Design Research Studio, we made small shifts to the course each week. We believe that it was critical for these shifts to take place and for us to share them with the students to demonstrate the importance of being agile, empathetic, responsive, and transparent when working in transition design. Nonetheless, some challenges were too large for us to address immediately. Therefore, we recorded ideas for overcoming obstacles in future manifestations of the course.

6.1 Explicitly seed transition design approaches earlier in the undergraduate curriculum

We believe it would be beneficial for design courses that precede the Design Research Studio to further highlight approaches that are relevant to transition design as a means of aiding students' deep dive into the topic during their senior year. For example, drawing students' attention to collaborative mapping as a form of making and describing the benefits of designing as a means of speculating rather than solving problems would help students adopt the mind-set and posture that is pertinent to the study and practice of transition design. Similarly, students noted the benefits of design studies courses that they had taken in prior years, which focused on cultures, systems, and futures, in aiding their current thinking in transition design. If we seed some transition design tools and methods earlier, students will be more familiar with them their senior year.

6.2 Build a comprehensive repository of materials in transition design
Several times throughout the course, we realized the importance of providing students with a range of readings relevant to the course content. In an attempt to not overwhelm the students, we introduced them to a few texts each week. However, as the term progressed, we discovered that the modest sampling failed to introduce students to a diverse set of perspectives, which we deem to be a critical component of thoughtful inquiry and debate. In the future, we plan to give students a list of required and recommended readings that include short descriptions of how they relate to each another. The nature of course activities also highlighted a need for case studies situated in the context of transition design, service design, and design for social innovation. We anticipate that these readings will help students understand the application of the theories we discuss, describe the characteristics of each area of design focus, and guide them through similar processes.

6.3 Gather a body of data on local transition design topic stakeholders for future study
Adhering to the ethical obligation to do no harm in communities by not taking advantage of stakeholders for research purposes, we sought alternative ways of providing students with pertinent information. In looking to practices in the field, we found that anthropologists often gather information from a large sampling of stakeholders that designers then use to inform the direction of their interventions. Although working directly with stakeholders creates a level of empathy that cannot be achieved by reviewing interview transcripts or field studies, this approach would give students a broad sampling of stakeholder input that they could not achieve by working with a few members of stakeholder groups. As a result, for subsequent deliveries of the course, we plan to build a body of data that students can use to ground their projects.

6.4 Continually connect course content to a broader context and practice of design
Despite having visualized the course as a set of interconnected elements, we inadvertently focused the students' attention on immediate tasks in subsequent sessions without reference to how they were situated within the broader context of transition design. As a result, students struggled to see the relevance of tasks and the connections among them. We will plan to build time for discussing and visualizing the connectedness of course content into the curriculum. Moreover, although we ask students to reflect on course activities and write about their thoughts, we believe students would benefit from well-articulated prompts that direct their attention and aid their development of a mental model for the course content.

7 Teaching and Learning Transition Design: Some Conclusions
Given that transition design is in its infancy, we are developing curricula based on emerging theories, borrowing relevant approaches from other disciplines, and learning while doing. Although we have outlined practices that we found effective and described discoveries we made, many questions have arisen that we believe serve as opportunities for improving transition design curricula.

7.1 See teaching and learning about transition design as a set of feedback loops
Our students have provided us with insights regarding the teaching of transition design that we had not foreseen. While some of their feedback reveals an anxiety for a new way of studying and practicing design, many of their comments describe successes or challenges in working with specific frameworks and obstacles they encounter when working with different teams of people for varying amounts of time. We believe it is critical to build opportunities for feedback loops in educational settings to aid the critical review of teaching approaches and inform appropriate revisions.

7.2 Create new tools for transition design practice
We have utilized approaches developed by adjacent disciplines that hold potential in aiding the teaching, practice, and research of transition design. Nonetheless, the application of many of these

methods indicates that although they hold merit, they require improvements to function effectively. Our students have identified problems with existing frameworks and are brainstorming ways of re-envisioning them to make them highly appropriate and useful to the tasks they encounter in transition design.

7.3 Develop ethical approaches for teaching transition design

The issue of ethical engagement with the public remains at the forefront of curricular discussions. Wicked problems are symptoms of other problems, and to engage in any aspect of them is to intercede in the problem itself, which produces an ethical dilemma for teaching. Do we use a hypothetical context to teach students methods void of interaction with stakeholders or do we strive to build relationships with community groups without knowing if the development of a long-term relationship is realizable? Both approaches are problematic. There is a need for new approaches that help students understand the contexts of transition design in which they are working that are effective and ethical.

7.4 Seed and catalyse systems-level change through all areas of design

Despite the challenges we encounter in developing teaching of transition design, we believe the integration of this new form of design is critical to the success of our students as they embark on lifelong careers in various areas of design. For our undergraduate students, the practice of transition design may seem unrelated to their post-undergraduate careers that often focus on designing products, communications, and environments. Nonetheless, we are confident that by exposing them to longer design futures, we are teaching them to be mindful about the long-term consequences of their actions as designers and the materials that they use.

8 Summary

In summary, we seek to educate the next generation of designers in a manner that empowers them to seed and catalyse positive systems-level change in design. In this paper, we outlined our endeavours in the context of an undergraduate design research studio, offered evidence of our successes and challenges, and interweaved our own reflections on this process. The activity of teaching and learning as a symbiotic process has facilitated a shift in our own mindset and posture as designers, educators, and researchers.

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Identifying the User in an Informal Trade Ecosystem

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doi: 10.21606/dma.2018.674

How do we identify the right target beneficiaries within an informal economic ecosystem for development interventions designed to maximize benefits and value for money? This was our initial research question when we conceived the human-centred design research program for exploratory fieldwork to map informal trade in the borderland of Kenya and Uganda. This paper narrates our discovery process and analytical journey identifying a previously unknown segment of micro-entrepreneurs whose business practices lead to the organic development of an economic microsystem - a "value web" or established network of customers, suppliers, and service providers. The individual actors in these microsystems collectively form a value creation engine which we identify as the target beneficiary or end-user, for the design of interventions meant to trigger progressively transformational change in the borderland's informal trade ecosystem. We describe the factors leading to our decision to consider the value creator's entire value web as the end-user, rather than the individuals at the heart of each such microsystem, for optimal outcome of systemic design interventions.

systemic design, complexity studies, design research methodology, informal economy

1 Introduction

Traditionally, beneficiaries of international development programme design have been conceptualized as the passive recipients of charity, with little or no agency. With the shift in thinking from aid to trade, there needs to be a concurrent shift in the way we frame the concept of the end-user or beneficiary when we design such programmes. (Doorneweert & Bhan, 2013) Trade implies an exchange of value between two or more parties, rather than the one-way transfer of value from a donor to a beneficiary. Thus, end-users in a trading economy must necessarily be recognized as active agents of value creation within their commercial ecosystems.

Approaching exploratory user research to map the last mile of the farm to fork value chain for subsistence farmers in East Africa in 2013 from this perspective, we discovered that agricultural trade networks did not in fact resemble the textbook diagrams (Figure 1) used to illustrate the ecosystem.

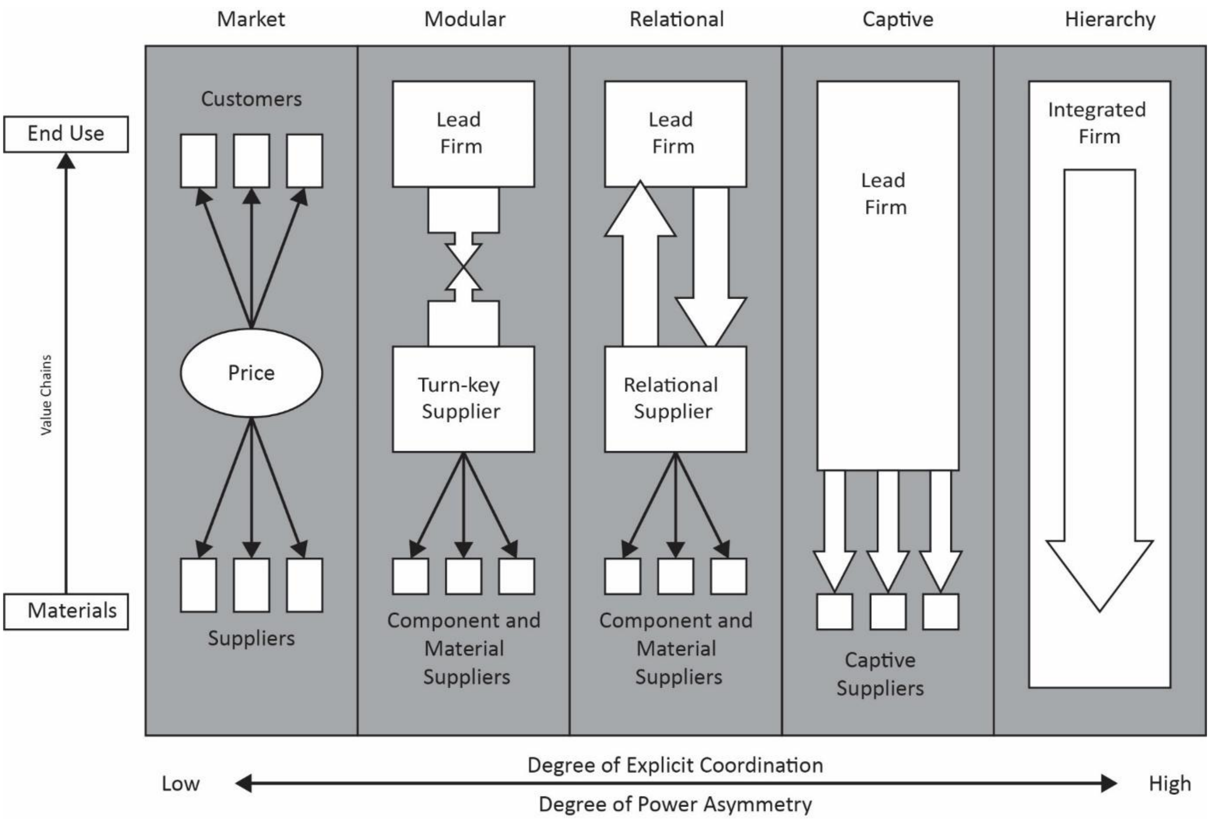

Figure 1 Five global value chain governance types (Gereffi, Humphrey, & Sturgeon et al., 2005)

> *Textbooks present orderly abstracted value chain models, also referred to as governance configurations, diagrammed in a manner that implies linear progression and a high degree of specialisation. The Kenyan 'farmer market' was not just a neat box in the formal structure of a value chain, but a flexible, multipurpose node in the rural economy's complex web of human interaction and exchange of goods, services and knowledge. The classic, orderly pattern of exchange in value chain form, based on assumptions of a structured, formal hierarchy of power residing downstream, does not, in fact, appear to exist. (Doorneweert, Bhan, Kimunyu, & Esko 2013, pg 12)*

That is, what we were seeing were all the signs of a complex adaptive system. (Barder, 2011) Although this economic sector in developing countries is categorized as "informal" (Hart, 1973) implying an ad-hoc or casual contrivance, these flexible, multi-purpose nodes were, in fact, value webs with indigenous forms of structure and organization organically evolving in response to market conditions.

> *This discovery signalled to us that instead of rushing to design new tools or solutions to enable farmers to bridge the last mile of the agricultural value chain, we needed to take a step back in order to better understand the existing situation linking the harvest in the field to the customer who purchases it. It underscores our recommendation for comprehensive exploratory user research in this last mile, and the need to first uncover and understand all the ways by which information flows through the ecosystem (Doorneweert, et al., pg 13)*

These discoveries subsequently informed our approach for framing the systemic design challenge and identifying target beneficiaries for pilot interventions aimed at social and economic development through increased trade.

> *Prior work in the last mile of the agricultural development value chain in rural Kenya has shown us that the linkages between activities and actors are not as linear nor as clearly*

> *demarcated as textbook diagrams make them out to be. There is a complex value web of relationships and transactions - value flows such as information on supply and demand; exchanges of goods and services; as well as fiat currency and currency equivalents - that take place in the social and economic ecosystem. Given the relationships between markets and the known proportions of agricultural produce being traded in the region, we believe that a similar value web exists at the borderland. This will be our starting point to anchor our exploratory user research. (Bhan & Gajera, 2015)*

Thus we began ethnographic fieldwork at the border of Kenya and Uganda to understand this phenomenon of the value web as the key node within the entire trading ecosystem. What we discovered throws open the entire field of understanding complex adaptive systems that are the target of international development programming (Ramalingam, Laric, & Primrose., 2014; Green, 2015).

While our fieldwork confirmed that there were indeed such value creating nodes in the ecosystem, we discovered that targeting them as individuals would not be sufficient for enabling progressive transformation through the design of interventions. We believe, for systemic impact, it is essential to include our users' entire economic microsystem as the focus for our intervention design in order to maximize the impact and benefits of the conceptualized borderland program - that is, we need to expand the scope of the user for our design process from the individual to the group. Below we describe our journey of discovery.

2 Scope and Methodology

The borderlands of the East African Community (EAC) are important for the trade and development sectors, as cross-border trade is a critical part of the region’s food security system. Further, women make up more than 70% of the region's informal cross-border trade (UNIFEM, 2009), and tend to head the more economically vulnerable households. We were requested to discover and map the dynamics of informal trade for TradeMark East Africa (TMEA), a non-profit company whose mandate is to boost trade facilitation and business competitiveness in the EAC. Their objective was to discover how to position themselves to develop structured programmes aimed at growing and formalising informal trade in tandem with their objectives of inclusive, sustainable prosperity through increased trade (TMEA, 2015).

The outcome was intended to be custom-designed programme interventions for beneficial transformation of the borderland’s informal trade ecosystem, within the guidelines of value for money (HM Treasury, 2004). The deliverables of the project included developing a robust methodology for borderland ecosystem mapping across the EAC. Thus, our design research task was two-fold:

1. We had to apply ethnography and human-centred design methods for exploration and discovery of the dynamics of the informal trade ecosystem, and identify the end users for whom we would conceptualize designs for pilot interventions.
2. And, simultaneously, we had to abstract enough understanding of these dynamics in order to generalize the ecosystem frameworks towards developing a robust qualitative methodology to cost- effectively map more such borderlands.

3 Approach to Framing the Problem

Cognizant of the fact that this study would break new ground by mapping the informal trade sector as an ecosystem in its own right, we scoped the boundaries of our study in such a manner as to provide flexibility for exploration and discovery while constraining the content for greater clarity. We had to combine the need for qualitative insights with the concurrent need to develop and iterate design research methods and tools in-situ.

We see the borderland as an ecosystem in its own right, distinct from the more agriculture dominated economy across rural East Africa, with greater emphasis on trade and services. The vast majority of this activity falls within the informal sector, as is the case with the bulk of the region's economy. Considering it an ecosystem allows us to take a holistic view rather than narrowing our focus on a particular demographic or specific activity. We step back from the details to take a broader view of the entire operating environment of the borderland economy.

Our second decision was to step back from the labels of informal economy and informal trade with all their contradictory definitions, categorization, and implications of illegality to consider only what is colloquially known as biashara. The Swahili word biashara can mean business, commerce, trade, the business enterprise itself as well as barter. This allows us to cover a far greater range of activities being conducted at the border than just the conventional meaning of the English word "trade". At the same time, it excludes the tax evasion by formal firms or other illicit activities at the border, since these are not considered biashara per se. (Bhan & Gajera, 2015)

We structured our initial discovery process to run both primary and secondary research in parallel, dividing ownership between each author and maintaining close communication in order to ground the findings from the field firmly in the context of the insights from literature review, and vice versa. Further, we paused for an internal midpoint review and analysis to frame our final round of fieldwork after the first two short rounds of immersion.

This means that our narrative thread of logical progression of insights shared below may not always follow a simple, linear path and may repeat points as we alternated back and forth between lines of enquiry and modes of research.

3.1 Framing the Context of the Operating Environment

For the purpose of framing the context for prototyping the research protocol as well as to understand the landscape of current thinking on both the informal economy in East Africa as well as the informal trade sector whilst maintaining a gender lens, we undertook a rigorous literature review (Bhan, 2016) that went back twenty years to the very first cross-border trade research and methodology explorations (Ackello-Ogutu, 1996). The geographic scope covered the East African Community (Kenya, Uganda, Tanzania, Rwanda, Burundi and South Sudan), and the Democratic Republic of the Congo. The thematic scope covered the informal economy (Hart, 1973; Chen, 2007), the informal cross-border trade in the region (Little, 2007; Ackello-Ogutu, 1996; Titeca & Kimanuka, 2012), the concept of a borderland economy (Khadiagala, 2010) as well as women in trade (UNIFEM, 2009; Spring 2009) and the final synthesis included just over 60 papers.

This review shed light on a number of unsubstantiated assumptions being perpetuated over the years, and acting as barriers to development, such as the conflation of unrecorded trade with the illicit or illegal. Women traders have borne the weight of the consequences of these assumptions. According to UNIFEM (2009) over 70% of all cross-border trader in Africa are women, and they face frequent and periodic harassment and abuse (Friedrich Ebert Stiftung & the Collaborative Centre for Gender and Development, 2006), often accompanied by official confiscation of their goods with the concomitant loss of income that implied.

Further, there was no regulatory recognition of either retail or wholesale trade as a profession or full-time occupation, nor were there any attempts at segmentation of these women traders by any commercially relevant attribute. All were lumped together as livelihood actors struggling to sell their produce by the side of the road. Informal cross-border traders (ICBT) were thus portrayed as economically vulnerable women on the margins of society, and new studies, relying as they did on previously recorded data, continued to perpetuate this stereotype with each new report.

Our challenge was that Women in Trade programmes were currently being designed targeting the *assumed* needs of this stereotypical beneficiary, rather than the real world needs of actual traders. Initial reports from the first field survey made it clear that not only did this stereotype need to be unpacked with better qualitative analysis but a more up-to-date representation of the “woman informal cross-border trader” was required to be synthesized with tangible evidence from the field.

Across the board, the literature spent far more time focusing on the definitions of the informal economy, the informal trade sector, and various degrees of legality, than on the human actors themselves. There was no recognition of their agency in developing regional business networks (Walther, 2015) and supply chains for cross-border and regional trade. Keen to shift emphasis back to the user, we reframed the entire context of informal trade as “biashara” – the Swahili word for commerce and trade, as opposed to “magendo” - the Swahili word for contraband and smuggling. This released our research resources to focus on the people themselves that made up the borderland economy.

These findings broadened the focus of our first fieldwork immersion to be more inclusive. Our aim was to widen the range of data points to assist us in mapping the informal trade ecosystem, as well as identify participants for the subsequent in-depth ethnographic study.

3.2 Discovery Driven Design Research Methodology

We took a systems’ thinking approach (Jones, 2014) to understanding the landscape of informal trade at the borderland, having framed it as an economic ecosystem in its own right at the outset. Our research protocol was based on methods and tools from human-centred design, (Kumar, 2012; Keeley, Pikkel, Quinn, & Walters, 2013; Kimbell, 2014) adapted for the constraints and conditions of the data-scarce, infrastructurally challenged parts of the developing world, such as prevalent on the border of Uganda and Kenya.

The ethnographic fieldwork was designed to include three iterations over a duration of two months. The first two were shorter explorations, whilst the third was planned as an in-depth ethnographic study with pre-selected participants identified from earlier rounds of fieldwork. The aim was to discover the relationships and value flows between the roles, and identify the key archetypes in the ecosystem.

The first survey was semi- structured and intended to broadly sample a wide variety of economic actors involved in cross-border trade. We had one team member on site conducting a short questionnaire, and responses were shared in real time with both authors thus integrating findings from the literature review into the feedback for research protocol design iterations. This approach permitted an iterative refining of the focus in the second short round of immersion which was to shortlist users for the third stage of in-depth study.

For instance, although the brief was to study informal traders, our discoveries in the first round of fieldwork led to the inclusion of support services actors such as transporters, brokers, money changers, mobile currency agents, etc., and host of other services such as mobile charging or rent a storage per night. They were deemed such an integral part of each trader's daily commercial activities that we expanded our scope of user research accordingly. Subsequently, the fieldwork for the third and final round was designed to include mapping out the commercial relationships - the value webs (Kumar, 2012; Doorneweert, et al., 2013) - of the selected primary end-users (the informal traders) in addition to understanding aspects of their daily life.

Primary methods for context immersion were ethnographic observation and in-depth interviews supported by exploratory market and spatial analysis by means custom-designed tools and guides to trace linkages between urban and rural, and formal and informal, as well as map trade routes in the region.

Over 60 participants were interviewed in-situ, spanning both sides of the border in Kenya and Uganda, between the border market towns of Malaba and Busia. Most informal trader participants were female and those offering support services were male, and this was found to be proportionately true in the region per the literature review.

There was an explicit understanding that there would be a high degree of ambiguity in this, the first borderland exploration, which we later codified as an additional phase of discovery in the design of our borderland mapping methodology. This design and process will not be described within the scope of this paper.

4 Insights from Fieldwork

The goals set for the first phase were to discover the value webs of informal trade and identify and describe the archetypes representative of this activity for more in-depth and structured qualitative research that would inform and inspire the conceptual design of the pilot programme/s.

4.1 Patterns of Biashara

As we surveyed traders operating across a range of scale of operations, goods sold, and geographic reach in the first iteration of fieldwork, we saw patterns emerge in the borderland economy. Not only was it a self-contained system with regard to all the necessary services for cross-border trade, regardless of distance, but there was a rhythm and meaning to the pattern, not simply the first impression of chaos that informal markets tend to convey. It was this insight that led to expanding the scope of users surveyed as mentioned in the methodology section above.

The first thing we noticed was that the majority of full-time traders in this borderland economy were not merely scraping by at subsistence level, these women were professionals and business owners, and their demeanour conveyed it. There was a distinct difference between them, and the women who thronged the weekly market selling fresh produce. These produce sellers were the stereotypical informal cross-border traders the literature had described, but as we discovered, they in turn didn't always think of themselves as full-time traders. Rather, such petty trading was considered a part-time activity to supplement incomes, and these traders were either fulltime farmwives, or worked only during the school year.

Two elements from this initial survey stood out as being of interest. First, the informal trade sector seemed to signal a certain degree of commercial success by moving visibly to establish new lines of business. At a certain stage of business growth, a second person would be brought in to manage day to day operations, freeing the trader to explore new opportunities for revenue generation, and multiply their income streams as a risk mitigation strategy. In fact, more than half the traders surveyed in Busia and Malaba markets were running more than one line of business. And, a handful had as many as four different income streams, including non-trade related entities such as a copy center offering business services to customs agents. This behaviour also offered us insights on the economic potential of this borderland, as well as its stability in a region where neighbours were prone to conflict.

The second element was that most of the ambitious retailers aspired to become wholesalers. That is, we documented their intent to shift from purely business to consumer (B2C) sales to increasing proportion of business to business (B2B) sales. Such traders often helped newcomers entering retail trade – through such means as direct apprenticeship, supplying them goods to be sold on commission, and through advice and guidance. In fact, as it turned out, such mentoring had economic value in the eyes of the traders, and this attribute helped us distinguish such value creators in the ecosystem.

This behaviour went counter to conventional modes of supply chain and distribution channel structures which rarely blend individual consumer facing sales with global trade in bulk shipments. Marketing to B2C and B2B customers tends to be separated at the business plan stage, and runs in parallel with different organizational structures and strategies.

What we discovered was that these were two of the main business development strategies for micro-enterprises that were organically evolved to cope with the limitations and constraints of their operating environment.

First, the need to diversify lines of business was necessary for two reasons:

1. There is a natural limit to how much one trader can grow the local customer base for goods such as clothing, footwear, household goods, etc. Unlike food, which is a consumable needing frequent replenishment, traders know that to increase their revenue streams they need to increase the size and value of each sale rather than rely on footfalls alone.
2. At the same time, without any decent safety nets or support from formal financial institutions, traders tend to mitigate risk by diversifying their income streams. This could be in the same product category or in a very different one. We noticed traders of all sizes experimenting with new items distinctly different from each other, such as selling day-old chicks and toilet paper. Or converting an observed need into a profitable income stream, such as renting out sacks to truckers to de-humidify their grain before crossing borders. Their aim was to identify demand for a profitable new line of business, through experimentation and iteration.

Second, the necessity of managing working capital requirements in an environment characterized by volatile cash flows and seasonality (Bhan, 2009), meant that planning and forecasting for business development required increasing the stability and predictability of their revenue streams. A proven tactic was the investment in mentoring newcomers, and nurturing a cohort of even smaller scale B2C traders, as described above. This ensured the trader had regular access to a relatively stable customer base, one that could be relied upon to provide periodic and consistent sales orders. This, in turn, provided an established revenue stream from a trusted network (Hart, 2000) whose day to day operations could be delegated, thus giving the business owner ample opportunity to focus on launching a second or third line of business.

That is, what we were discovering was evidence of a segment of traders falling outside the documented categories of either formal small and medium enterprises (SMEs) or the stereotype of the marginalized and vulnerable livelihood actors living on the edge. For narrative purposes, we labelled them the "Hidden Middle". These so called "informal" cross-border traders were, in fact, highly respected value creators within their micro-communities - building trusted relationships, mentoring the less experienced, and establishing supply chains in the form of stable networks.

This discovery helped us identify the user participants for in-depth observations, interviews and day in the life shadowing conducted subsequently.

4.2 Framing our theoretical approach for the design of iterative programming meant for complex adaptive systems in the context of international development

Initial insights had invalidated many of the assumptions implicit and explicit in the literature review, and pointed to the existence of segments of traders who were undocumented. The discovery phase had provided enough evidence of nodes of value creation composed of multiple stakeholders, not just the primary target beneficiary of the informal cross-border trader per our project's terms of reference.

The evidence pointed to an existing ecosystem that had organically evolved to create value by building stable, trusted networks of cooperation in cross-border trade, based on relationships between people. All it needed, from the perspective of intervention design, was fine tuning for boosting productivity, efficiency, and improving ROI (return on investment), not the kind of top down disruption that traditional programmes caused by disabling the flows of value in their attempts to impose pre-built ecosystems without ever questioning if there was already an existing one.

If indeed we could map the bounds of this complex adaptive system holistically, rather than in minute detail, then we could grasp enough of the sense of the value flows within the whole informal trade network, and discern the relative importance of its nodes. For this kind of systemic design to trigger positive transformational change through growth, we needed to identify the optimal target users for intervention pilots that would offer maximum value for money (HM Treasury, 2004); that is, concepts optimized for social impact, with benefits rippling out into the entire community.

And, the value creators we had discovered seemed to be the most likely candidates for this role since it was in their own business interests to grow trade and revenues across their entire trading network. Boosting the purchasing power capacity of their own economic microsystems (their value webs) would in turn benefit them, and this behaviour resonated with existing patterns of business growth strategies that we were to document in detail.

Therefore, we would need to understand this, during the final fieldwork, before we could move on to identifying the attributes by which to segment traders in the borderland or crafting personas for human-centred systemic design. We selected a representative sample of traders cutting across product categories, number of lines of business, education level, years of work experience, and the retail infrastructure.

4.3 Value Creators Hidden in the Middle

We began by tracing the value flows in the complex interdependent micro-system that each full-time trader's value web represented. Figure 1 is Alice's value web visualized with colour codes identifying the different forms of value – information/knowledge; services; goods; money and cash equivalents – being exchanged.

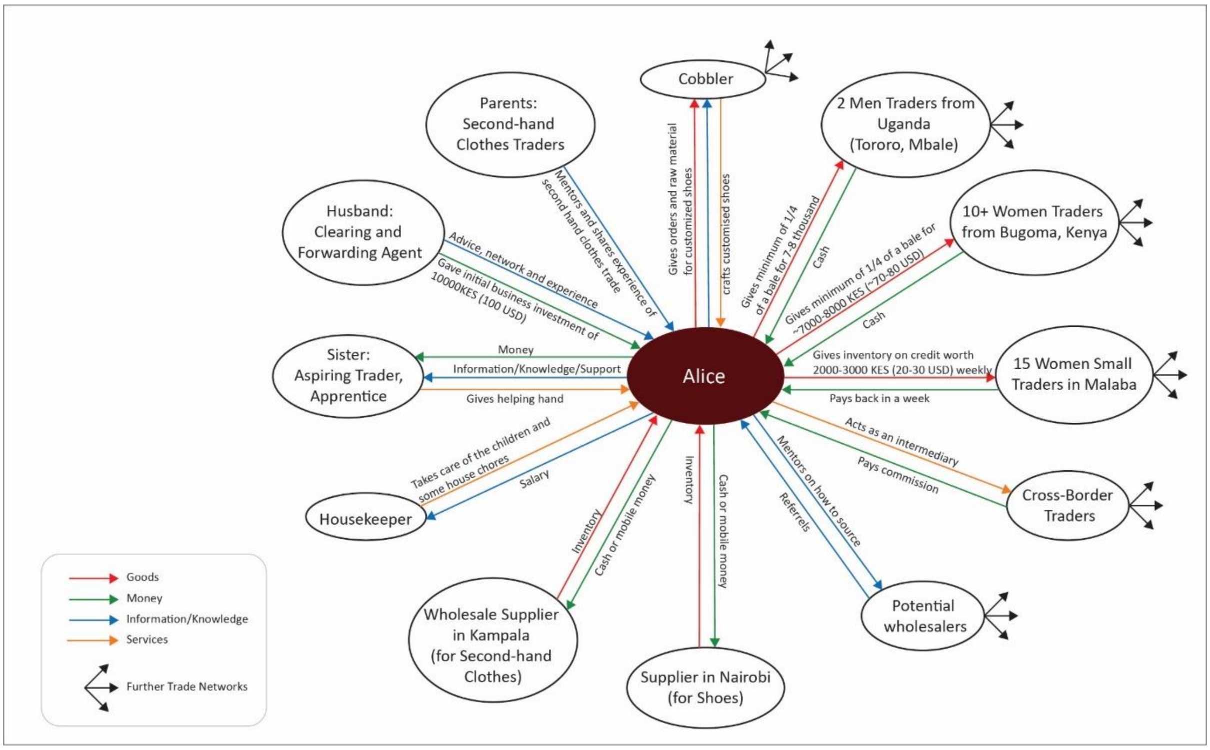

Figure 2 Alice's value web as captured during the fieldwork

Alice's economic impact is undeniable – after establishing a school supply storefront, her second line of business is wholesale of second-hand clothes. She supplies traders of both genders, on both sides of the border, as well as offering new entrants goods to sell on commission. That is, she lessens their burden during the apprenticeship process by taking payments only after they have sold. She also employs her sister to manage her shop. Alice's husband is a customs agent and this gives her a competitive edge in cross-border trade. Her third line of business is custom-made leather shoes, where she supplies local cobblers with leather uppers and rubber soles she imports from Nairobi.

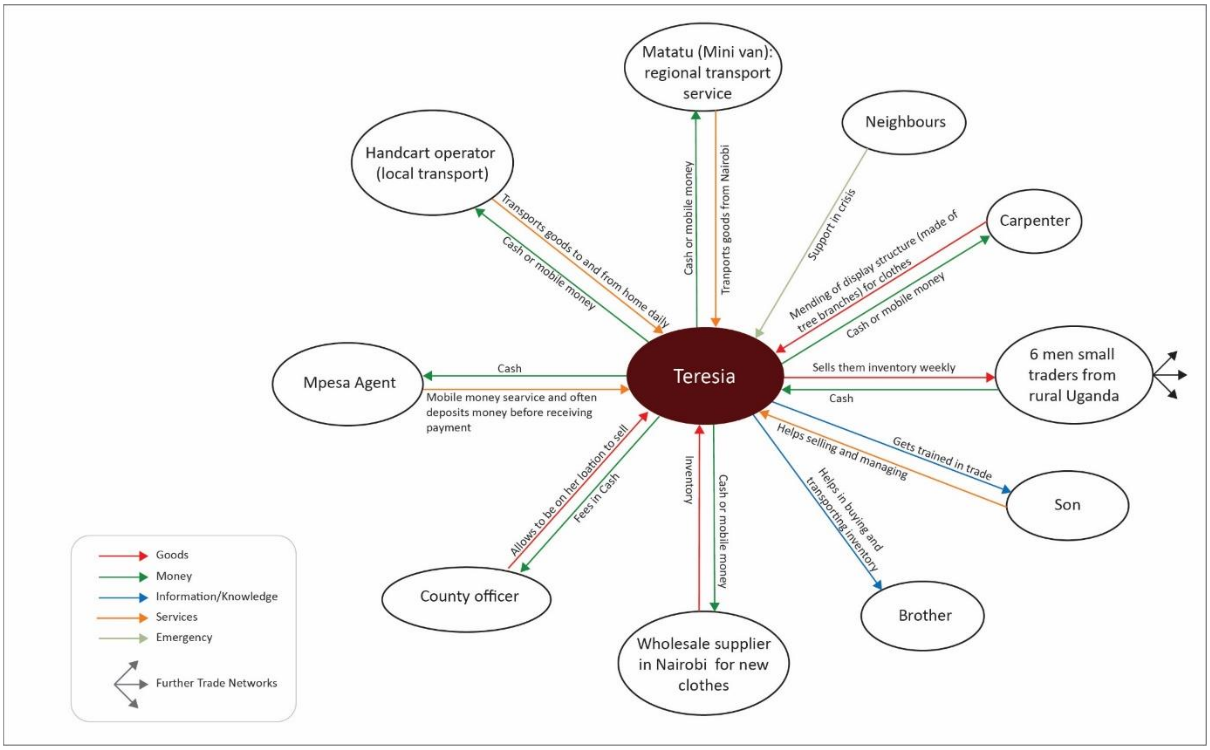

Figure 3 Teresia's value web as captured during the fieldwork

Teresia has not yet achieved Alice's scale of operations, having only recently begun establishing a wholesale network to supply a group of six Ugandan men. Teresia is a single mother and has been bootstrapping her business, failing to get a loan for working capital at the bank. But this has not stopped her from building and maintaining her micro-system, including support services such as transport and mobile money.

The task of synthesizing microsystems into value webs gave us a tool to distinguish between trader segments, and the subsequent analysis and synthesis provided us with fodder for selecting attributes for each segment. Since this was the first borderland, our aim was to seek generalities in trader business characteristics that could be applied as a lens to segment and evaluate the economic distribution of small scale and woman traders for any given borderland, given the dual-purpose nature of our fieldwork. Once defined, the attributes could be used as a foundation for a census level Trade Survey. Comparative analysis of the value webs provided visual evidence of differences in commercial operations even within the value creator segment. At the same time, we knew that this would only be prototype segmentation since validation would only occur after implementation in more borderlands.

4.4 Segmentation attributes and the "Hidden Middle" in the trading economy

Profit margins and income streams are difficult to estimate in the volatile conditions of the cash intensive informal sector and price is negotiable between the buyer and the seller. However, every experienced trader knows their pattern of investment in inventory, including seasonality of demand over the course of the natural year (Bhan, 2009). Thus, to estimate the scale of operations, two simple questions were asked – how many lines of business have you established? And, how often do you buy new inventory and for how much?

Table 1 Indicative Segmentation Range for Borderland trading economy

Monthly Inventory Purchases	Less than USD 600	USD 600 to USD 1000-1500	USD 1500 to USD 2500-3000	USD 3000 and upwards
Trader Stage	Part time trader and/or farmer; Apprentices	Entry level fulltime traders, Proto employer	Value creators, Established traders	Pre-formal SMEs, Business owners with multiple lines

At this borderland economy, the barest minimum requirement to keep business running as a fulltime trader – that is, relying solely on the cash flow from sales of trade goods, including perishables – was a monthly investment capacity in inventory of around USD 600. A business was considered established enough for the trader to start considering business development strategies for revenue growth after her investment capacity in trade goods began to exceed 1000 US dollars every month. This kind of distribution by periodic investment capacity offered us the means to capture the economic distribution for each borderland's trading economy.

In addition to their estimated average monthly inventory investment capacity, there was a natural correlation of education level to increasing sophistication of trade. With education, and the advent of affordable smart phones and data plans, along with ubiquitous mobile money solutions, trade had been disrupted at the borderlands. This was one of the reasons for the stereotype of the subsistence level woman trader as they were the only ones seen visibly trading in the marketplace and counted while crossing the border posts.

The Hidden Middle were hidden due to the transformative capacity of the personal mobile phone in a sector as heavily dependent on communication as trade. Value creators traded far more extensively, geographically speaking, and their deals were of higher value. But due to the discreet nature of making deals by phone, these traders and their activities remained invisible to the traditional researchers at the borderlands, and in the informal economy in general. It was only by diagramming their entire value webs were we able to see and communicate the full scale of their activities.

Giving personalities to traders at different phases of their entrepreneurial journey allowed us to craft a representative narrative of how the informal trade dynamics played out in the context of first, the trader’s own value web, and secondly, how these microsystems networked with each other to build up the regional trade ecosystem. And, we could begin crafting personas to represent trader segments, such as Teresia who has the capacity to invest between USD 1000 to 1500 monthly, and Alice whose three lines of business may require investments of around USD 3000 each month as working capital.

5 Design Implications for an Ecosystem Approach to Policy and Programmes

Our fieldwork confirmed and further deepened our understanding regarding the existence, and identification criteria, of influential nodes in the informal trade ecosystem, that could be designated the primary beneficiary for the systemic design of programmes and interventions (Kimbell, 2011) meant to trigger positive, transformational change.

The informal trade ecosystem's business development strategies were such that investing in the highest grade of professional traders with extensive value webs outside the mainstream economy would have far more impact than simply focusing on subsistence level livelihood actors without an established or stable trading network. Interventions designed for an Alice as the target end-user would have ripple effects throughout her entire micro-system as a whole, including support services such as local and regional transportation, mobile money agents, brokers and other intermediaries. Growth strategies for boosting trade and revenues could thus be optimized based on the economic distribution pattern of each such borderland.

Our discoveries lead us to posit that simply targeting each trader segment with customized programmes will not be enough to enable systemic change of the whole borderland informal trading economy; we will have to address their entire value web as the target beneficiary of an integrated set of programmes.

5.1 The Node is the Value Creator's entire Microsystem

Rather than considering the discrete individual as the active node in the informal economic ecosystem, our findings lead us to expand our scope to consider their microsystem as the node to target with our interventions. From the theoretical perspective, such a concept design prototype would act as the pilot to see how many of the microsystems centred around each value creating trader change in response to the interventions, and by what degree and scale. This approach to iterative programme design for complex adaptive systems also offers us the opportunity to rapidly design and test ecosystem scale pilots far more efficiently and affordably.

Shrinking the scale of systemic design down to selected handfuls of such microsystems would provide a more manageable scale of inputs to monitor and evaluate for iterations in programme design. By sampling microsystems from the range of trader segments, we would not only be able to identify the optimal stage of a business's development journey for interventions to boost trade related growth, but the data gathered would assist in developing a generalized framework of an economic microsystem, which we think may be the basic building block of the informal economic ecosystem. This is due to having identified such value webs in both the last mile of the agricultural value chain as well as the informal trade ecosystem. That is, we have begun laying the foundation for developing a reasonably accurate working model of the informal economic sector in East Africa.

5.2 Framing the Problem and Identifying the User for Informal Ecosystems

Our methodology is grounded in the first principles of human centred design (HCD) customized for operating environments where legacy consumer insights are scarce, and data flows unreliable. The selection of the primary "user" for whom we will design is a critical decision, as context and profile will subsequently act as a filter for evaluating concepts for best fit. Traditionally, the word user, in user centred design, or the word human, in human centred design, has denoted the individual, in the singular. However, due to the complex and volatile nature of the informal ecosystem the needs of the design process itself can best be served by expanding our scope of "the user" from the individual to the group – in this case, the trading economy's microsystems.

This is a group that would not be immediately recognizable or visible to a casual visitor. It is not an existing social organization such as a farmer's association or a cooperative, nor a women traders' self-help group. It is a micro-system composed of the entire supply and demand network of goods and services that generates revenues for established traders.

Selecting the entire group would be far more influential for the spread of new ideas and provide visible evidence of the beneficial outcomes of planned interventions. This would help in on-boarding more of this segment after the pilot programmes. The slower start implicated in the design and prototyping process by working with groups rather than individuals offers more time to refine the system design prototype at the micro level thus helping create a firmer foundation for interventions to take root.

Rural and informal economies are far too closely interdependent due to the people-centric nature of their transactions and any intended systemic change must occur on a significant enough scale for programmes to achieve their intended goals within the timelines set for their financial support. The need for exit strategies requires triggering self-sustainable change that can organically evolve and spread, and addressing each value creator's entire web as the beneficiary changes the way we would approach the design of pilots and programmes. It also transforms our perspective of the economic contribution made by these value creators with significant impact on poverty alleviation programmes (Bhan, 2017).

6 Conclusion

Design research methods in collectivist societies as compared to individualistic societies have a different approach and implications (Hofstede, 2001). As discussed above, the need to consider a micro-system rather than an individual end-user as a unit of investigation proved to be context appropriate for the rural and informal market and trading economy in East Africa.

Though dependent on the conditions of the client brief, this approach has scalability. We were able to build in a flexible phase of discovering and exploring in this first such project, and now have codified this need for liberty in research planning into our design methodology.

Finally, for social innovation purposes, in the resource constrained environments, interventions may not always take the form of tangible products or services neatly wrapped in a great user experience. It depends on what is actually required and what is the strategy for adaptation. The authors observed that even the “most logical” solutions such as bank accounts did not fit the requirements of the participants. Solution design must take the perspective of optimal triggers for progressively beneficial transformation, be it a policy, product or simply enhanced understanding of the context.

7 Next Steps

We have developed a theoretical framework for triggering progressively beneficial transformation in an informal economic ecosystem based on our discoveries in this project. This theory of change will be validated through pilot programmes, and the methodology prototyped for mapping borderland economies iterated with each subsequent location. The borderland described in this paper is located in a stable region with impressive trade facilitation at the border post. How we customize our framework and approach for more fragile conditions, or comparatively analyze value flows in thicker borders will be our next research task.

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DRS 2018 Design Research Society 2018 Catalyst

University of Limerick
25th–28th June 2018

Catalysing Pathway Creation for Transition Governance

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doi: 10.21606/dma.2018.448

Transition management is one of the key governance methodologies for catalysing vision building, experimentation and pathway construction for sustainability transitions. Its adoption in new country contexts may, however, require redesign. Finnish energy and climate policy already features wide experimentation, visioning and long-term roadmaps. Yet transition arenas could help connect these existing instruments, particularly if redesigned for a mid-range timescale. We improved the path creation toolsets and procedures to create more detailed pathways and analyses of pathway step interrelations. Our path creation system uses magnetic elements that could be easily moved around a large metallic board, a set of procedures and a digitalized counterpart of the board for out-of-the-workshop commentary and reporting. The system was used to create eight mid-range transition pathways and was reported to have facilitated and anchored well the discussions by participants with cross-sectoral backgrounds. Overall, the redesigned system underscores the potential that codesign for sustainability transitions holds, for instance, in developing transition governance instruments further.

transitions; design research; collaborative envisioning; energy

1 Introduction

The need for thoroughgoing system transitions has become urgent in several areas such as energy, transport and water use. Climate change and advancing resource scarcity exert growing landscape pressure on the dominant sociotechnical regimes in these sectors. At the same time, alternative technologies and social arrangements are maturing in many sectors and offering alternatives that can begin to reconfigure or replace the dominant sociotechnical regimes (Geels, 2004; Geels & Schot, 2007).

In the energy system, improved energy efficiency and the replacement of fossil fuels with increasingly cheaper renewable energy are changing the ways in which energy is produced, distributed and used in all sectors. For example, an increasing share of intermittent electricity production creates the need for new market models, products and services: demand response, storage and flexible production. The need to anticipate and investigate the forms and timing of the needed changes as well as their impacts on different sectors thus becomes evident. Transition requires change in the current dominant regime as well as new technologies, business models, competencies and institutions. Many of these changes benefit from (or require) anticipatory action, societal experimentation and policy changes and thus require localized forms of governance (Heiskanen, Kivisaari, Lovio, & Mickwitz, 2009; Sovacool, 2016).

The steering and governance of systemic transitions has been investigated since the late 1990s in several multidisciplinary lines of research. The nurturing, empowering, shielding and expanding of alternative niche innovations has been researched in strategic niche management and the social embedment of technology (Hoogma, Kemp, Schot, & Truffer, 2002; Rene Kemp, Schot, & Hoogma, 1998; Kivisaari, Lovio, & Väyrynen, 2004; Smith & Raven, 2012). Policies, policy mixes and rationales for interventions that disrupt dominant sociotechnical regimes and make room for change have been investigated (Kivimaa & Kern, 2016; Weber & Rohracher, 2012). Among the longest lines of transition steering is transition management (TM), which originated in the Netherlands in the 2000s and has developed through a Dutch energy transition initiative (René Kemp, Loorbach, & Rotmans, 2007; Loorbach & Rotmans, 2010) and a range of regional and city-specific transition projects (Frantzeskaki, Wittmayer, & Loorbach, 2014; Roorda, Frantzeskaki, Loorbach, Van Steenbergen, & Wittmayer, 2012).

In recent years design for sustainability transitions has entered onto the transition research and governance scene. Design research has engaged the field in various ways, for instance, it has generated experiential future scenarios and change pathways (Gaziulusoy & Ryan, 2017a, 2017b), and has pursued long-term local experimentation engagements aimed towards low carbon transition have drawing from community design and practice theory (Jalas et al., 2017; Manzini & Rizzo, 2011). It has further built anticipatory strategic design initiatives in order to target the critical aspects of evolving transitions (Mok & Hyysalo, 2017). Design agendas have also been proposed that resonate with sustainability transitions research, such as transition design (Irwin, 2015; Irwin, Kossoff, Tonkinwise, & Scupelli, 2015) and design for environmentally sustainable social innovation (Jégou & Manzini, 2008; Manzini, 2014). Through all these engagements the potential of design research has been begun to be noted by other disciplines, for instance, it is visible in codesign being seen as one of the contributing fields to TM (Ferguson, Brown, Frantzeskaki, de Haan, & Deletic, 2013).

Our work is positioned in the above developments to advance the governance of transitions in a specific country context (Finland) in the mid-range (to 2030). It stems from the design work package of the larger Smart Energy Transition (SET) consortium and is focused on multidisciplinary governance experiments between the public sector, private companies and citizens. Our particular interest has been to redesign transition management tools to suit the Finnish context. The political cultures and dynamics of non-state actors differ from one country to another and 'transferring' the TM methodology to new country contexts involves necessary translation – which can be seen as a source of innovation in itself. The translations may vary heavily, ranging from different hybridizations to more profound implementations that question and rework the methodology pervasively (Heiskanen et al. 2009 p.213-415), and in doing so they can make useful contributions to theoretical development as well (ibid. p. 425).

Regarding the Finnish context, there are over one hundred experiments related to energy transition and relatively established parliamentary long-term climate roadmap (running to the year 2050) as well as mid-range climate roadmap and governmental energy and climate strategy for mid-range planning (running to the year 2030). However, what is currently missing is the means to connect the visions and goals with experiments on the ground in the mid-range, in other words, the means to deliberate over the change pathways, which is one of the core aims of *transition arenas* within the TM methodology.

Transition arenas are deliberative settings where groups of societal stakeholders can envision and build pathways of change to transition goals. On beginning to implement transition arenas in the Finnish context, it became evident that the available path creation toolsets were geared towards a long-term focus of 40–80 years (Frantzeskaki, Broto, Coenen, & Loorbach, 2017; Roorda et al., 2012) and, consequently, they were too broadscale and unspecific to guide mid-range concretization. Given our mid-range focus that only extends to 2030, our pathway creation tools needed to become considerably more specific as well as supportive of multi-actor deliberation in fast-paced workshops.

In the next sections we contextualise the pathway creation tools and their design challenges, along with our research through design methodology. We then introduce the final pathway creation system, the outcomes of its use in the transition implementation arena in Helsinki in 2017, and the participant and facilitator evaluations of the system. Conclusions and further research avenues follow.

2 The rationale and design challenges for pathway creation tools and methods

The focus of TM is on long-term policy design with relevant groups of "frontrunner" stakeholders. TM practices happen through creating spaces for searching, learning and experimenting on the transformation of the current system. It aims, on the one hand, to capacitate frontrunners with visions, concepts and seeds for thought that can be utilised in political decision making beyond the political cycle of elections. On the other hand, TM focuses on identifying settings for sociotechnical experiments and learning from them so that the experiments can be strengthened and scaled up, and eventually displace the problematic aspects of previously dominant regime (René Kemp et al., 2007; Loorbach & Rotmans, 2010).

TM further emphasizes the process of constructing pathways for meeting the long-term vision and specific transition goals. A further aim lies in creating a perspective on intersectional dynamics that can encourage transitional chance: "The general approach is one of nurturing and growing rather than planning and controlling long-term societal change." (Voß, Smith, & Grin, 2009 p. 277). In order to plan for long-term change, the focus is not only on the positive expectations for change, but also on negative ones that may prevent or hinder the change goals from unfolding (ibid p. 280). The schematic overview of TM is as follows (Loorbach & Rotmans, 2010; Voß et al., 2009):

1. Establishing a transition arena (or arenas)
2. Developing a common vision
3. Pathway development through backcasting techniques
4. Experimenting with pathway options
5. Monitoring, evaluation and revisions to pathways and experiments

TM as an approach for long-term policy design has faced some challenges over the years it has been practised. Voß et al. (2009) provide an overview of the policy design challenges TM faces. The common denominator that Voß et al. (2009) identified in TM challenges is that "TM as a concept for policy lacks effective provisions for inclusive participation and fair deliberation within 'transition arenas'". They further argue that the original TM principles have veered, in practice, towards the domination of powerful incumbent actors in arenas, a somewhat instrumentalist focus, and limited width and depth of civil deliberation. Voß et al. (2009) seek to remedy these aspects through increased civil society participation and ensuring a broader sustainability focus.

Our response seeks to address some of the critique of Voß et al. through seeking to anchor the transition arena vision and goal setting phases in the parliamentary long-term climate roadmap for 2050, a mid-range climate plan for 2030, and energy and climate strategy for 2030 in order to foster higher legitimacy for the process in conjunction to existing democratic processes. We further explicitly link the pathways of change to the many experiments that are already running so as to give voice and visibility to civil society, the public sector and business actors who are already active in transitions. The frontrunners who participated in the arena were carefully selected from among 90 Finnish change makers, known through an SET-consortium's wide networks in energy and climate governance. The final selection was based on participants' competences and complementarity regarding the Finnish energy system. The selected 23 persons formed a group that covered well the frontiers of Finnish political, civil servant, business, and civil society actors regarding energy transition and together they provide a wide variety of angles with which to examine the topic.

The transition arena process in Helsinki was carried out over six three-hour workshops held at one-month intervals, during which participants could comment on refined results from the previous workshop in the closed website of the arena. The schedule was as follows:

Workshop 1. The drivers, challenges and contingencies for transition

Workshop 2. Vision and transition goals for 2030

Workshop 3. Formation of pathways, part 1

Workshop 4. Formation of pathways, part 2

Workshop 5. Immediate actions for launching the pathways

Workshop 6. Completing the results and commenting on the final report

The design challenge regarding mid-range path creation tools and procedures for workshops 3, 4 and 5 comprised of six interlinked aims and seven further specifications:

1. To allow a small group of 3–7 co-located participants from different walks of life to deliberate and effectively form a path to a mid-range transition goal from the current state
2. To provide participants with clear means to analyse the interrelationships between pathway steps and the timing of needed actions
3. To help participants to evaluate the realism of the suggested steps and the range of actions (regulatory, investment, business, technology development, civil society, research, behavioural change etc. actions) through which the pathway steps can become realised or their realisation supported
4. To help participants to recognise pathway and step interlinkages and the most critical steps in which societal choices have to be made
5. To help participants to highlight alternative transition paths with respect to the most important change drivers and uncertainties
6. To consider the effects of the most important uncertainty and contingency factors in the pathways and the steps therein

The chosen arena implementation method set the following specifications for the final design of the pathway creation tool:

a. The working time with one pathway is limited to one or two half-day workshops
b. The participants should be busy, and they should quickly understand how to use the tool
c. The tool should be flexible so that it can be modified during the pathway creation process if needed; the openness of the arena process may lead to goals and directions that were not planned beforehand
d. The elements of the path creation should be easily recognizable so that the participants do not confuse them with each other, even in the hectic pace of the arena workshops
e. The materials should be easily movable over the game board
f. The materials should enable feeding the needed information into the process as well as incorporating the information created during the process without truncating it
g. The contents should be easily digitized
h. Game boards should allow at least four persons to work on an individual pathway at a time

3 Research through design in creating the path creation tool

In designing the pathway creation tools we drew from designing tools for codesign (Ehn & Kyng, 1991; Muller, Wildman, & White, 1993), participatory design games and their development (Eriksen, Brandt, Mattelmäki, & Vaajakallio, 2014; Vaajakallio, 2012) and game design (Zimmerman, 2003). Our design decisions were based on several testing and codesigning sessions within the design team, within a broader set of colleagues who were not involved in the design and with a yet broader set of transition arena team members. The very final iterations were made between the two workshop sessions of the transition arena process. Each time the pathway tool prototype and instructions were enacted akin to playtesting (Zimmerman, 2003), and the designers observed the situation, made notes, and asked questions and design ideas from the participants. After the testing sessions they adjusted the design to get to the next prototype version. The design team had a further division of responsibilities in testing and iterative design. Author 1 held responsibility over the overall concept development and balancing of different priorities in each iteration. Author 2 was responsible for the detailed design and productization of the pathway creation tool and, with Author 3, Author 2 explored the material choices and ideated design alternatives to be tested in iterations. Author 4 acted as substance expert on energy systems and relayed information about issues and participants to the rest of the team. The design team was further helped by a public deliberation expert who participated in all testing sessions and kept a continuous eye on the quality of the deliberation that the tool and its procedures may foster, as well as the on the validity of the design with respect to more traditional backcasting methods in futures research. These different competencies and perspectives fostered productive dialogue about the solutions and issues to be considered in the process.

4 The outline, elements and procedures of the path creation tool

4.1 Outline and key elements

The pathway creation tool is premised on a set of predefined forms and categories. These are used in constructing change pathways and were designed to give sufficient visibility to both content and form for all the participants during the process and also to both ease the movement of the elements and transforming the pathway in the course of the pathway construction.

The pathway creation work takes place on a 240 cm x 150 cm metallic board, onto which only a white print with light hexagonal grid has been permanently printed to give structure. All other elements are magnetic to allow flexibility in moving timelines and elements around as pathway construction progresses. The magnetic elements – pathway steps, arrows and pathway step realization actions – all have a writing surface on which participants can add content with markers. The magnetic elements allow the easy manipulation of pathway interrelations and the markers allow the easy modification of content as text can be wiped out with wet cloth. The size and height of the vertical board is designed to allow 3–5 people to work effectively on elements, both independently and in a group, and to allow them to reach to the top of the board (at 230 cm) and the bottom (at 79cm, see Figure 1).

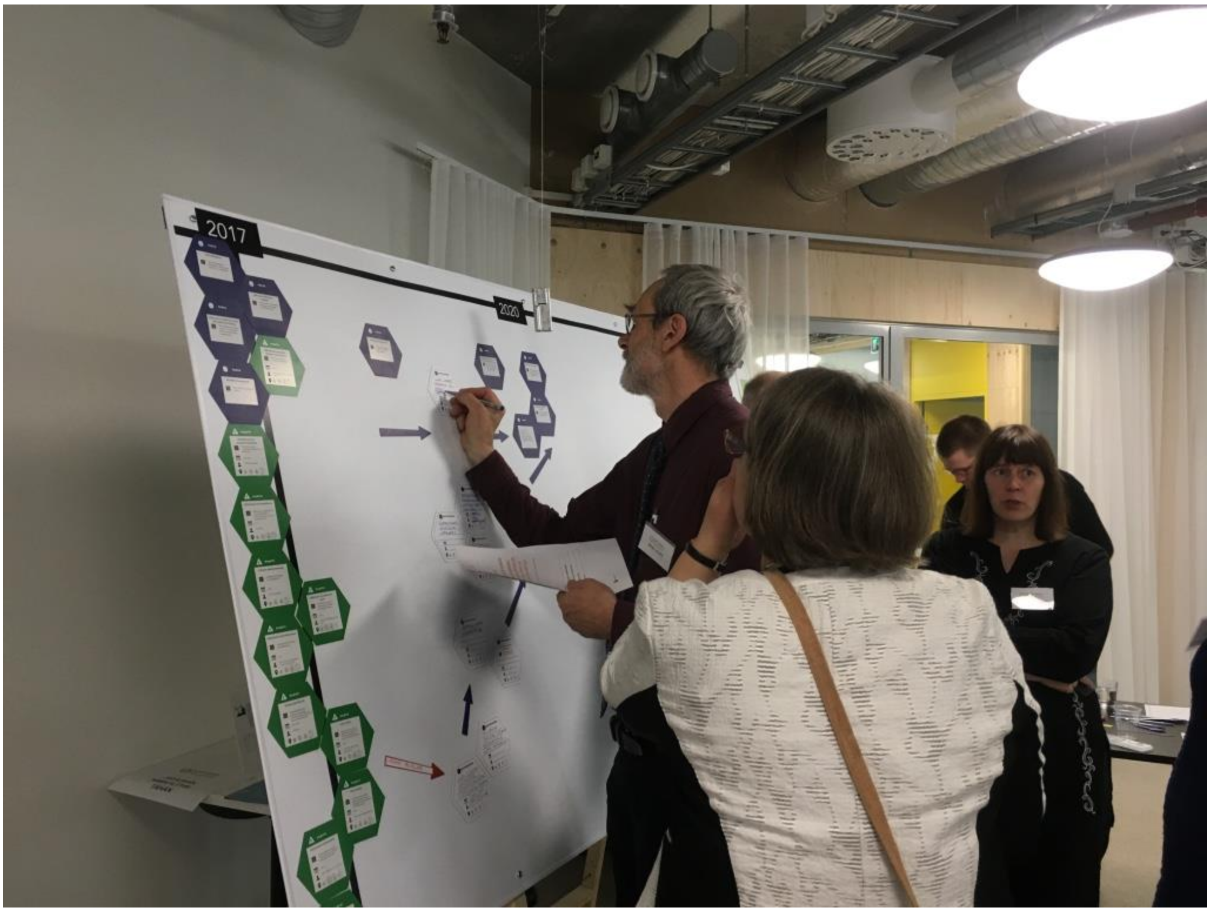

Figure 1. Pathway creation in its early stages.

The primary elements of the pathway creation system are the “pathway step” and “pathway-step action” elements. Both have the same structure: upmost, the designator of the form (e.g. *pathway step* or *investment*, then four rows for describing the step content, followed by timing (in years), the key actor(s), and the scale(s) which this element concerns: a national issue, a regional issue, on the suburb/village scale or concerning individual buildings and consumers (Figure 2). To differentiate the elements a combination of distinctive symbol, text and colouring is used for each.

Figure 2. A pathway-step element and an example of a filled-in pathway step.

The pathway-step action elements concretize how each pathway step can be realised or facilitated. The ones created thus far are specific to energy transition: energy production, business, end consumption, regulation, investment, other, technology, pilot (Figure 3, left-hand side). We also designed a set of organizer elements to guide the work. “Fact elements” are used to render visible key milestones and facts about the pathway (see more below) and the question mark, exclamation mark and quotation mark are used to point out missing or insufficient pathway steps regarding change targets, critically important areas and needs for new research respectively, with the aim of focusing participant attention on these areas (Figure 3, right-hand side). The choice of hexagon-shaped elements, descriptive labels and colour coding was based on their common use in countless board games and ideation systems (Hodgson, 1992).

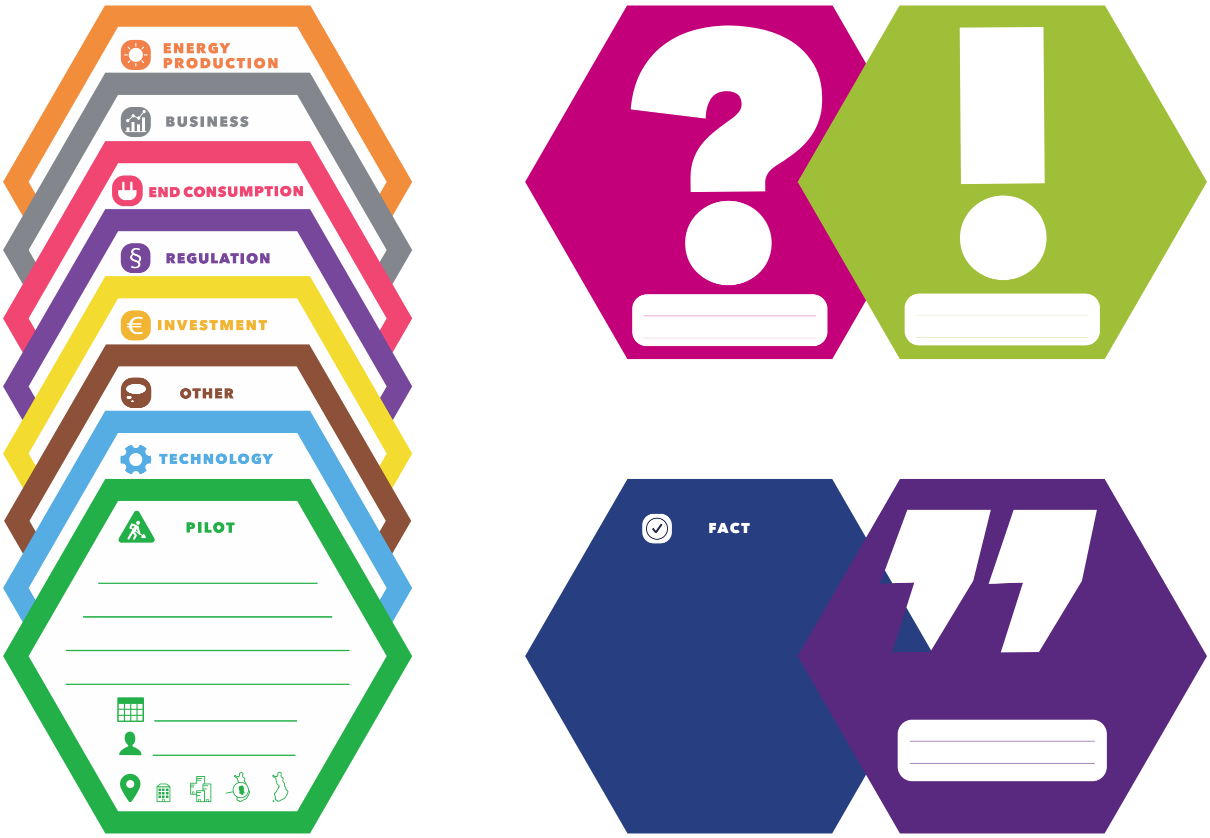

Figure 3. On the left are pathway-step action elements: energy production, business, end consumption, regulation, investment, other, technology, pilot. On the right are organizer elements: a fact, an attention marker, a missing action marker and a research marker.

The interrelations between elements can be clarified with magnetic arrows (which allow writing onto them) to show how one pathway step leads to another. Once the pathway is completed on the board it is rendered digitally, which allows further commentary, cleaning and the opening of all content to full sentences that are understandable to those beyond the participants in the path creation (see Figure 4 for a completed pathway).

Prior to the pathway construction, participants are given a 4–6 page information package related to the current state, the envisioned pathway goal and known challenges. The information in the package is also partially rendered visible on the board in a data-derived “persona” (Cooper, 2004) sheet of a family living in 2030, implicated by the pathway (Figure 5), as well as through placing key facts and pilots tentatively on the board as prefilled fact and pilot elements (see the block green and blue elements in Figures 3 and 4).

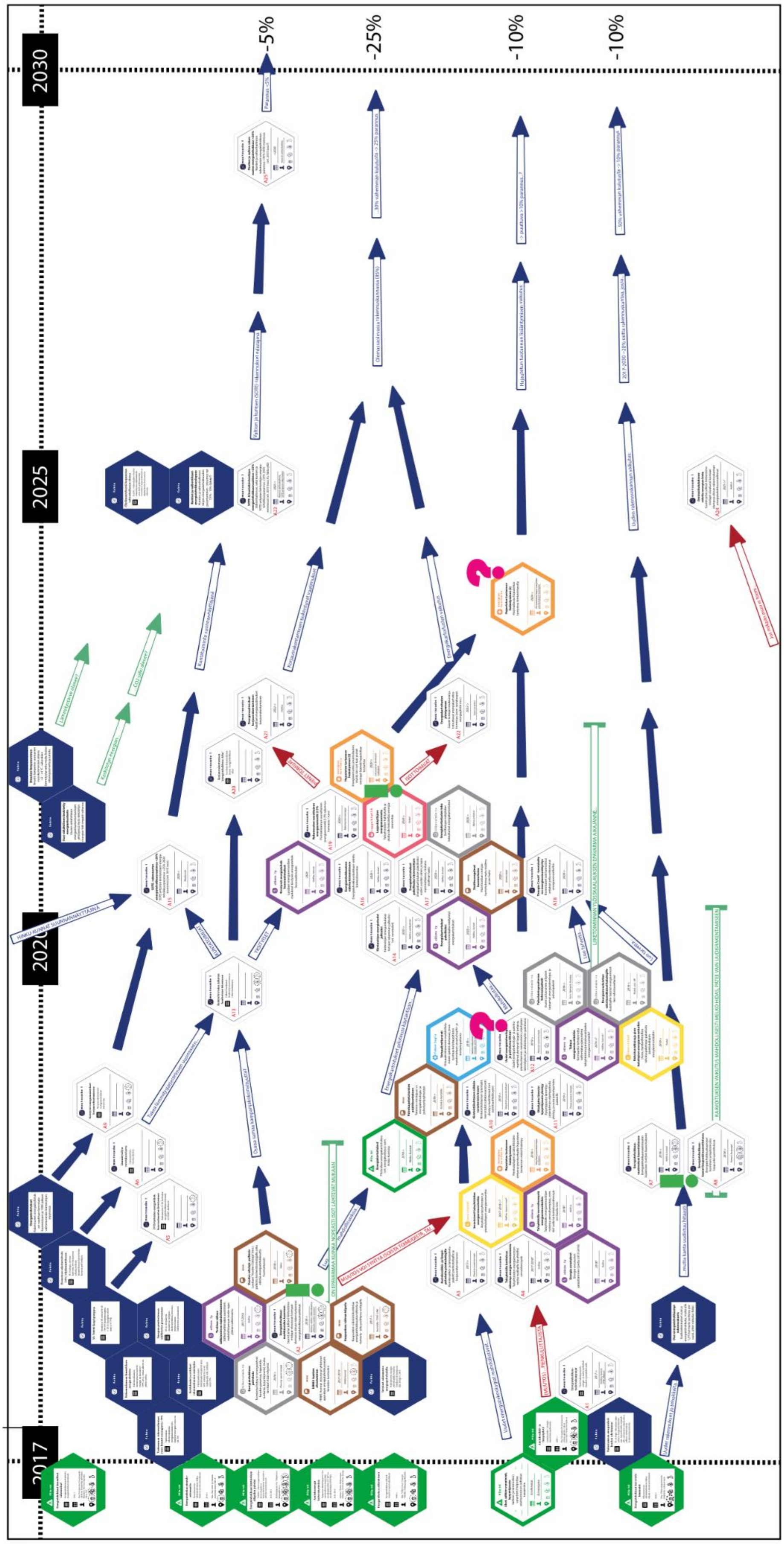

Figure 4. The final digitized path for halving a building's net-energy use by 2030.

VISION PERSONA

Smart Energy Transition

FAMILY KUKKONEN & JOKINEN

SOFIA KUKKONEN: 48 years
Teacher, 3600€/month

ARI JOKINEN: 46 years
Teacher, 3500€/month

LINDA KUKKONEN: 8 years
Grade schooler

LIVING

Centre of Oulu, Torikatu, 82m2 apartment building, built 1972.
Sofia is in the board of housing cooperative together with Erkki 74 years, Markku 78 years and Lasse 55 years.

ENERGY CONSUMPTION AND USAGE

Heating: District heating, indoor air temperature 22-24C
Electricity: 2400kW per year

FREE TIME

Each family member has their hobbies in the centre of Oulu.

TRANSPORTATION

Own car and public transport in the centre of Oulu

INTEREST

– Improve the real estate energy efficiency cost-effictively.
– Save in expenses, support climate friendly energy.

ASSUMPTIONS RELATING TO PATHWAY IN 2030

"Reducing household energy consumption by change in behavior by 15%"

A) Pipe and roof repairs planned for the house, window repair in 10 years' timeframe. Sofia has suggested the housing cooperative that everything should be done simultaneously. She has also proposed for 20m2 solar panels, 30m2 solar heat collectors, extra insulation, forced ventilation and connecting the house in remote controlled demand response system for heating. The rest of the board is doubtful about how can the residents finance big repairs. The middle age of residents of the house is 63 years.

B) Sofia has ordered a preliminary review from ESCO company, but the role of its actions in the middle of other repair projects is unclear.

Picture 5. One of the final personas implicated in the envisioned mid-range 2030 goal.

4.2 *The procedure of pathway construction*

From the starting position, the participants begin by discussing the target and pathway on a general level. The facilitator urges them to write down their thoughts about pathway step elements whenever an obvious step is identified. As steps cumulated, discussions begin to include their interrelations and potentially missing steps. In all the paths created thus far, the elements were rearranged several times and sub-pathways emerge, either from the onset or through the branching of the paths. At some point, the deliberation tends to veer towards considerations of whether each step is needed, whether some steps are realistically attainable and whether all the steps in all the sub-pathways together amount to sufficient change regarding the transition goal.

Once the main pathway steps have found a more or less steady and mutually agreed on form, the participants move to identifying the most important and most crucial steps and marking them with yellow stickers, and correspondingly marking where blocking points may reside in the pathway with black stickers.

This constitutes the first phase in the pathway construction. At this point the first documentation round happens through participants being asked to explain to the video camera the pathway and its key features and new insights they gained during the path construction.

The second phase of the pathway creation process is a more detailed examination of all steps, or at least the most important steps. The actions needed to realize each pathway step (technology development, regulation, changes in consumer behaviour, pilots, investments et cetera; see Figure 2) are discussed and marked down. At this point it is common that some pathway steps become merged and some new steps are added in. Also, some pathway steps may now be considered to actually be the actions for realizing another step (Figure 6). At the end of the second phase, the participants video the detailed concretizations to ensure that the ideas written down on cards are sufficiently elaborated.

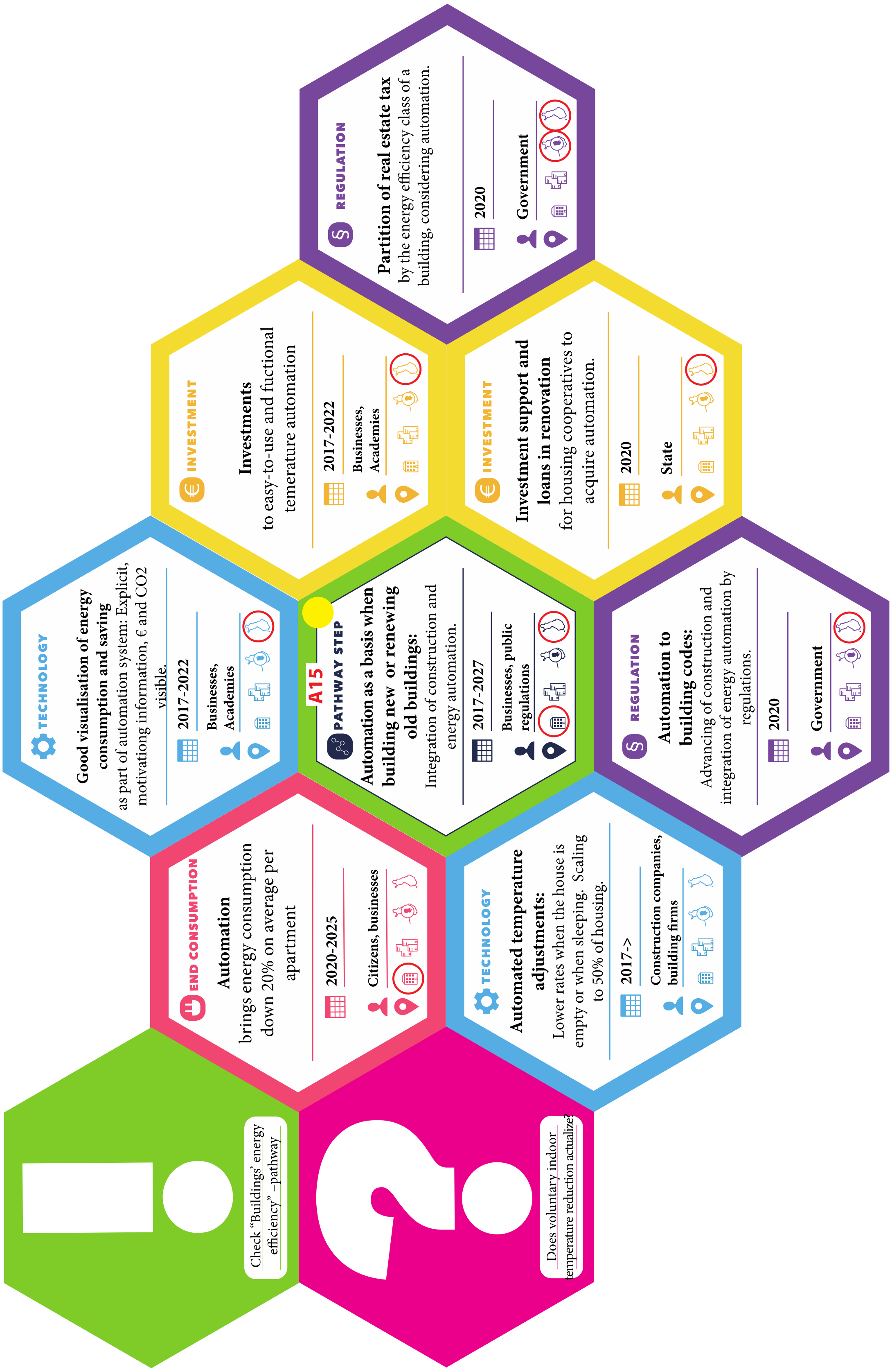

Figure 6. An example of a pathway step for which the facilitating actions have been explored in detail (translated by the authors).

The third phase of the process moves into uncertainties and contingencies. At this point the facilitator changes from blue marker pens and blue arrows to green ones and adds in probability markers of varying lengths (Figure 7). The participants then go through each step and examine the likelihood of the steps; can they occur sooner or later and how uncertain are they? The overall uncertainty factors are already identified in the second workshop of the series and can now be used to gauge the uncertainties related to specific pathways. The participants then add potential contingency responses, which are marked with green arrows, and green-stickered and green-written pathway steps. The outcome is again videorecorded. The very final phase is that of considering the alternative, mutually exclusive change pathways to the original pathway. These are identified with red-stickered steps, red texts and red arrows. This step is done last because alternative paths typically require rearranging the original paths and thus the originals must have been first documented without interference from mutually exclusive paths or steps.

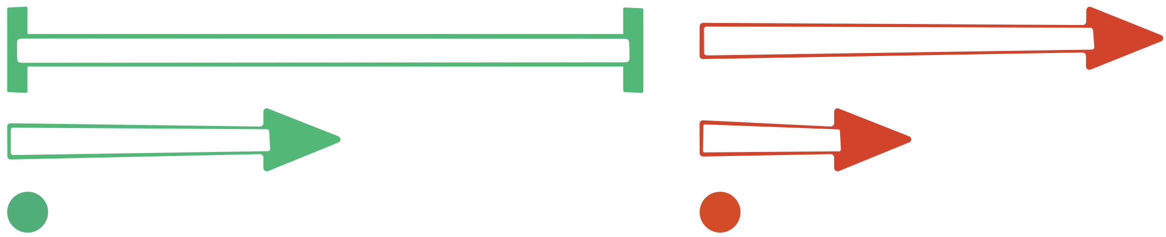

Figure 7. Uncertainty arrows, probability markers and stickers (left) and alternative arrows and stickers (right).

Once the entire pathway is complete it is digitized and uploaded on the password-protected support website of the transition implementation arena. If pathway construction is spread to multiple workshops, incomplete pathways can also be digitized and shared in the platform to allow between-sessions commentary.

Pathway creation relies heavily on following the procedures, facilitator assistance and her or his actions to keep both the participant discussion and path construction actions on track. To aid this, both detailed participant instructions and facilitator instructions were created, along with a guide for how to transfer the physical board's state into a digitized environment in a unified way. We found it useful to use two separate people for each board – one working as facilitator and the other as a note taker – who both participated in digitizing the contents. The digitalization was done using InDesign's and Illustrator's ready-made templates that could, in turn, be directly used in the final reporting format of the arena process.

5 The outcomes and participant evaluation of the path creation process and tool

5.1 *Process outcomes*

The transition implementation arena succeeded in creating a range of outcomes: articulating a more ambitious and inspiring energy and climate vision for Finland in 2030; creating an understanding of the change drivers, impediments and uncertainties in achieving an ambitious energy vision; identifying thirty intermediate goals for 2030; and, most importantly for us here, creating eight detailed pathways of change for the most important transition goals and identifying over one hundred immediate actions to be taken along these pathways. The amount of information which the transition implementation area creates is considerable. Even when heavily condensed, the Helsinki process amounted to a 200-page report (HYYSALO et al., 2017).

The 2030 pathways that were created were as follows: coal is phased out by 2030; creating 2000 MW in demand–response capacity in electricity; creating 2000 MW in demand–response capacity in heating; halving building net-energy use; reducing household energy use by 15% with behaviour-change measures; having 750 000 alternative energy vehicles on Finnish roads by 2030; reducing total mileage by 10% through mobility as a service; and doubling the clean energy technology exports of Finland. Some of these transition goals were such that there was a fair amount of background studies that could be used to ground the work and the participants had already made exercises related to some of them, such as the promotion of electric cars. Some others, such as the ambitious 15% energy consumption reduction through behaviour change and the doubling of cleantech exports, featured greenfield aspects. These paths thus included new ideation over what pathway steps might be sufficient and feasible (even in principle) in order to reach the transition goal. This took more time than anticipated and in such paths the resilience analysis based on contingency factors had to be reduced.

The final report was released in November 2017. It was handed over to a Minister of the Finnish Government and its key messages were discussed in a panel by four members of Finnish Parliament and the head of the board of the largest Finnish public financing agency in an event in which one hundred invitees from ministries related to energy transition, businesses, civil society and academic organisations participated. The report was featured on headline TV news, morning TV and in 16 newspaper articles, which basically covers all the relevant major Finnish media. It further received 250 posts in a “new energy policy” social media discussion group and 30 related blogs and several columns appeared.

Decision to launch three new transition arenas has already been made. The participants in the 2017 Helsinki arena also wanted to hold a monitoring meeting in May 2018 to see if any further coordinated actions were needed and could be ideated among them. There has also been considerable interest from other actors and several discussion invitations from both regime and niche actors have followed. Whist this is promising, it is too early to speak of the research’s societal impact apart from it evidently having gained some attention and interest.

5.2 Path creation tool evaluations

The path creation tool was evaluated by both by the arena participants and the facilitators after the arena process. Twelve statements and an open commentary field were used. The most positive aspects received an average of 4 or above on a 1–5 scale from both participants and organizers; and these were for statements 1, 4, 6, 8, 9 (see Figure 8), which all deal with the overall experience and quality of deliberation in using the pathway creation system. The statements least agreed with were 12, 11, 10 and 5 (see Figure 8 and the discussion below). Statement 7 featured high variation in participant responses and we suspect this to have resulted from ambiguity in the Finnish wording as open-ended questions received mostly affirmative responses on this topic.

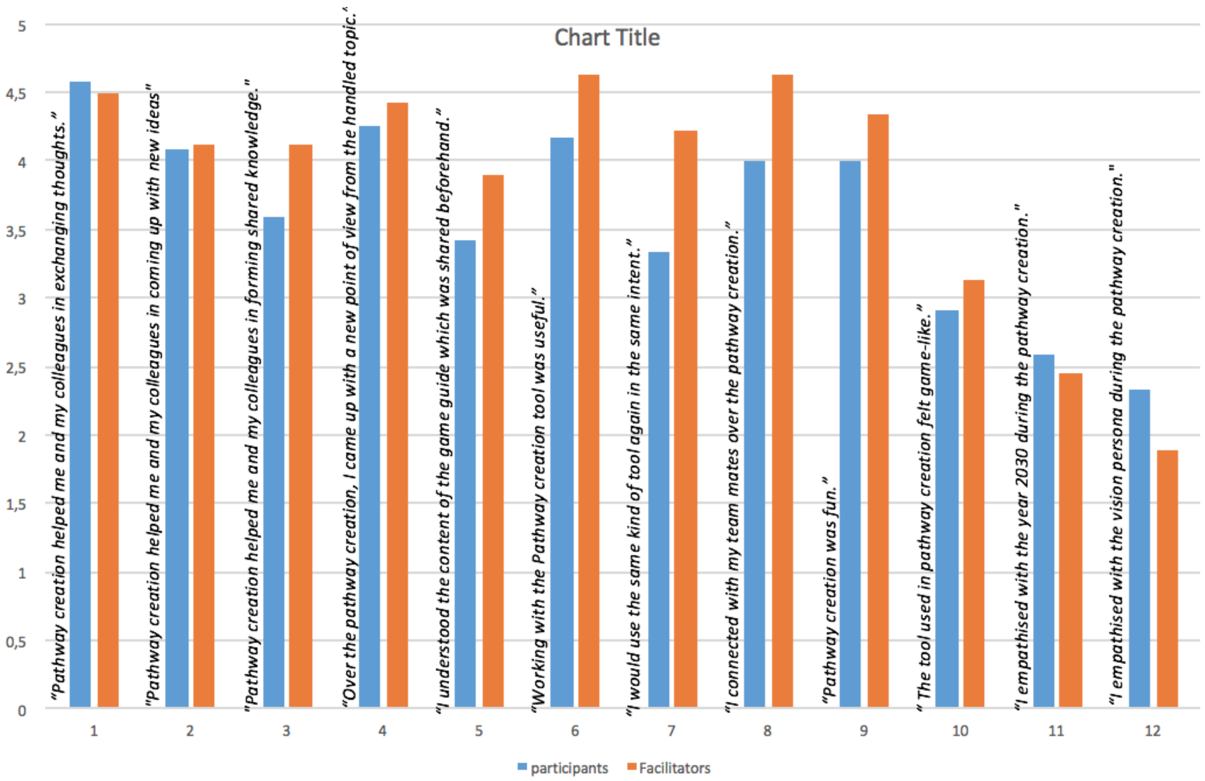

Figure 8. Participant and facilitator evaluation averages of twelve statements about the path creation tool.

The relatively low scores given to statements 11 and 12 regarding envisioning 2030 and empathizing with the vision personas reveal that our attempts at generating a more experiential near future were either not either experiential enough or not seen as relevant given that the focus of the arena was on system-wide actions and the whole mid-range time span. Also our primary aim with the personas had also been to convey cognitive information about the goal state in 2030 rather than generating empathy.

Responses to statement 10, about the pathway creation tool being experienced as a game by and large matched the design team's intention: to borrow elements from game design but retain the path creation tool as a collaborative envisioning tool that would not become too playful or seen as a simulation game. This could have curbed the openness of deliberation among participants. Finally, the averages between 3.5–3.7 for statement 5 (on the provided manuals for the process) draws attention to the time limits that some the busy, highly positioned participants had when familiarizing themselves with the tasks beforehand – the design team's pictorial guide received positive feedback from many participants but it could not be internalized in just two minutes, as some clearly expected to do.

In the final feedback discussion and in open-ended responses, the participants emphasized that the real innovation in the pathway creation tool was that it had forced them to create concrete pathways and be able to notice how difficult it is to carry out such a process and prioritize single, truly relevant steps. The participants were happy about the facilitation of the process and regarded the pathway creation as good facilitation technique which did not feel like 'traditional workshopping, but focused work' (as one participant phrased it). The facilitators' insistence on coming up with documentation instead of talk and on concrete solutions was seen as valuable, as well as the emphasis on identifying causal connections and system interrelations. Several participants also suggested that the process could be applied for several other purposes if it could be somewhat tailored.

[The path creation tool] illustrated the complexity of issues outstandingly, as well as the need for a concrete operation path along with a long-term vision in order to take things in the right direction. The pathway creation tool could/should also be utilized in policy and strategy planning. (participant feedback)

Also, some critical considerations were raised. One participant felt the pathway building process took longer than expected, another felt that the goals, steps, means, immediate changes and measures resulted in too much complexity and a somewhat disorganized way of working. A final critical remark concerned the division work: could the participants not just give short, insightful presentations to each other and then just use free conversation among each other? This implies that the pathways would then be constructed by the organizers for the participants' commentary.

The organizing team members appraisal of the tool was mostly positive, and the tool was voiced to be logical, visually ambitious and pleasant. One facilitator thought that possibly the biggest end result for pathway creation was the new way of working. The qualities of the tool were seen as inseparable from the overall process though:

[Visualizing the pathways] worked well, although it was important that the structure supported iterations since some structuring had to be made. Often success was thanks to the good facilitators and well-selected participants. (an organizational team member)

This also pointed to difficulties in the facilitation process in two groups in which the whole structure of the pathway changed several times, causing plenty of work for the facilitator and note taker. It was also sometimes difficult to distinguish which actions were supposed to be categorized as *pathway steps* and which as actions supporting those steps. Finally, some facilitators were concerned that maybe the pathway creation did not support raising 'extra innovations'.

Overall, the feedback indicates that the pathway creation tool was appraised positively and that it helped the pathway concretization process, the sharing of expertise and the generation of new insights. The limited time frame for creating complex pathways led both the participants and organizers to recognise that some steps and ideas required more refinement, and whilst some refinement could be made for the final report (through rounds of commentary), the participants continued to express willingness to go deeper into the topics after the process. The high level of expertise among the participants and facilitators was a key aspect to successful work in a very fast-paced process, but, at the same time, these same qualities led to a scarcity of time for the process for some participants.

6 Conclusions

In many countries energy policy is undergoing a thoroughgoing shift from ensuring supply capacity to managing system transitions. The dominant energy system, based on fossil fuels, relies on large centralized production units that respond to fluctuating demand. With the increase in intermittent renewable wind and solar energy, energy efficiency measures, demand response and storage solutions, and active prosumer roles the energy system is moving towards far higher distribution and interactivity. The real question is of how each country and region can move from the current system to the future one – not only is the transition complex to manage but the policy and business cultures in the energy sector are not geared towards transitional thinking.

To catalyse the needed changes, methods of transition governance provide an important alternative. In the course of the current paper we have discussed how codesign for sustainability transitions can help improve the means used in transitions governance. The redesign of the path creation toolsets and procedures rendered the transition arena work better suited for mid-range planning, they aided more effective participant interactions and deliberation, and they elaborated one way to adjust transition governance to the specificities of country contexts (contexts which feature important variation).

The design challenges for the pathway creation system outlined in Section 2 were mostly well addressed by our design when judged by the participant and facilitator feedback. The notation, elements and procedures we developed were sufficient for fast-paced multidisciplinary teamwork in the arena. Embedding these into templates and materials that could be easily and flexibly altered appears to have been a good solution too. Regarding shapes, hexagons are used in countless board games and their affordances for combinations (as well as potential future alterations) are thus well known. The dimensioning of elements and the metallic board also worked well and produced the kind of conditions for small group work that we envisioned. Opting to use off-the-shelf materials that could be easily altered, shared and ordered (basically 2 mm thick refrigerator magnet material, plain iron sheets with a taped pattern on top, the WordPress based website, forms and digital easily adjustable templates made with InDesign, Illustrator and MS-Word) worked well by and large. The easy production of elements currently allows ongoing tailoring of the arena elements for different contexts. To aid documentation and commentary, the physical tools were paired with digital templates to which the form and content could be relatively easily transferred, and these digital elements worked sufficiently for documentation and commentary. Regarding the procedures and facilitation, the creation of a clear procedure for the pathway creation process allowed for creating participant and facilitator guides, which proved useful the arena process. At the same time, the pathway creation system does not work as a stand-alone kit (at least, not yet) and requires facilitator training and domain-specific background info package creation, and it is greatly helped if facilitators have domain knowledge that allows them to take the initiative in shaping the unfolding path on the pathway canvas. Video tutorials could potentially be made to lessen the training needs in the future. Overall, both participants and organizing team members found the path creation system to improve interaction, the quality of discussions and in particular to anchor the discussion in concrete changes.

This work has implications for both design for transitions and design for governance more generally. Regarding designing for transitions, our work illustrates that there is plenty of important work designers and design researchers can pursue to enhance the main avenues of transition governance that have been set in motion by social scientists. Whilst transitions governance has a considerable multidisciplinary community and a history of analysing and fostering long-term systemic change (and it may well be illusory for design researchers to seek to ideate replacements for these models), the means used to facilitate these complex processes benefit from more targeted design.

Sustainability transitions affect wide constituencies of society and, as Voss et al. (2009) point out, this calls for wide civil society engagement, in other words, it calls for various forms of designing for governance. Codesign for sustainability transitions can take many forms, such as means created to aid multi-sectoral deliberation. At the same time our experience underscores that designing for governance is most effective as a multidisciplinary team effort in itself. The Helsinki transition arena redesign was pursued together with the SET-consortium policy and innovation scholars who have experience of years of interaction with relevant civil servants, politicians, business people, NGOs and so on. The in-depth domain understanding of policy cycles, remits, and persistent and current challenges in different governance institutions was vital for the success of our design. The domain knowledge was used to anticipate the issues that needed particular attention, tuning facilitators in the workshops, estimating participants' available time allotments, attainable goals and so on. Storming in with just the design team would have been far less likely to succeed.

Even though the pathway creation system worked well in the arena process, there are some clear avenues of further design and experimentation. Firstly, in the future the documentation procedures should be developed further to ease the transfer of content and form from the pathway boards to the digitalized environment. Illustrator and InDesign templates were found to be somewhat alien by anyone other than designers, and hence more commonly used programs could be explored for the purpose as most arena facilitators will not be designers. Ultimately, automatic digitalization would be preferred. Secondly, the transition arena process and tools should next be given to a city, regional or ministry "owner" who would take the main responsibility for the process and its documentation, and the design researchers would only facilitate the process and be consulted about it. This may foster higher ownership of the results and reduce the workforce demands that were high in the current arena process. Third, the current pathway formation processes ended up varying facilitation techniques, ranging from a relatively structured one implicated by our facilitation instructions to lose, iterative and more discussion-heavy processes. Thus far it seems that the more structured facilitation is, the more effective it is and the less it sacrifices the quality of deliberation, but this should be tested in the future by running same pathways construction tasks with varying facilitation styles.

Acknowledgements: This work was supported the Strategic Research Council of Finland consortium 293405 “Smart Energy Transition: Realizing its potential for sustainable growth for Finland's second century”.

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Design as a Catalyst for Sustainability Transitions

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doi: 10.21606/dma.2018.292

Transitions towards sustainability need for radical and structural changes in the social, cultural and organisational dimensions in addition to technological innovations and infrastructural changes. Sustainability transitions have been a research and practice agenda for several decades. Currently, a new area in design for sustainability field is emerging that bridges the theories and practices of sustainability transitions with theory, education and practice of design. In this paper, we investigate the emergence and evolution of this new area through a literature review of selected publications that represent the current approaches of integrating the theories of sustainability transitions and design. We provide an overview of the current status of the field as well as a comparative analysis of the main contributions regarding their theoretical groundings, sustainability definitions/measures, framings of role of design(ers) and methodological propositions.

sustainable design, design for sustainability, transition design, sustainability transitions

1 Introduction: Sustainability Transitions and There Comes Design

We are going through quite troubled times. This is not the first time; even if we forget about our struggles through millennia with wars, plague and other epidemics, natural disasters, brutal emperors and several other ailments that has shaken our civilisation (and caused the demise of some others') and focus on the last 100 years there have been many moments of existential anxiety for us, "humanity". In the past 100 years, we have been through two World Wars, witnessed horrifying genocides, survived the Great Depression (and few other global financial crises), lived under the threat of a potential nuclear holocaust, been through the long and shivering winter of the Cold War, witnessed two major nuclear plant -one in Chernobyl and one in Japan-, and several severe chemical plant accidents. None of these troubled us - at least in retrospect - as much as the current complex of globally significant, some of which mutually reinforcing, socio-ecological problems. The earlier problems were either human-induced-trauma-on-human, or, in the case of natural disasters, were more or less spatially and temporally contained, even if devastating. Today we are more troubled than ever. For example, we know that the impact of anthropogenic climate change on oceans may last longer than modern human settled societies have been on Earth (Norris et al., 2013). If the state of oceans in some hundred thousand years into the future is not a sufficiently cathartic framing of how troubled we are, let's put things into more of a perspective that we can hopefully relate to.

The "Planetary Boundaries" framework (Rockström et al., 2009; Steffen et al., 2015) sets out precautionary boundaries -a safe operating space- for nine critical processes of human-driven environmental change. According to this framework, currently two (biosphere integrity and biochemical flows) out of nine boundaries have been severely breached posing high risk, two of them (climate change and land-system change) breached these boundaries posing increasing risk and two boundaries (novel entities and atmospheric aerosol loading) are yet to be quantified. Only three of the nine boundaries (freshwater use, ocean acidification and stratospheric ozone depletion) are currently not breached. Beyond these nine boundaries, we all face the possibility of abrupt, large-scale changes in Earth system functioning and significant risks to societies and economies worldwide. In addition, emission reduction targets that are required to reduce the risk of severe climate change are still not being met and the window to limit average global temperature rise between 1.5 to 2 degrees centigrade compared to preindustrial levels is closing (Raftery et al., 2017, UNEP, 2017). Raworth (2012), developed the concept of social foundations to complement the planetary boundaries framework and argued for a "safe and just operating space" which lied between the environmental ceiling and social foundations. The social foundations she identified include food security, water and sanitation, health care, education, energy, gender equality, social equity, voice, jobs, resilience. She demonstrated through illustrative indicators that humanity is currently falling below these social foundations for which data are available.

These and numerous other studies triggered the acknowledgment of an urgent need for radical and transformative restructuring of socio-technical systems that meet our needs (Ryan, 2013). Stemming from the acknowledgement of this urgent need, starting from early 1990s, a new area of research emerged out of science and technology studies field and matured over the past two decades. This field is often referred to as system innovations and transitions to sustainability, or shortly, sustainability transitions (Geels, 2005; Loorbach 2010). Sustainability transitions require institutional, social/cultural, organizational as well as technological change (Loorbach, 2010); that is, they need to take place at societal level. Recently, Gaziulusoy and Ryan (2017a) have argued that transitions are creative, technical and political design challenges that require imagining new systems, evaluating system concepts and developing those that are promising and, designing participatory deliberation processes to attend to the political nature of transitions. Ceschin and Gaziulusoy (2016) have analysed the evolution of design for sustainability (DfS) field over a couple of decades since its early conception. Their analysis indicated that the field has enlarged its scope both in terms of timeframes and with references to complexity of problem and solution contexts over the years and moved from a palliative position to one that is strategic. They have identified a new research and practice area emerging in the DfS field since the beginning of this decade responding to the acknowledged urgency of action and the requirement for structural societal transformations, partly influenced by the then maturing system innovations and transitions theories. Ceschin and Gaziulusoy (2016) categorised the contributions in this emerging DfS area under socio-technical innovation level in the hierarchical evolutionary framework they developed. In this framework, socio-technical innovation category resides at the top-most level and subsumes spatio-social, product-service system, and product innovations.

In this article we present a comparative analysis of the main contributions into this new DfS area focusing on their theoretical groundings, sustainability definitions/measures, and proposed methodologies and methods with the purpose of providing an overview and current status of this emerging area and establishing ground for identifying future research directions

2 Design and Sustainability Transitions: A Short History

It is difficult to pin point an exact start for evolution of thought in an area for the same reasons that it is not possible to put an exact date on when a particular species emerged; evolution is a continuum. The best dating practices investigate tangible evidences -traces, remains - left behind to identify the earliest time of appearance. In the case of thought, those evidences consist of text; pieces of writing materialising thought through words. Therefore, we investigate the emergence and evolution of this new DfS field integrating sustainability transitions and design as reflected in writing. Our method of gathering together the written material has two parts. First, as contributors of this emerging area we already have in-depth knowledge of the published work, particularly in the academic fora. This set of publications establish a link between design and sustainability transitions. Second, in order to account for work we may not be aware of and also to include grey literature, we followed a systematic search in google and in main academic databases which cover design titles. As we tried to find those work that integrate design (as a discipline) and sustainability transitions we searched for these and close variants in title, abstract and keywords. We have filtered the search results for disambiguation. Table 1 provides the final list of publications as relevant for our purpose.

Table 1. List of publications used in constructing a history of integration of design and sustainability transitions

Resource (by year)	Title	Type of document
Brezet (1997)	Dynamics in ecodesign practice	Journal article
Young et al. (2001)	Exploring sustainable futures through 'Design Orienting Scenarios' – The case of shopping, cooking and eating	Journal article
Cipolla & Peruccio (2008)	Proceedings of the Changing the Change: Design Visions, Proposals and Tools, An international conference on the role and potential of design research in the transition towards sustainability	Edited conference proceedings
Ryan (2008a)	Climate Change and Ecodesign	Journal article
Manzini (2009)	New design knowledge	Journal article
Dewberry & Johnson (2010)	Design interventions, prediction and science in the sustainable transition of large, complex systems	Conference article
Gaziulusoy (2010)	System Innovation for Sustainability: A Scenario Method and a Workshop Process for Product Development Teams	PhD thesis
Joore (2010)	New to Improve, The Mutual Influence between New Products and Societal Change Processes	PhD thesis
Kossoff (2011)	Holism and the Reconstitution of Everyday Life: a Framework for Transition to a Sustainable Society.	PhD thesis
Ceschin (2012)	The introduction and scaling up of sustainable Product-Service Systems: A new role for strategic design for sustainability	PhD thesis
Gaziulusoy, Boyle & McDowall (2013)	System innovation for sustainability: a systemic double-flow scenario method for companies	Journal article
Ryan (2013)	Critical Agendas: Designing for Sustainability from Products to Systems	Book chapter
Ceschin (2014a)	The societal embedding of sustainable product-service systems. Looking for synergies between strategic design and transition studies	Book chapter

Ceschin (2014b)	How the Design of Socio-technical Experiments Can Enable Radical Changes for Sustainability	Journal article
Heiskanen et al. (2014)	User involvement and radical innovation: The case of heat pumps in Finland	Book chapter
Gaziulusoy (2015)	A critical review of approaches available for design and innovation teams through the perspective of sustainability science and system innovation theories	Journal article
Gaziulusoy & Brezet (2015)	Design for System Innovations and Transitions: A Conceptual Framework Integrating Insights from Sustainability Science and Theories of System Innovations and Transitions	Journal article
Irwin (2015a)	Transition Design: A Proposal for a New Area of Design Practice, Study, and Research	Journal article
Irwin (2015b)	Transition Design: A new area of design research, practice and study that proposes design-led societal transition toward more sustainable futures	Monograph
Irwin, Tonkinwise & Kossoff (2015)	Transition Design: An Educational Framework for Advancing the Study and Design of Sustainable Transitions.	Conference article
Joore & Brezet (2015)	A Multilevel Design Model: the mutual relationship between product-service system development and societal change processes	Journal article
Kossoff, Irwin & Willis (2015)	Transition Design	Editorial for a journal special issue on Transition Design*
Kossoff, Tonkinwise & Irwin (2015)	Transition Design: The Importance of Everyday Life and Lifestyles as a Leverage Point for Sustainability Transitions	Conference article
Mateu (2015)	Design in Transition, Transition Design	Conference article
Ceschin & Gaziulusoy (2016)	Evolution of design for sustainability: From product design to design for system innovations and transitions	Journal article
Gaziulusoy & Ryan (2017a)	Roles of design in sustainability transitions projects: A case study of Visions and Pathways 2040 project from Australia	Journal article
Gaziulusoy & Ryan (2017b)	Shifting Conversations for Sustainability Transitions Using Participatory Design Visioning	Journal article
Gaziulusoy & Ryan (2017c)	Imagining Transitions: Designing a Visioning Process for Systemic Urban Sustainability Futures	Conference article
Hyysalo, Johnson & Juntunen (2017)	The diffusion of consumer innovation in sustainable energy technologies	Journal article
Mok & Hyysalo (In Press)	Designing for energy transition through Value Sensitive Design	Journal article

*This special issue has 10 articles which are not separately listed here

The list of publications in the table is indicative of emergence of ideas and themes that now constitute the accumulated knowledge informing the ongoing integrations of design and sustainability transitions. It is not possible for us to discuss each entry in this list in detail within the scope of this article. Nevertheless, we would like to go over what could be considered as "key points" in the publications timeline that can assist with establishing a historical understanding of origins and development of thought at the intersection of design and sustainability transitions.

Brezet (1997) is the earliest resource that mentions system innovation in the context of design. In this now very difficult to find print article, he identifies four types of *ecodesign innovations* with increasing potential of environmental improvements*:* product improvement, product redesign, function innovation and system innovation. He explains system innovations as changes that are required in infrastructure and organisations as a result of new products and services. This resembles to an early, perhaps somewhat premature definition of system innovations that is now one of the core terms in sustainability transitions literature. As defined by Geels (2005), system innovations are transitions from one socio-technical system to another. Brezet (1997) refers to The Dutch National Inter-Ministerial Programme for Sustainable Technology Development (Weaver et al., 2000) which took place between 1993 and 2001. This program was then yet-to-be the precursor of system innovations and transitions research. Brezet (1997) states that in this program scenarios and back-casting is used to "develop a vision for sustainable function fulfilment by systems in the year 2040" (p. 23).

Another key point is when the first conference on design and sustainability transitions - Changing the Change Conference - was held in Turin, Italy (Cipolla & Peruccio, 2008). In this conference 138 papers were presented from 27 countries. The conference highlighted that radical change in lifestyles and ways of meeting needs was required and that sustainability had to become the meta-objective for all design research activity. Although not separately listed in Table 1, among these 138 papers, as indicative examples of the content, Ryan (2008b) argued for design-visioning for paradigm change, Vezzoli, Ceschin & Kemp (2008) established a link between design and transition management and Boehnert (2008) discussed what designers can learn from the Transition Towns movement.

Between 2010 and 2012, first PhDs that established a link between design and sustainability transitions were completed. Gaziulusoy's (2010) work was situated at the intersection of sustainability science, system innovations and transitions theories and design theory. Joore (2010), on the other hand, situated his work tightly within industrial design engineering, exploring the mutual influence of new products and societal change processes. Ceschin (2012), situated his work within the maturing research area of sustainable product-service systems (SPSS) and argued SPSS can be considered as system innovations as they require changes in user practices, organisational structures, regulatory frameworks and culture. These three PhDs were similar in the sense that they all referred to and used multi-level perspective of system innovations (Geels, 2005) and other models and theories of system innovations and transitions literature in constructing their theoretical/conceptual frameworks. They also focused on product (understood in a broad sense) development and each differently demonstrated how the work of designers is or can be linked to societal change processes for sustainability. Kossoff (2011) on the other hand followed a very different path. He argued that it is the everyday life that needs to be sustainable. He referred to contexts within which most pre-industrial societies satisfied their needs as *domains of everyday life* and argued that the relative sustainability of those societies stemmed from their control over satisfaction of needs (rather than top-down control of needs satisfaction in modern societies) in holistic ways. His understanding of design - particularly transition design - should be an activity of everyone and should constitute facilitating emergence of nested domains of everyday life and make them *whole.*

Building on ideas of Kossoff (2011), Irwin (2015a) published an article presenting a transition design framework for design education, research and practice. This article has coined the term transition design and popularised it within the broader community of design academics and practitioners. She situated transition design as an emerging area at the end of a design continuum, following service design and design for social innovation, thereby, making links between transition design and other new areas of DfS. In 2012, Carnegie Mellon University, School of Design have started to implement curriculum formulated using transition design as an umbrella framework across all levels of design education (Irwin, 2015c). In 2015, the first journal Special Issue on transition design was published (Kossoff, Irwin & Willis, 2015).

The other key points include a first, exploratory study on the roles of design in transition processes (Gaziulusoy & Ryan, 2017a), explicit use of particular design approaches in transition projects (Mok & Hyysalo, In Press), and investigations of evidences of user involvement in the design and diffusion of new technologies in transition projects (Heiskanen et al., 2014; Hyysalo et al., 2017).

3 A Comparative Analysis of Contributions at the Intersection of Design and Transitions

According to the analysis presented in the previous section, we observe that origins of integration of design with sustainability transitions goes as far back to late 1990s. At the time, the thinking was situated in ecodesign - the dominant framing at the time of design dealing with sustainability challenges - and predominantly focused on resource related challenges imposed by production-consumption systems. We observe early endeavours of situating *the social* and *everyday life* at the core of DfS dealing with radical system changes in the work of Young et al. (2001). It was inevitable this expansion of scope has come about as, even in the very early connection Brezet (1997) made with design and system innovation, there is acknowledgement that such large-scale changes cannot be addressed solely at product development level but there is a need for infrastructural and organisational changes. This realisation is evident in the work of Gaziulusoy (2010), Joore (2010) and Ceschin (2012) who, although focused on product development, saw this activity as systemically situated in the larger context of societal changes. The geographical diversity of Changing the Change Conference of 2008 is evidence that sustainability transitions related thinking in design across the board was well underway before the first PhDs in the area were completed. Late 2000s and early 2010s have seen a significant influence of system innovations and transitions theories (Geels, 2005; Loorbach, 2007; 2010) in DfS work. These theories provided *some foundations* on how socio-technical transformations happen and how they can be steered so that design researchers could start to establish links between design theory and practice and sustainability transitions. The three PhDs mentioned above, although fundamentally based on system innovations and transitions theories, generated a set of theoretical (and operational) frameworks with similarities but also differences. Kossoff (2011), on the other hand, situated his work in philosophy, social ecology, and everyday life discourse without any reference to system innovations and transitions theories.

Table 2. Theoretical foundations of selected work

Contributions	Theoretical foundations
Gaziulusoy (2010); Gaziulusoy, Boyle & McDowall (2013); Gaziulusoy & Brezet (2015)	Sustainability science; complex adaptive systems; system innovations and socio-technical transitions theories; futures studies (scenarios)
Joore (2010); Joore & Brezet (2015)	Industrial design; systems engineering; sustainable product development; system innovations and socio-technical transitions theories
Ceschin (2012); Ceschin (2014a; 2014b)	Product-service systems; strategic design; system innovations and transitions theories; strategic niche management
Kossoff (2011); Kossoff, Tonkinwise & Irwin (2015); Irwin (2015a); Irwin (2015b); Irwin, Tonkinwise & Kossoff (2015)	Chaos and complexity theory; Goethean science; holism; needs theory; everyday life discourse; indigenous knowledge; post-normal science; social psychology; social practice theory; alternative economies; socio-technical system innovations and transitions theories

Following this line of thought, in this section we provide a comparative analysis of contributions selected from Table 1 that are representative of the current diversity of work that builds bridges between design and sustainability transitions. In this comparative analysis, initially we try to delineate theoretical origins of these contributions. As all of the work under analysis are highly integrative in their nature, it is not easy to single out a body of literature as *the* foundational theory each contribution is based on; they are situated in or make use of a multiplicity of disciplinary lineages and bodies of literature. In addition to the multiplicity of theoretical foundations of each contribution, there are also overlaps between contributions. Some of the contributions are either based on or incrementally expand earlier contributions. We have grouped these together. Table 2 presents theoretical foundations of selected contributions.

In addition to delineating theoretical foundations, we also tried to understand how sustainability is framed and measured, how the roles and agency of design are framed or implicated, and what kind of methodological frameworks and methods are proposed by these contributions.

3.1 Framing and Measures of Sustainability

Gaziulusoy's (2010) work (see also subsequent publications, Gaziulusoy, Boyle & McDowall, 2013; Gaziulusoy & Brezet, 2015) is significantly influenced by the ideas of sustainability science, particularly by complex adaptive systems theories. According to her framing, sustainability is a systemic property therefore talking about sustainability at product level is not possible without references to the system the product is embedded in. Sustainability is not an absolute property; it can only be established relative to the nominal lifespan of the system to be sustained. Whether the subject system has reached its nominal lifespan can only be assessed ex post facto. Therefore, sustainability cannot be measured (at least in absolute terms) but sustainable systems can be envisioned and enacted upon across relevant system levels and timeframes. She argues for adoption of the strong sustainability model in system innovations and transitions projects as well as in company strategies which informs product development. Her central focus for intervention is companies because, she argues, companies are critical actors in sustainability transitions; they influence and are influenced by societal visions of sustainability and they frame the direction of product development through strategy.

Joore (2010) does not take up a mission for developing an elaborate frame for sustainability. Instead, he simply adopts a definition from an earlier work by Tukker and Tischner (2006); that is causing minimum negative environmental impact while maximizing social well-being and maximizing economic added value. Because his aim is not to propose alternative theories, but instead through an integrated reading of existing theories, to investigate the role new products can play in societal level change, and it is only consequential that the context his work is embedded in deals with sustainability transitions, it is understandable he does not confront the challenge of dealing with elusiveness of sustainability as a research term. Ceschin (2012) on the other hand, although minimal, provide some discussion touching on some overarching themes in sustainability discourse such as growth, equity and limits. He argues that sustainability can only be achieved by drastically reducing consumption of environmental resources, at least by 90%, compared to the average consumption by mature industrialised contexts, and by equally distributing them.

Kossoff (2011) is critical of the work of *mainstream* academic work on sustainability as being more about preserving the status quo than challenging the fundamental assumptions upon which our current society has been established. He argues that sustainability requires not only ecological, social, economic, but also cultural, political, existential problems to be addressed so that *everyday life* becomes sustainable *again* across its all *domains*. He is against quantitative framings of sustainability and advocates qualitative understandings that incorporate non-utilitarian, in addition to utilitarian, human activities. He defines sustainability as *wholes of everyday life* and counts self-organization, participation, emergence, multiplicity in unity, intrinsic relatedness, and meaningfulness in the everyday life of specific places as indicators of sustainability. It is understood that the work of Kossoff (2011) has influenced the subsequent discussions and framings in Kossoff, Tonkinwise & Irwin (2015); Irwin (2015a); Irwin (2015b); Irwin, Tonkinwise & Kossoff (2015) as these do not discuss in detail theories that inform framings of sustainability but reflect the ideas elaborated in Kossoff (2011). The position adopted in these works can be summarised as sustainability being a place-based property of globally networked communities, informed by evolving visions which propose whole lifestyles and diffuses in everyday practices.

3.2 Agency and Role of Design(ers)

In Gaziulusoy's (2010) framing, designers are significant actors in sustainability transitions as they are going to create the new products, services, and meanings within new socio-technical systems. But, despite this significance, they have partial agency in influencing change at societal level. This is partly because their work takes place in the operational timeframe of transitions so they are bound by short-term requirements that are imposed on through company strategy. Therefore, in her theoretical framework, company strategy plays an intermediary role translating diffuse, long-term, societal-level visions of sustainability into concrete decisions at design level in the short-term. Similarly, company strategy plays an intermediary role for design level to take part in societal-level vision-making. According to Joore (2010), the role of design(ers) varies at different system levels from *normal* product design to visualiser and co-thinker of visionary future solutions. This, in a way, is similar to indirect agency as framed by Gaziulusoy (2010). In Joore (2010), the agency of designer is high and direct at product development level but as the scope of the system get larger, the agency decreases and the role becomes indirect or diffused. According to Ceschin (2012), designers can (and should) play multiple roles in sustainability transitions. These include designing sustainable product-service systems, designing transition paths for societal embedding of these and designing socio-technical experiments within which new sustainable product-service system concepts be ideated and developed.

Gaziulusoy (2010), Joore (2010) and Ceschin (2012) draw pictures of designers who are more or less similar to current generic designer archetype with somewhat expanded skills and knowledge base as well as implied attitudes and values aligned with sustainability. It is not difficult to imagine these designers being educated in our present university programs. However, the same cannot be said for the picture Kossoff (2011) draws. According to him the fundamental task of the transition designer – and everyone can be one – is to facilitate the emergence of domains of everyday life which have gone into decline through modernity and protect or repair the relationships at all levels of scale that exist between people, nature and artifacts. A transition designer discusses, conceives and plans, for example, a compost heap at the household, a citizen assembly at the city or ecological education at the regional levels – he/she is a multi-faceted, place-based activist. Irwin (2015a), Irwin (2015b), Irwin, Tonkinwise & Kossoff (2015), rather than the role of design(ers) in detail, qualities of a mindset and posture that transition designers should adopt that are aligned with imagining and bringing into existence place-based sustainable everyday lives.

3.3 Methodological Frameworks and Methods for Design

Gaziulusoy (2010) (also see Gaziulusoy, Boyle & McDowall, 2013; Gaziulusoy & Brezet, 2015) developed an operational tool for the use of design and innovation teams to align their day-to-day decisions and strategic outlook with unfolding and upcoming sustainability transitions. This operational tool - a scenario method - integrated explorative and backcasting scenarios approaches in order to causally link present reality with future aspiration. Ceschin (2012; 2014) also developed a very elaborate tool set for practicing designers. This tool set included tools to formalise SPSS concept visions, tools to develop and formalise transition strategies, tools to manage the network of actors and, tools to monitor and evaluate the transition process.

4 Conclusions

In this paper we reviewed the short history of an emerging DfS area that deal with sustainability transitions. We found that the history of the area goes as far back as to late 1990s, initially influenced by the The Dutch National Inter-Ministerial Programme for Sustainable Technology Development. The maturation of system innovations and transitions theories facilitated the emergence of sustainability transitions thinking in design. Currently, there is a diversity of theories influencing theoretical development and practice in this new area including sustainability science, complex adaptive systems theory, systems innovations and socio-technical transitions theories, futures studies, product-service systems, strategic niche management, needs theory, social practice theory, Goethean science, holism, indigenous knowledge, post-normal science, social psychology and alternative economies. This diversity indicates a lack of unified foundational theory on one hand, on the other hand it presents a picture of potential directions the field can evolve towards. In the coming years, there will be a need for putting effort into developing rigorous theoretical foundations for the field that will support, improve and complement the ones that already exist. There is still a need for further delineating the roles design can play in transitions processes as the work undertaken so far has been mostly exploratory or speculative. The observed preliminary adoption of the field in practice can provide fruitful empirical input into these theoretical developments and also can assist with development of practice-relevant models and tools. Empirically informed theoretical developments can be instrumental in testing the foundational assumptions that seem to have informed some theoretical models proposed so far and can assist in scientific development of this area to potentially become ground breaking in parts of design theory and practice that deal with sustainability in general and sustainability transitions specifically. The implications of this emerging area on research, education and practice of DfS specifically and design in general is thus significant.

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Section 10.

Tools of Design

Editorial: Tools of Design

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doi: 10.21606/dma.2018.009

> *"[Tools] exist so that we may do more, see better, gather information, transform things, make decisions, investigate new frontiers, interact more fluidly and precisely, achieve higher forms of aesthetic satisfaction—extend our reach." (McCarty & McQuaid, 2015)*

1 Introduction

Tools have been with us as long as humanity; ever since we picked up a stone and used it to crack open a nut. Paleoanthropologist Louis Leakey even considered that "the most significant step that ever was taken in human history, the thing that turns animal into man was this step of making tools to a set and regular pattern" (Meredith, 2011). They are among the first examples of human design (McCarty & McQuaid, 2015) and are integral to how we encounter our surroundings and "attain the results of our imaginings" (Decker in Piedmont-Palladino, 2007).

Tools are the material and intellectual extensions that can augment our physical and cognitive abilities (McCullough, 1998), and, as such, play a crucial role in all aspects of the design process and in various forms. They can be the conceptual frameworks that provide "a vocabulary for constructively intervening in processes of meaning making" (Krippendorff, 2005) or the mechanical machines that help us expand the precision, complexity and scale of our work (Cardoso Llach, 2015). Their manifestation can vary from a general methodological representation of knowledge or processes such as a flow chart (Dubberly, 2004) or even games (Habraken & Gross, 1988) to a specific physical instrument in which certain affordances are embedded (Spier, 1970). Their design and use may be abstract and ad hoc to fit into the early stages of the creative process (Mitchell, 1993) or more structured to integrate into discrete digital programs such as CAD (Loukissas, 2012).

Both for research and design, these tools can act as important catalysts to "realize what did not exist before, to introduce desirable changes in the world, to project the technological, social, and cultural consequences of a design" (Krippendorff, 2005). Being so closely intertwined with our design process means these tools can have paradigm-shifting effects on the insights gathered and designs created. As Culkin (1967) succinctly describes: "We shape our tools and, thereafter, our tools shape us." In the process of designing tools for something, we learn more about that thing, but also make decisions that shape the outcomes that we—and others who use our tools—produce. Especially today, when computation and digital technologies continue to play an increasingly important role in both society and our design process, how can we understand the potential for change these tools have on our designs and the development of the very tools themselves?

The answer to this question is wide ranging; the present additional Tools of Design track cannot attempt to cover the enormous range of topics that could be discussed, but offers a selection of papers that discuss issues very pertinent to design and design research today. The papers range from theory-driven explorations of existing tools used in the design process to reports of more applied investigations of custom designed tools. The authors both draw from the history of the development of certain design tools to understand the impact on the designs we have today, as well as consider how these tools can shape the technologies and designs we create in the future.

2 Developing tools for our design research and creative processes

One of the key parts of the design process is idea generation; gathering and translating insights in a design project into new opportunity areas and potential solutions. In 'Changes in design research: sources and methods of ideas generation in industrial design', Ying Sun, Sander Münster and Carlo Michael Sommer interviewed 12 experienced designers to investigate which sources, methods and tools were used, when, why and what influence they had on the resulting ideas. While acknowledging that the real design process is more non-linear and iterative than simply presented in their work, the authors collect a useful overview—and good starting point for further investigation—of the methods and tools used by designers in the idea generation process.

Card sets are one type of tool that is often used to aid the idea generation process, as well as provide summaries of design methods or offer solutions for specific problems. In 'Card-based tools for creative and systematic design', Robin Roy and Warren James analyse the history of this tool used in the design process and present a new classification for the use and development of them based on an exploration of 72 such card-based tools. Aware that these tools are often mainly used by those who develop them, the authors trial some of the tools, concluding that the card sets that are more likely to lead to more practical design outcomes for both novice and professional designers are those which summarise domain-specific methods that can be applied to real world tasks.

Lulu Yin and Eujin Pei describe a real-world application of a card-based tool as part of a larger toolkit in their paper 'A co-experience toolkit: investigating the issues of the pavement environment and the relationship with elderly pedestrians'. As part of their pavement design research, the authors developed a toolkit to aide those involved in the study of urban planning in better understanding the needs of elderly users. Despite having a fairly specific application, the paper presents a useful case study on how to iteratively develop a tool throughout a project.

As the above project demonstrates, in design research it is very important to understand the user's—often emotionally driven—perspective. In 'Point of View framework: describing the audience's emotional connection to information design artifacts', Soojin Jun examines design strategies that can enrich the user's emotional connection to information design artifacts. Through applying the framework to two information design case studies, the author demonstrates the potential for this tool and a beginning for providing a metalanguage for researchers and designers to more explicitly describe a user's emotional connection to information design.

Turning this idea of emotional connection to information back on ourselves, Francesca Mattioli, Silvia Deborah Ferraris, Venere Ferraro and Lucia Rosa Elena Rampino consider the mixture of biases that may be present in interdisciplinary and cross-cultural teams and present a tool to help reveal differences in interpretations in their paper 'My-bias: A web-based tool to overcome Designers' Biases in Heterogeneous Design Teams'. The research adds a useful tool to not only a designer's individual reflective practice, but other fields in which teamwork takes place, and contributes to an interesting debate on the range of team dynamics required for creativity.

3 Tools to understand and design new technologies

The explosion of computation in our lives today has prompted many authors to consider how we research our interactions with these digital technologies and develop tools to reflect on and explore their potential. One such paper is 'Discovery DiDIY: An immersive gamified activity to explore the potentialities of digital technology' by Marita Canina and Carmen Bruno. Using game-based tools to guide participants through experiential co-design activities that help them understand the business and social potentialities of digital DIY technologies such as 3D printing, the authors demonstrate that this more playful approach has an important role to play in amplifying the emotional involvement of the team and creating a fertile environment for lateral thinking.

Another tool applied to understand projects related to 3D printing is presented in the paper 'Annotated portfolios as a method to analyse interviews' by Marita Sauerwein, Conny Bakker and Ruud Balkenende. An important tool used in the design research process is the qualitative analysis of interview data, with many software programs existing to help structure the process. Here, the authors present the addition of annotated portfolios as an improved method for creating more immediately visual analyses of interview data; a tool to help summarise, categorise and represent information about the elements of a design at multiple levels of interpretation.

A project that applies many of the types of tools described above to understanding how teams can better develop digitally connected products is described in 'Developing a Design Toolkit for the Internet of Things' by Ilaria Vitali and Venanzio Arquilla. Despite not yet being fully tested, the authors' detailed description of the toolkit's development provides useful information for both novice and expert researchers and designers developing new Internet of Things based-products.

Another, more experiential and collaborative tool that aims to explore attitudes towards and develop design insights for a new digital technology—this time autonomous vehicles—is described by Arun Ulahannan, Rebecca Cain, Gunwant Dhadyalla, Paul Jennings, Stewart Birrell and Mike Waters in their paper 'The Ideas Café: engaging the public in design research'. Here, members of the public and experts are brought together in an informal cafe setting to discuss issues relating to autonomous vehicles, such as trust in the technology. While similar to other design research methods such as focus groups, the Ideas Café's open and contextually-located approach allowed conversations to move from one-on-one with experts to sharing thoughts with the whole group, resulting in consensus building and excitement to continue participation in future research.

Another approach for understanding and designing the interactions with an autonomous vehicle that used metaphors and enactment to support imagining and sharing conceptual visions was presented in the paper 'Horse, butler or elevator? Metaphors and enactment as a catalyst for exploring interaction with autonomous technology' by Helena Strömberg, Ingrid Pettersson and Wendy Ju. While acknowledging some limitations in the technique, the authors demonstrated through several workshops that their tool can enhance a multidisciplinary design team's creation of interaction designs for certain scenarios related to autonomous vehicles.

4 Integrating computation into the tools of design

As has been written about extensively, computation is becoming increasingly integrated into our design tools (Bernal, Haymaker & Eastman, 2015). These last papers consider the effect these new technologies have on both our designs and our role as designers. In 'A Study on the Roles of Designers Co-Evolving with Tools', Jeong-Sub Lim and Eui-Chul Jung analyse the faculties of designers and assess how they have evolved throughout the history of computer-aided design tools. As well as providing a good overview of the development of computational design, the authors present an interesting approach for considering how our interactions with these tools will change in the future.

Focusing on one area of computational design tools—specifically, graphic design software—Nolwenn Maudet continues this historical analysis of the changing interactions of designers with these technologies in the paper 'Reinventing Graphic Design Software by bridging the gap between Graphical User Interfaces and Programming'. Identifying a gap between the GUI-based softwares that just mimic the skills of the designer and the programming techniques that require coding skills, the author describes how elements called graphical substrates—customisable interactive visual tools—can improve the creativity and user-friendliness of these computational design tools.

The theme of customisation is continued by Viktor Malakuczi, Loredana Di Lucchio, Alex Coppola and Ainee Alamo Avila in 'Post-Series Design: a tool for catalysing the diffusion of personalisable design'. Discussing how the growth of digital fabrication tools enables the creation of one-off and customisable designs, the authors present a tool to support designers in identifying meaningful opportunities and developing conceptual and computational designs for personalisable products.

Inspiration in a designer's creative process is also often a very personal—and increasingly digital—process. In 'Surfing for Inspiration: Digital Inspirational Material in Design Practice' by Janin Koch, Magda László, Andrés Lucero and Antti Oulasvirta, the authors present the results from a survey that asked designers about their practices for finding inspiration material online. While the proliferation of such sources enables designers to collect a large repertoire of potential design solutions, further developing these tools to include additional information related to the initial designer's experience and process could help users to better trust the material and relate it to their own work.

Apart from the online tools mentioned in the above paper, collecting inspiration and synthesising it into new ideas are currently not supported well by computational design tools. In my own paper, 'An Ontology of Computational Tools for Design Activities', my co-author V. Michael Bove and I present a review of computational technologies that could play a role in these tasks. Using a framework that aims to help designers and researchers more easily understand the potential of these new technologies by deconstructing design activities into more discrete underlying tasks, neural networks and stochastic algorithms were found to provide features that could potentially allow for discovering and linking new information together in unexpected ways.

The ocean of information and possibilities opened up to us as designers and researchers by digital tools such as the internet reflect the same vastness that the Tools of Design theme can have. The papers presented here show only a small part of this wide range of research, many of which focus on the new digital technologies that are becoming increasingly integrated into our lives and creative processes. The almost infinite nature of designing tools to help us design better technologies, which are themselves tools, suggests that designers and researchers have tool-making in our DNA. This is the beginning of a conversation that will hopefully grow and evolve, as will our tools of design.

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DRS 2018 Design Research Society 2018 Catalyst

University of Limerick
25th–28th June 2018

Changes in Design Research: sources and methods of idea generation in industrial design

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doi: 10.21606/dma.2018.561

Design idea generation is a process rooted in individual knowledge and is often considered a precedent-based type of reasoning, where knowledge is continuously transformed to produce new insights. Selecting and organizing inspirational sources has a profound impact on how industrial designers generate creative solutions and creates its own challenges. Many authors have focused on what materials designers look for while searching for inspiration. However, there is less research concerning the approaches used to guide the process of envisioning design solutions when using these sources. Therefore, we conducted open-ended semi-structured qualitative interviews with 12 designers, to learn about how experienced industrial designers select inspirational materials and transform the generated insights into ideas, including the design thinking and mindset involved. The aim is to expand novice designers' knowledge of idea generation.

industrial design, idea generation, design source, design methods

1 Introduction: the gap between empirical research and idea generation

Design projects develop through three stages: inspiration, ideation, and implementation, as Tim Brown (2009), CEO of IDEO, describes. Inspiration means gathering insights from every possible source and identifying an opportunity, whereas ideation means translating insights into ideas and conceiving general solutions. The function of research in the design idea generation process, which moves from inspiration to ideation, is to ensure that the evidence and insight obtained enables the designer to answer the initial question as unambiguously as possible (De Vaus, 2001). The use of inspirational sources and quality of research ultimately affects the design process because it helps define the challenge, and the way problems are solved (Singer, 2003). Moreover, it is the designer who generates, selects, tests, and refines ideas to improve the design problem and arrive at an effective solution. Thus, it is vital for designers to understand how they influence this process via generating creative and innovative design ideas (Gonalves et al., 2014). This is crucial because design idea generation is the activity most frequently associated with creative problem-solving. The ideas generated at this stage are used throughout the creative process. Idea generation is central to the success of the innovative problem-solving process (Herring et al., 2009).

Despite many research efforts, there is still no overall consensus on how best to incorporate the inspirational materials and fieldwork data into the idea generation process. The research literature on design idea generation is still emerging, and more attention needs to be paid to sources and approaches that designers use to generate ideas. Therefore, we investigate how designers choose and use sources of inspiration within the ideation process, to answer these research questions:

1. What sources do industrial designers use in generating design ideas?
2. How do industrial designers transfer sources of inspiration into ideas?

The researchers intend, firstly, to provide a grounded overview of how industrial designers, especially experienced designers, select appropriate inspirational materials and other information. Secondly, we will identify how these sources are transformed into the knowledge that informs the design, the design thinking and mindset involved in the process, to expand novice designers' options for generating ideas with appropriate sources and approaches.

2 Literature review and related work

Given what appears in the literature about design idea generation, we sorted the review into four categories. (1) When: The timing of design idea generation; (2) What: The type of source used by designers to stimulate idea generation; (3) Which: The tools supporting the idea generation process; (4) Who: The expertise level of the designers generating the ideas was compared. Table 1 lists the main categories about design idea generation in the reviewed articles, arranged by year and topic. It was found that most researchers had examined what designers look for while searching for inspiration materials during the ideation phase. Nevertheless, the reasons behind the different sources used during idea generation are still unclear. Moreover, since an outstanding challenge during ideation is to transform inspirational material and other information into ideas or insights that inform design, more structured approaches could be useful to guide the process of envisioning design from inspirational sources. More effort is needed to reach a comprehensive and complete understanding of how industrial designers select and utilize inspirational sources to generate ideas with appropriate approaches, and the design thinking and strategies involved in the process. Such an endeavor would offer a wide variety of sources that help industrial designers, especially the novice designers, to reach beyond the constraints of their world-view and into a new world of choice and diversity (Ireland, 2003).

Table 1. Main categories of design idea generation in the reviewed articles

		When		What (source)							Which (tool)						Who				
				Type of source					Effect of source		Traditional tool						Different level of designer				
Year	Author	Unintentional	Intentional	Pictorial	Textual	Verbal	Tangible	Others	Positive	Negative	Sketching	Collage	Storyboard	Prototypes	Digital Tool	Others	Expert	Professional	Student	Novice	Others
2003	Tovey et al.			●					●		●				●			●	●		
2004	Cross		●				●		●	●	●					●	●				
	Petre	●	●					●	●							●	●				
2006	Mckay		●	●		●			●	●		●							●		
2007	Perttula & Sipila							●	●	●											
2009	Herring et al.			●			●		●					●		●		●			
	Saunders		●						●			●	●			●					
2010	Smith et al.	●	●				●	●	●	●											
	Goldschmidt et al.				●				●								●		●		
	Cai et al.	●	●	●	●			●	●								●			●	
2011	Gonçalves et al.	●	●	●	●	●	●	●	●	●							●			●	
	Mcginley et al.		●		●	●		●	●						●	●		●			
2012	Gerber					●			●					●				●			
	Hallgrimsson						●		●					●	●			●			
2013	Viswanathan et al.			●			●		●	●					●					●	
	Zhao	●	●					●										●			
	Pniewska et al.		●						●	●				●					●		
	Pan et al.										●				●				●		
2014	Gonçalves et al.	●	●	●	●	●	●	●	●	●		●	●			●		●	●		
	Laamanen et al.			●		●	●	●	●		●					●		●			
	Chansri et al.			●			●		●		●				●						
	Sas et al.		●				●	●	●		●			●	●	●	●	●			
	Vijaykumar			●	●			●	●						●			●	●		
2015	Hutchinson et al.		●		●			●	●						●	●			●		
2016	Vasconcelos et al.		●	●	●		●	●	●	●							●	●	●	●	
	Han et al.		●					●	●						●						
	Yilmaz et al.		●	●	●				●	●				●		●	●	●	●	●	
	Bacciotti et al.		●					●	●						●		●	●			●
2017	Tau & Nagai	●	●					●	●										●		
	Mirtalaie et al.		●					●	●							●		●			
	Watschke et al.		●			●			●	●					●				●	●	

3 Method

3.1 *Grounded theory approach*

Grounded theory proved to be a useful approach in the face of the complexity of the phenomenon being studied and seems to hold promise in the domain of user experience design (Pramod & Uday, 2010). Glaser and Strauss (1968) have shown that grounded theories of the social process can be used to generate static models or typologies. On reviewing collected data, repeated thoughts and concepts become apparent. When more data is obtained and considered, codes can be grouped into concepts and categories, and then provide a grounded overview of the researched topic. Therefore, the grounded theory approach is particularly suited to the development of process theories that account for how things happen in social settings. It can support researchers in interpreting and conceptualizing social units. We took this approach, collecting and analyzing qualitative interview data to investigate how designers select appropriate sources and the approaches they take to generate reasonable ideas.

3.2 Sampling

We interviewed 12 experienced industrial designers in different fields such as interaction design, product design, and communication design (see Table 2), six with at least 16 years and four with over 20 years of experience. Because our focus is on industrial and interaction design, all our participants have the related background and expertise. The sample consists of five participants working in academia, six participants working in a company, and one participant working as freelancer, respectively. Nine participants work in Germany, one in Italy, one in the Netherlands, and two in China.

Table 2 Participant profiles

Participant profiles				
No.	**Design area**	**Years of expertise**	**Current position**	**Design practice**
D1	Product design	39	Professor	Academic, Italy
D2	Interaction, visual design, design research	23	Professor	Academic, Germany
D3	Industrial design	20	Professor	Academic, China
D4	Interaction, communication, space design, digital media	20	Professor	Academic, Germany
D5	Interaction, communication design	16	Designer	Company, Netherlands
D6	Product, industrial design	16	Designer	Company, Germany
D7	Interaction, product design, computer science	15	Teaching assistant	Academic, Germany
D8	Interaction, interface, communication, industrial design	12	Interface designer	Freelancer, Germany
D9	Industrial design	10	Project manager, designer	Company, China
D10	Product design, industrial design	9	User experience designer	Company, America
D11	Product, industrial and human center design	9	User experience designer	Company, Germany
D12	Industrial, interaction design	8	Designer	Company, Germany

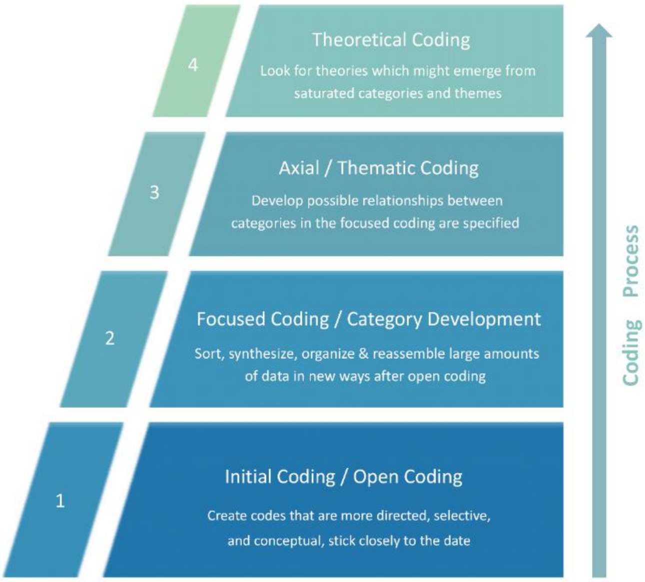
3.3 Data collection instruments

We conducted intensive qualitative interviews to learn about the designers' substantial experience of how they select and use their various sources and transform them into design ideas. Our interviews were semi-structured, combining a set of core questions with the freedom to follow up points as necessary (Zina, 2010). The advantage of a semi-structured interview with open-ended, non-judgmental questions is its capacity for absorbing unexpected statements and stories that emerge, besides acquiring the intended data (Charmaz, 2006). The one-on-one interviews were conducted face-to-face or online (Skype and WeChat) depending on the availability and accessibility of our respondents. The conversions were audio recorded.

3.4 Data analysis procedure

The audio data were entirely transcribed, coded and analyzed. Charmaz (2006) stated that coding is the significant link between collecting data and developing an emerging theory. Our coding procedure is primarily made up of four stages: Initial coding, focused coding, axial coding and theoretical coding, as follows (see Table 3).

Table 3 Four main coding phases



Firstly, the goal of initial coding is to remain open to all possible theoretical directions (Charmaz, 2006). The most crucial rule at this stage is to stick closely to the data rather than applying pre-existing categories. Secondly, the chosen codes at the focused coding stage are more directed, selective and conceptual than many ones at initial coding stage (Glaser, 1978). We aimed at ascertaining and developing the most prominent categories in large amounts of data. For instance, we combined the codes 'user shadowing', 'interview', and 'user experience activity' into the code 'know the people', to have an integrated code representing the common objectives of different methods. Thirdly, we used axial coding to relate categories to subcategories, specify the properties and dimensions of a category, and reassemble the data which had been fractured during initial coding. Axial coding answers the questions "when, where, why, who, how and what consequence," which are inherent to the analysis as building blocks for making theoretical contributions (Whetten, 1989: 490-494). We used a similar framework - what, which, how, what consequences and why to analyze the design idea generation process and chose three participants as examples to present our analysis approach (see Table 4).

We analyzed our interview data within a matrix structure. All the participants' names were put in a row and the interview questions placed in a column. The data could be displayed with one designer per question, but also with all designers related to one question. The participants' sources of inspiration are placed in the 'which' framework. The methods and tools used to transform the sources are put into the 'how' framework, and the reason why participant chose to do so are put in the 'why' framework. We used the collected data and coding to develop a conceptual framework, which provided the initial classification of sources and approaches. The framework was revised and refined as new codes emerged to capture specific types of sources and additional methods. Fourthly, theoretical coding was used to help theorize the collected data and focused codes, in order to understand how experienced designers select inspirational sources and transform these into ideas.

Table 4 Comparative framework used to interpret the generated data

Building blocks to organize data analysis		Participant D2	Participant D7	Participant D12
Who	Background info	**Design area:** Interaction, visual design, design research **Current position:** Professor	Interaction, product design, computer science Teaching assistant	Industrial, interactive design Designer
When	Generation time	Procedural ideas which need constant exploration	After splitting the related design elements, and then integrate	Generate in iterative design process
Which	Source (Input)	Problem or task Other design work Communication to designer/friend/colleague/ user/client/student Observation Fieldwork data Empathy Other designers' work Media Big data Library materials: book Academic: literature research Anthropology: mood board	Problem or task Intuitive thinking Nature Other design work Communication to designer/friend/colleagues/student Multimedia: visual document Experiment: build tool Multimedia: Internet Visual document: movie Academic: literature research Physical electronic Technology	Daily stuff: nature, book Other design work Problem or task Observation, User experience Fieldwork data Communication to designer/friend/colleagues Creative design events Experiment Multimedia: social network Internet: app Technology Market research Biology, Anthropology
How	Method	**Research:** Know context Understand real problems Media search Competitive product Analysis User shadowing Observation Interest group discussion User research Use experience research Briefing workshop Mood board Eye tracking test **Analysis:** Analysis advantages & disadvantages Empathic design Data visualization research Group workshop **Synthesis:** Idea testing Usability testing Sketching Prototype	**Research:** Know context Understand real problems Competitive product analysis Media search Publication search Interview Interest group discussion User research Use experience research Briefing workshop **Analysis:** Analysis advantages & disadvantages Empathic design Group workshop Computer thinking Divide into small parts **Synthesis:** Tool thinking Remove the complexity Sketching Prototype Experiment Producing software as a tool	**Research:** Understand real problems Media search Publication search Industry background Competitive product analysis Experts interview Interest group discussion Personas User research User journey Use experience research User observation Quantitative questionnaire Scenario analysis Brainstorming **Analysis:** Analysis advantages & disadvantages Scenario analysis Observation to insights Insight clustering matrices **Synthesis:** Sketching Prototype Experiment Concept evaluation User testing
	Tools	Sketching Digital prototypes, paper prototypes Software: Rhino, Keynote Programming tools Sensor: Arduino Facility: 3D Printing, computer numerical control Interview Eye tracking	Sketching Visual diary Digital prototypes, paper prototypes Software: Rhino, Grasshopper, Fusion Programming tools: Processing, HTML and CSS Arduino Facility: 3D printing, 3D scanning Tools built by designers themselves	Sketching Visual diary Digital prototypes Paper prototypes Other crafts material
Why	Reason	Distinction between people have to use and people can use Make detailed requirement and need very analytical Can be much more creative Understand the users in domain See what has already been out there Understand the contexts Helpful to generate insights for complex situation Allow designer to talk differently about design Ingenuity plus extra spark equals creative design	As the fundamental part of design work, all design work is based on research, and then deepen and forwarded One of the most important things Find inspiration or solution from field research Assist user to generate idea by observing their language or problems Related products to make design closer to attributes Help to know the whole process of production Know the possibilities in the future	Really important Ideas do not pop up from nowhere, but research Research generate facts which help to design Research about what has been done before Know the problem and what should design Design team made up of developer, designer and researcher Should do research to understand user and the whole project The more research, the better you understand user and generate idea Research gives you lots of insights High level designer should understand research and its value
What consequences	Evaluation	Resolve the problem for people by research Have to be objective Related to user's existing ideology Comforting to use Best to meet the starting point or problem Products have didactic, educational aspect	Satisfaction from client Understand what works sometimes Sustainable idea which could be further investigated and developed	Evaluate ideas with user testing and experiment Evaluate the pre-set parameters from the very beginning Easy to understand and everything in one glance Evaluate the pre-set goals Industrial design is about having surface, interactive, and experience design, all together to be successful

4 Results

From the interview data, it is clear that the 12 designers generated a variety of sources and approaches. The following sections present the results, including the source and method selection in different phases and how inspirational materials were transferred to design ideas. The topics which emerged from our analysis are explained by including direct quotes from the participants. Fieldwork is a significant source at every stage of ideation.

4.1 Sources used by designers to generate ideas

Our interviewees mention various sources, including ‘Daily stuff’, ‘Media’, ‘Emerging technology’, ‘Knowledge of other disciplines’, ‘Fieldwork’, and ‘Design practice’. Table 5 presents all the sources of ideas which the participants mentioned.

Table 5 Types of source designers used to generate ideas

Different types of source					
Daily stuff	Media	Emerging technology	Knowledge of other disciplines	Fieldwork	Design practice
Nature	Internet	Technology article	Mathematics	Observation	Experiment
Material/Structure	Website	Negative report	Ergonomics	Briefing	Problem/Task
Common sense	App	Unpilot craft	Computer science	Requirement	Other products
Personal experience	Book	Artificial intelligence	Biology	User research	Peer's work
Personal interest	Magazine	Big data	History	User experience	Build tool to design
Emotion	Newspaper	Lab data	Sociology	Dialogue stakeholder	Creative design event
Intuitive thinking	Scribble	Sensor	E-commerce	Expert opinion	Rough prototypes
Cultural background	Image	Technology policy	Market research		Documenting
	Game	Electronic components	Mechanical		Visual diary
	Film	3D printing	Anthropology		
		Future application	Psychology		
			Business		
			Management		
			Economics		
			Literature		
			Aesthetics knowledge		
			Other publications		

4.1.1 Daily stuff

Some participants stated that their inspiration comes from their everyday life and daily stuff could be the source of ideas. Nature was a great source of inspiration (D2, D12): “I love contrasting. I learn things from nature, to see what nature does. Then see whether the way could be used in my design” (D12). We could see a significant benefit when participants made good use of nature in their design. Besides, ideas could be generated at any serendipitous moment, which was not necessarily planned. “My idea is kind of put potentially interesting or intuitive things into my head at random so that they pop out at a later time. I need to think about something” (D1). However, almost every innovation is based on a certain degree of research or experience. Idea generation is an accumulation process which needs constant exploration to reach an appropriate and valuable solution. Sometimes designers get stuck at some point, but ideas pop up at times with good accumulation. With more research and accumulative input, ideas are generated more easily and naturally, which echoes an old Chinese saying presented by one participant: “When a melon is ripe, it falls off its stem. When water flows, a channel is formed" (D3). The saying indicates knowledge of things is naturally accomplished upon maturity, which illustrates the importance of research and accumulation in the ideation phase.

4.1.2 Getting the 'state of the art' from various media

The number of media used by participants had increased massively in the digital age. The designer is supposed to keep accessing and updating their knowledge of the required information from various media such as the Internet, new apps, books, magazines, newspapers, games, or movies, to understand the impact of product trends on industrial design. Most designers preferred to use the Internet at the beginning of ideation. "The most important source, I would say, the general Internet. I cannot say which particular part, I focus on the technology aspect, and also the biological aspect. And in general, what is happening in the user experience area" (D12). Besides, because of the information explosion, it is no longer possible for any single designer to comprehend all its facets from different media. There are specific websites designers prefer to check regularly to meet the different requirements (all interviewees) such as Pinterest to find images of related products (D11), Product Hub to know what new products are out there (D8), or Twitter and Facebook to 'like' particular home pages or designers to get the wanted information or updates (D12). There are also specific blogs (D4, D8, D12) such as Tech-crunch on state-of-the-art technology and economic aspects. "The bottom line is to look at my peers' work, which is very important for me. So, I have a few specific blogs I'm looking at. That was changing, but always project documentation like articles about your topics" (D4). At any time, the book is still a significant source which designers admire and can get insights from. "I read a lot of books. You know books are still something I like very much. The books are about different topics such as digital design or product design, some books are quite old now, but for me, the good insights never fade" (D2).

4.1.3 Emerging technology

It appears that emerging technologies are significant inspirational sources for many participants (D1, D2, D3, D4, D5, D7, D8, D9, D12). These interviewees repeatedly pointed out that emerging technology is an essential lens for observing and interpreting information and therefore helpful for generating ideas related to artificial intelligence, 3D printing, big data and so on (D1, D3). "I keep an eye on science and technology development, to get more comprehensive information about technology and their applications. In this information, just some specific stimuli could accelerate the idea generation" (D5). The inspirational source also includes an awareness of the technological space in terms of possibilities and shortcomings: "I mainly focus on emerging technology, especially negative reports of such technology, or some bad result caused by the technology. I try to see these events from different perspectives, which would let me see their improvement direction more easily" (D6). We found that interaction designers in particular (D2, D4, D5, D7, D8, D12), love to follow technology development and trends, understand the impact of new technologies and tools, and be constantly searching for the next big trend which would give them inspiration for ideation: "You might know that Germany decided to get rid of nuclear energy by 2022. I immediately know that the smart home project is a critical area" (D8). The number of Internet of Things devices entering the market has increased massively. New technologies not only open the door to many new design possibilities for end-user products but also offer designers specific directions when generating design ideas. Therefore, emerging technologies may play different roles during the ideation phase, from framing ideas to narrowing the scope of the practical work.

4.1.4 Knowledge of other disciplines

Participants also generate ideas from knowledge or insights from other disciplines besides design, such as mathematics, computer science, biology, history, sociology, anthropology, e-commerce, ergonomics, market research, mechanical, psychology, business, management, economics, literature or aesthetics knowledge (D1, D2, D3, D4, D8, D11, D12). "My design solution for an autonomous navigation system was inspired by the shopping experience of e-commerce, which is very similar to the user experience of the pilotless automobile in my design" (D11). For instance, one participant thought that ideas could be formed in combination with mathematics and behavioral theories.

“When designing a chair, we need to consider sitting behavior, the material and environmental factors, the important discussion with the mathematician about the related parameters, by which group of people it is used, and corresponding sitting requirements by specific groups” (D7). We found that knowledge of other disciplines benefits the designer in different aspects such as overcoming the confines of the design and expanding the interdisciplinary interaction between design and other disciplines. This is also why a design professor suggests that his design students keep being curious about the things around them, “because you need to and can learn from other fields or disciplines. The designer should firstly be curious in the right way and sort information appropriately. They should have their eyes open and constantly discover and then scan things around like a ‘living scanner’. When you know how people live or how products work, you may change a little bit in their daily life” (D1).

4.1.5 Fieldwork

Some participants expressed that insights from fieldwork and design practice are significant for idea generation. Every participant mentioned that knowing the context is essential to locate the problem and identify user needs. “Actually, we had an agenda with the client and some briefing. So we could figure out what they really want and what they want to achieve. That is sometimes not so clear. So we use several briefings and rebriefing to really figure it out” (D4). Communicating with project stakeholders, such as the client, product manager, or fellow designer, also provides the insights during idea generation (D1, D3, D6, D8, D12). “I think it's very important and you need to have this dialogue with the client or product manager, or stakeholders in the project at the beginning a lot to understand what the right question for the right context is” (D9). Most interviewees found user studies helpful in inspiring ideas, including studies of potential, skilled, expert or extreme users (D1, D3, D4, D5, D6, D8, D9, D11, D12). “Extreme users are the perfect source of inspiration because they personalize their products. They do exactly what they need, and they have amazing ideas” (D8). This echoes the statement of Matt Cooper-Wright (2015), an interaction designer at IDEO London, that interviewing a professional racing driver tells you a lot of good driving experience and talking to a professional chef if you need a lot of insights about a food project.

4.1.6 Design practice

Participants got ideas for their practice from other design work, prototypes, experiments, a problem or task, peers’ work, building a tool to design, creative design events, documenting, or visual diaries. For some interviewees, seeing other products and peers’ work or prototypes was important. One compared idea generation with essay writing. “Nobody could write it without seeing other articles. Similarly, you also can’t design without seeing other products. The designer needs to see other products to comprehend in their way and then extracts some elements or small pieces and uses them appropriately to help resolve problems in their design” (D2). With the development of material science, some participants expressed that they get inspired by material tests in practice (D7, D12). “For product design, when you have different materials, you do experiments on this material, do different variation and combination a lot, to see how different things work together” (D7). Moreover, when the client has more individual or customized needs, existing tools might not meet the requirements of the project. At some point participants need to create their own physical or software tool to try ideas out. “I represent a small but still significant group within interaction design. I use a lot of software to develop tools to create ideas. It is a new way of thinking and creating and I have a highly iterative process in the making phase. It is a little bit like you can use software to extend your thinking” (D2). We can see a trend that in practice exploration, like material-driven design or experiment-driven design, provides designers with infinite new possibilities.

4.2 Methods used by designers in different phases

The interviews showed that design idea generation is not linear, but an iterative and generative process. The design idea is not simply generated at the beginning but emerges throughout the design process. There are three significant phases during ideation generation: The ‘research’, ‘analysis’ and ‘synthesis’ stages, which also form an iterative process. In each specific phase, the industrial designer usually applied some methods for various purposes. Table 6 presents all the idea generation methods which the participants mentioned.

Table 6 Idea generation methods which the participants mentioned

Research		Analysis	Synthesis	Generate ideas
Know the context	Know the people	Frame insights	Explore the concepts	
Media search	User shadowing	Analysis workshop	Flowchart	
Publication research	Personas	Brainstorming	Storyboard concept	
Competitor analysis	Use experience activity	Generating randomness	Concept sketch	
Expert interview	Interview	Force associated	Produce software as tool	
Interest group discussion	Field visit	Fishbone chart	Concept prototype	
As-Is process	Cultural probes	Insights clustering matrix	Concept generate matrix	
Keyword bibliometrics	Questionnaire	SWOT analysis	Concept evaluation	
		Analysis pros and cons		
		Observation to insights		
		User group definition		
		User journey		
		User response analysis		
		Empathic design		
		Material experiment		
		Divide into modules		

4.2.1 Research phase

At the research stage, the designer seeks to understand two things: the context and the people. The context includes circumstances affecting the environment in which innovation happens such as the existing products, services, experience and brands.

4.2.2 Understand the context

Participants use several methods during this phase to understand the context of the project. These included ‘media search’ (D2, D4), ‘publication research’ (D2, D12), ‘competitor analysis’ (D2, D9), ‘expert interview’ (D8), ‘interest group discussion’ (D6), ‘As-Is process’ (D10), and ’keyword bibliometrics’ (D12). For instance, interviewees use the Internet to focus on offerings that are similar to theirs and learn about the organization’s relationship to our competitors in the industry. “From competitive products, I would find out their objective user and the business model. It would make my design objectives clearer. I almost do competitive product analysis every time. Because by understanding competitive products, I learn how to keep the advantages and improve on the disadvantages” (D9). The designer also studies what is happening or emerging on the cultural landscape via the Internet and other publications. “I think everyone starts at Google. Well, you have to understand the domain, and I think it is also one of the most charming things about design that you cannot be very sure about a new domain” (D2). By doing expert interviews, the designer tries to learn about the latest developments and possible futures of a topic. “I need expert knowledge. In the beginning, I go to the context of experts. It is important, because when I do a design project, I should be a mini-expert in a short time. And I do not know some new topics. It is always a good idea to go to someone who is into this” (D8).

4.2.3 Understand the people

A good design is sensitive to and based on people’s needs and patterns of behavior (Kumar, 2013). “By doing design research, you would understand the market and user requirements more deeply” (D9). Participants mentioned several methods for achieving this, including ‘user shadowing’ (D2), ’personas’ (D12), ‘user experience activity’ (D4), ‘interview’ (D2, D9), ‘field visit’ (D9), ‘cultural probes' (D8) and 'questionnaire' (D6, D7, D9). The participant accompanies the user and observes how they use the product or service within their natural environment via user shadowing. "What I think is really really good is this kind of shadowing that you have that one of the people on the team just really sits next to a person, next to a real user and just tries to follow him or her through the entire day, makes notes and tries to understand how they use the software" (D2). Interviewees also use 'cultural probes', including any sort of artifact (like a map, camera or diary), along with evocative tasks, given to the user to record specific events, feelings or interactions, as a means of gathering inspirational data about their lives, values and thoughts, and thus stimulate the designer's imaginations. "It is a sort of game file or questionnaire. You only need to write your answers. Maybe they give you a camera, take pictures of your daily life. I like it because you can do many different things to find out behavior" (D8). In general, understanding the people is a significant phase in the design process with its focus on empathy, observation, personal engagement and problem-solving.

4.2.4 Analysis phase

With their understanding of the context and people, designers have some background data and pre-knowledge about the project. The next step is to apply appropriate analytical frameworks to the data, to analyze these data and organize their thinking, to frame the insights and ultimately turn them into actionable ideas. The interviewed designers use different methods for this including: 'analysis workshop' (D8), 'brainstorming' (D1, D2, D3, D5, D7, D8, D9, D10, D11, D12), 'generating randomness' (D4, D7, D9), 'forced association' (D10), 'fishbone diagrams' (D10), 'insights clustering matrix' (D6, D8), 'SWOT analysis' (D3), 'analysis of pros and cons' (D3, D6, D11), 'observation to insights' (D9), 'user group definition' (D9), 'user journey' (D12), 'user response analysis' (D8, D9), 'empathic design' (D1, D7), 'material experiment' (D1, D2, D7), and 'dividing into modules' (D7).

Similarly to the sources used from other related disciplines, designers use SWOT analysis, adapted from the field of marketing, to evaluate strengths, weaknesses, opportunities, and threats which may affect a project. As a result, they can highlight the client's needs to create an efficient design with an awareness of potential strong and weak points, establish success factors, identify areas needing improvement and prepare valuable reasons to support their choices. Other methods are adapted from related areas such as fishbone diagrams (also called Ishikawa diagrams) from the business administration field. Each cause for imperfection is a source of variation, and causes are usually grouped into major categories to identify and classify these sources of variation. "It is a great visual method when identifying possible causes for problems in the product design process" (D10). Designers analyze and generate insights with methods such as generating randomness. This is actually a cluster of methods or activities, including talking to people to generate random conversation content and forced association to build a relationship between two random elements. "I love to talk to people to generate randomness, as the content of talking is random and uncertain. It arouses lots of association of ideas for me" (D9). Generating randomness is also a new way of using computer programming to generate a series of products with similar features from which designers could choose. "It's an interesting point, this generating uncertainty by the computer which influences idea generation. It was one of the reasons why I got more and more into computer programming" (D7).

4.2.5 'Synthesis' phase

After collecting and analyzing the insights about the context and people, the designer usually moves from the world of inquiry into the world of possibilities. Basically, duirng synthesis, designers try to explore the concepts with open-mindedness and a spirit of creativity. However, structured methods and processes are also necessary. The methods the participants mentioned were: 'flowcharts' (D8, D11), 'storyboard concept' (D3), 'concept sketch' (D5, D6), 'producing software as a tool' (D4, D7), 'concept prototype' (D4, D6), 'concept generation matrix' (D5, D6), and 'concept evaluation' (D11, D12). It seems that designers prefer to generate ideas visually. Designers use flowcharts to develop their understanding of how a process works and to improve it. They use visualization to analyze or design a process. Similarly, designers visualize concepts as sketches to show how they work in abstract terms. The visualization converts ideas into concrete forms which are easier to understand, discuss, evaluate and communicate than text-based descriptions.

Our interviewees use concept prototypes to create concepts. With the principle of building to learn, concept prototypes can trigger thinking about alternatives or necessary modifications to initial concepts. Furthermore, the designers embody concepts in tangible forms to assess their adaptability and get feedback from potential users. This normally includes paper and digital prototypes, which could both be done on different levels. “I think the paper prototype is a great methodology, very low key and very easy and quick to try out. You can do it on different levels of complexity. And evaluate them, find strengths and weaknesses, and build on that. I think that's the only thing that I would say is a golden rule” (D4). Exploring concepts involves both openness to creative and radical ideas and preserving context-driven and human-centered rules that were generated at an earlier stage. This happens in a nonlinear and iterative cycle until new and valuable ideas and solutions are generated.

4.3 How to transfer sources into ideas with appropriate methods

Finally, we sought to provide a grounded overview of why different sources are chosen and how they are transformed into insights that inform design with appropriate methods, in different contexts during the research, analysis, synthesis phases, respectively. Understanding the context is the starting point and basis for idea generation. “I think the design is always about context. There is no golden rule. It always depends on the problem, the people. You have to figure out what’s the right tool for it in different contexts” (D2). The framework we created for this (Table 7) is based on a series of questions: which source, what method, what it does, how it works, what the consequences are and why it has benefits. Such a paradigm tries to provide novice designers with a deeper understanding of the process of envisioning design solutions from inspirational sources or other information, including the design thinking and mindset involved. For instance, fishbone diagrams are usually used in the analysis phase to cope with the problem or task in design practice, or issues relating to the briefing, expert opinion or requirements in fieldwork. This method is intended to identify all the causes that contribute to a problem. It could be used following the three steps indicated. The benefits of this method in dealing with particular sources include the fact that using visual tools prompts critical thinking and focusing on the underlying reasons for the current issue. Other sources, methods and transformation procedures which we identified in the research, analysis and synthesis phases are presented below.

Table 7 A paradigm of how designers transfer sources to ideas in the research, analysis & synthesis phases

Phase	Method	Which source	The transformation procedure				Group
			What it does	How it works	What consequences	Why it has benefits	
Research	Media research	Various media Knowledge of other disciplines	Looking at which is published in popular media	1.Identify relevant topic 2.Seek info 3.Summarize finding	Opportunity area for innovation	1.Capture knowledge 2.Promote shared understanding	Know the context
	Publication research	Media: book, magazine, newspaper, internet, website	Finding what has been written about specific topic	1.Define the topic 2.Search publication 3.Obtain insights	Documented observation about topic	1.Capture knowledge 2.Promote shared understanding	
	Competitor analysis	Media: Internet, website, image Design practice: other products, peer's work	Mapping the competitor	1.Identify competitor 2.Establish rules & map for comparison	Data about competitor	1.Facilitate comparison 2.Reveal relationship & opportunities	
	Expert interview	Fieldwork: expert opinion Knowledge of other disciplines	Speaking to experts to know advanced & potential update	1.Determine topic 2.Talk to experts 3.Transcribe & summarize	Understanding of essential info & opinion	1.Define direction 2.Bring new opinions	
	Interest group discussion	Fieldwork: talk to user, dialogue with stakeholder Knowledge of other disciplines	Finding ideas from innovative offerings & people	1.Seek interest group 2.Find what is being discussed in group 3.Review, summarize	Understand update, trend & get viewpoint	1.Define direction 2.Bring new opinions 3.Capture update	
	As-Is	Fieldwork Knowledge of other disciplines: market research	Defining the current state of the product development in a organization	1.Access to product stakeholders 2. Elicit info of current state 3.Use document review to confirm	Clarify how the product development works	1.Capture knowledge 2.Promote shared understanding	
	Keyword bibliometrics	Daily stuff Media Emerging technologies Knowledge of other disciplines	Using keywords for research ideas	1.Extract keyword 2.Use keyword to search 3.Summarize findings	Insights & patterns revealed by the search	1.Process large sets of data 2.Reveal patterns	
	User shadowing	Fieldwork: observation, user research	Observing how user uses the product within natural environment	1.Participant accompanies user 2.Observe & makes notes of how they use the product 3.Derive insights	User experience of product using and feedback	1.Focus on details 2.Provide evidence	Know the people
	Personas	Fieldwork: user research	Defining user's personality to explore concept	1.Generate user attributes 2.Create personas around user type 3.Build a visual profile for personas	Visualization of profile of different personas	1.Build empathy 2.Facilitate storytelling 3.Structure existing info	
	Use experience activity	Fieldwork: user research	Engaging people in simulated experience	1.Identify question 2.Design & run activity 3.Capture insights	Observe user's behaviour	1.Focus on experience 2.Focus on details	
	Interview	Fieldwork: user research	Finding ideas & insights by talking to people	1.Plan interview 2.Conduct interview 3.Transcribe and conclude	Understand user needs & opinions	1.Define direction 2.Focus on details	
	Field visit	Fieldwork: observation, talk to user	Observing people in contextual activity	1.Assemble resource 2.Observation 3.Interview	Observe user's experience	1.Focus on details 2.Provide evidence	
	Cultural probes	Fieldwork: observation, prototypes	Obtaining feelings and interaction of user with artifact	1.Assemble tasks with artifact 2.User record feeling & interaction 3.Derive values & thoughts from record	User's experience with artifact	1.Focus on details 2.Provide evidence 3.Build empathy	
	Questionnaire	Fieldwork: user research	Asking a series of questions for the purpose to gather info from respondents	1.Build questionnaire 2.Conduct questionnaire 3.Conclude	Insights about user and environment	1.Quantitative data support 2.Numerical detail data	

Analysis	Method	Which source	The transformation procedure				Frame insights
			What it does	How it works	What consequences	Why it has benefits	
	Analysis workshop	Fieldwork: user research, research finding	Analyzing participant's response to get pattern, insight	1.Review finding on workshop 2.Organize into analytical framework	Identification of key insights, and what those indicate	1.Systematic analysis 2.Handle large set of data 3.Reveal patterns	
	Brainstorming	Fieldwork: briefing, expert opinions, dialogue stakeholder Daily stuff: intutive thinking	Group activity to find a conclusion for a problem by gathering a list of ideas spontaneously	1.Define a topic 2.Open discussion and welcome wild ideas 3.Combine and improve ideas	Collection of refined direction or concepts	1.Encourage creative thinking 2.Promote shared understanding	
	Generating randomness	Fieldwork: talk to user, dialogue with stakeholder, Design practice: experiment	Generating randomness through activities	1.Prepare the activities 2.Conduct the activity and generate results 3.Ideas emerges	Various results or ideas	1.Facilitate creativity 2.Encourage innovative thinking	
	Forced association	Daily stuff: intutive thinking, personal experience, cultural background Design practice: other products, image	Building relations in two or more random elements	1.Determine the random elements and build relations 3.Provide solutions with elements	The relations in different elements	1.Facilitate creativity 2.Encourage innovative thinking	
	Fishbone diagrams	Fieldwork: briefing, expert opinion, requirement Design practice: problem/task	Identifying all contributing root causes of problem	1.Agree on a problem 2.Brainstorm major causes 3.Write sub-causes	Identify potential root causes	1.Visual tool for critical thinking 2.Focus on current issue	
	Insights clustering matrices	Fieldwork knowledge of other disciplines	Clustering insights and showing their relation	1.List entities clustering 2.Determine the relation and scale	Diagram showing how insights are connected	1.Facilitate comparison 2.Make process transparent	
	SWOT analysis	Media: Internet Design practice Emerging technologies Knowledge of other disciplines	Evaluating product's strength, weakness, opportunity & threats	1.Determin initial intent 2.Set SWOT 4 features 3.Organize into 2*2 diagram & analyze	Diagram showing SWOT 4 features	1.Create overview & insights 2.Identify challenge & opportunity	
	Analysis of pros and cons	Media: Internet Design practice Emerging technologies Knowledge of other disciplines	Evaluating product's advantages and disadvantages	1.Determin initial topic 2.Analyze and compare product or idea pros and cons	Insights about product or idea advantages and disadvantages	1.Create overview & insights 2.Identify challenge & opportunity	
	Observation to insights	Fieldwork: observation	Finding idea from studying creative offering	1.Observe user 2.Make notes 3.Analyze & derive insights	Collection of structured insights	1.Create the empathy 2.Understand the suffering of use	
	User groups definition	Fieldwork: user research, Internet	Defining the different users	1.List user type 2.Identify attribute scale 3.Define user group	Distinct user groups strongly rooted in research	1.Facilitate comparison 2.Structure existing problem	
	User journey (Scenario)	Fieldwork: user research, user experience	Mapping user's journey	1.Show activities in timeline 2.Find problem or pain points 3.Define user group	Visulization of activity cluster represents journey users go through	1.Focus on experience 2.Reveal relationship	
	User response analysis	Fieldwork: user research, user experience	Analyzing user's response and derive insights	1.Gather user data 2.Visually code the results 3.Analyze the pattern	Insights about patterns in user response	1.Systematic analysis 2.Organize data for easy access	
	Empathic design	Fieldwork: user research Daily stuff: emotion, personal experience	Paying attention to the user's feelings toward a product	1.Understand user's needs 2.Find problem 3.Identify the attribute	Insights about patterns in user's needs	1.Focus on user's feeling 2.Create the empathy	
	Material experiment	Daily stuff: material/structure Design practice: experiment, prototype	Material of different combinations & experiment	1.Understand materials 2.Experiment to explore by different combinations 3.Change condition & try	Collection of structured concepts	1.Process large data 2.Reveal patterns 3.Encourage comprehensiveness	
	Divide into module	Design practice: problem/task Fieldwork: requirement, briefing	Dividing the problem/task into module and resolve	1.Analyze the problem or task 2.Divide the problem or task into modules to give ideas for each module	Design ideas made up of sub-solutions	1.Disassemble the problem into modules 2.Give idea to each sub-module or task understanding	

	Method	Which source	The transformation procedure					
			What it does	How it works	What consequences	Why it has benefits	
Synthesis	Flowcharts	Research finding	Developing a visual understanding of how a process is done	1.Understand the product use or service process 2.Visualize the process	Visualization of process about product use or service	1.Make abstract concrete 2.Reveal the process	Explore the concepts
	Storyboard concept	Research finding Fieldwork: expert opinions	Constructing narratives explain how solution work	1.Create characters & describe their experience 2.Map journey & storyboard	Refined concepts	1.Facilitate storytelling 2.Make abstract idea concrete	
	Concept sketch	Research finding	Visualizing concept as sketches to see how they work	1.Gather generated concept 2.Sketch out core idea 3.Move from rough to detail	Visualization of what concepts look like & how they work	1.Facilitate discussion 2.Make abstract idea concrete 3.Reveal relationship	
	Producing software as tool	Design practice: Experiment Emerging technologies	Using software develop tools to build needed software	1.Determine the needs 2.Use tools to build software to explore	Create software as a tool Individualized ideas	1.Personalized 2.Encourage iteration	
	Concept prototype	Fieldwork Knowledge of other disciplines	Embodying concept in tangible forms & getting feedback	1.Identify concept 2.Create prototype, test & improve	Refined concepts	1.Encourage iteration 2.Make abstract concrete 3.Promote new ideas by doing	
	Concept generation matrix	Research finding	Generating a comprehensive set of concepts based on research insight	1.Share stories with what-if card 2.Evoke possible direction	Collection of intended concepts	1.Bring new perspectives 2.Promote collaboration 3.Facilitate storytelling	
	Concept evaluation	Research finding Fieldwork: user research	Rating concepts with value of user, provider & stakeholders	1.Create user and provider value criteria 2.Create evaluation matrix & score	Refined concepts	1.Facilitate comparison 2.Balance user and business needs 3.Support decision making	

5 Discussion and conclusion

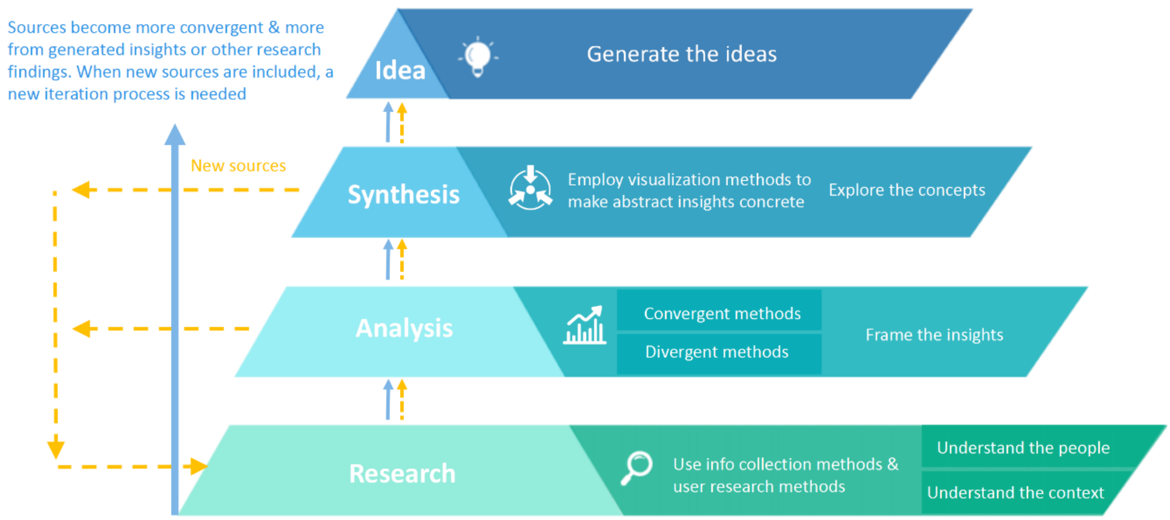
Design idea generation is a process most frequently associated with translating insights into ideas and conceiving creative solutions. In the long run, if a designer wants to derive maximum benefit from inspirational sources and other related disciplines, more transparency is needed in design research. Firstly, we used grounded theory to investigate which sources contemporary industrial designers select to generate ideas and why they choose them. Secondly, we examined what methods designers use to deal with the sources in different phases. Thirdly, we discussed how to transfer sources into ideas with appropriate methods in different contexts, a procedure of asking what each source does, how it works, what the consequences are and why this has benefits (Table 7).

These methods could be allocated to three phases: research, analysis and synthesis, which combine in non-linear and iterative processes for the designer to cope with various sources during ideation (see Table 5.1). In the research phase, most designers pointed out that one needs to understand the context and people before generating ideas. Designers mainly use information collection methods to do this, drawing on three main sources. Media, knowledge of different disciplines and dialogue with stakeholders all help designers gain a full understanding of the surrounding conditions in which trends and changes happen. Specifically, various media are widely and conveniently used to find out about the latest developments in a particular industry in the digital age. Knowledge of different disciplines is made up of two parts: individual knowledge and knowledge of related areas. Ideation is a precedent-based type of reasoning in which knowledge is continuously transformed to produce new insights. Communicating with stakeholder allows the designer to understand the specific area more efficiently. To understand the users, user research methods are mainly used; the data are acquired via fieldwork to obtain an empathic understanding of people's needs and patterns of behavior.

During the analysis phase, designers use divergent and convergent methods iteratively to deal with the data generated in the previous phase or other sources. Divergent methods (e.g. generating randomness or brainstorming) are employed to make full use of the sources and find relationships. Regarding convergent methods, designers apply various analytical or systematic frameworks (e.g. fishbone charts, insight clustering matrices, or analysis of pros and cons) to create categories for their sources. They can then compare and analyze them from different perspectives, to generate compact and actionable insights.

In the synthesis phase, designers usually employ visualization methods (e.g. flowcharts, storyboards, or prototypes) to the generated insights, or other research findings. This makes abstract insights concrete, facilitating comparison and reflection, which form a basis for exploring and generating creative concepts or new ideas. Most sources used in this phase are from generated insights or other research findings, without many primary or raw sources involved. If new sources are included, a new iteration process is needed to generate fresh insights. However, in the scattered and open-ended process of design idea generation, designers need to move back and forth seeking sources of information and solving problems during all three phases. Together with the paradigm described in Table 7, a more compact structured framework would be useful for novice or student designers to guide the process of envisioning design from inspirational sources on the big picture (Table 8).

Table 8 A more compact framework of how designers transfer sources to ideas



This study primarily provides an overview of how industrial designers transfer various sources to insights, helping them to generate ideas with appropriate methods (Table 8). During this research, we developed an instrument paradigm (Table 7), which novice or student designers could use to explore innovative concepts during the ideation process. Other researchers could use this paradigm for a different group of samples to analyze how designers generate ideas. Interestingly, we found that different groups of designers have similar or contrasting opinions about sources or methods of ideation. Our next step is to identify how designers transfer inspirational sources into ideas at different stages in their careers. Such a comparison would enable us to help novice designers improve by defining their weakness compared to more experienced designers at the ideation stage. Last but not least, let us consider the chaos that usually is visible during the idea generation process. What is the relationship between systematic methodology and chaos when generating design ideas? Should ideas be generated in a more open-ended situation or with more structured research? Both these questions deserve further investigation in the future.

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Card-based Tools for Creative and Systematic Design

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doi: 10.21606/dma.2018.284

Many card-based design tools have been produced, initially mainly to stimulate creative thinking, with an upsurge after 2000 when many more such tools were produced, especially to aid user experience and human-centred design. Different authors have categorised the tools in different ways, usually based on small samples, and there is no accepted classification system. Our analysis of 72 card-based design tools produced a new classification and also identified that the tools work in several different ways – e.g. offering creative stimuli or summaries of design methods. Trials of card-based design tools for stimulating creativity seem to enable designers to generate more innovative design concepts, but the practicality of the concepts is not proven. The card-based tools most likely to lead to practical outcomes are those which summarise domain-specific design methods or good practices that designers can apply to real-world tasks. Often these tools are used and tested by those who developed them. Hence, more independent, controlled trials are needed to help establish their practical effectiveness.

cards; design; tools; classification

1 Introduction

Sets or decks of cards – similar to playing cards – are a long-established type of tool to aid designing. An Internet search shows that there is a large number of card sets that that are relevant as tools for design. In this paper we provide a brief history of card-based design tools and examine previous attempts to classify them. We present a new classification based on a detailed survey of these tools, which reflects the number and range of such tools that have been developed. We also discuss how the tools are supposed to work and whether they are effective as practical design tools.

2 A brief history of card-based design tools

One of the earliest examples of design-based card decks is *The House of Cards* created in 1952 by the famous American designers, Charles and Ray Eames. Each of the 54 cards shows a different object. Charles and Ray refer to these objects as “the good stuff”, selected to celebrate “familiar and nostalgic objects from the animal, vegetable, and mineral kingdoms.” (Pitiot, 2011). Slots on each card enable them to be interlocked to build structures (Figure 1a). The cards are therefore often bought as a classic design object or used for play. But their intention is to provide images of the

Eames' favourite objects to help inspire design ideas. As Pitiot (2011) says, "The House of Cards was designed to stimulate innovative thinking… working with the cards was intended to improve creativity in a playful way."

Other card decks to aid creative thinking, designing and problem solving began to appear in the 1970s, alongside the movement to develop systematic design methods. An example is the *Meta Cards*, published in 1972 for students of the design element of an Open University course. The 20 cards are based on the various chapters in the seminal textbook *Design Methods* by J. Christopher Jones (1970). The *Meta Cards* offer strategies and methods for correctly identifying problems, widening the search space, overcoming mental blocks, and helping in design situations where new insights are required. For example, one of the *Meta Cards* suggests starting a design project by "Collecting relevant information", but warns "don't collect more information that you can absorb in the time… which is very little unless it falls into a pattern". Another card advises selecting concepts by setting measurable "Criteria" that "enable everyone to agree on whether the design succeeds or fails…they must be measurable." (Figure 1b). On the cards' reverse is further information, about collecting information and setting measurable criteria.

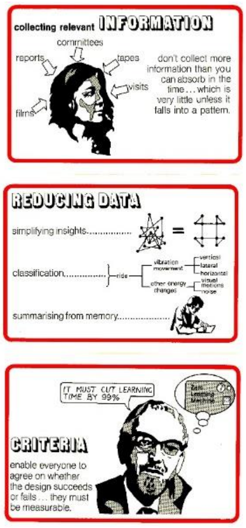

Figure 1a (left) Charles and Ray Eames' House of Cards (1952) slotted into a structure. source: R.Roy
Figure 1b (right) Three of the Meta Cards aimed at different stages of the design process. source: Crickmay and Jones (1972)

One of the best-known card-based tools is *Oblique Strategies*, originally produced in 1975 by Brian Eno and Peter Schmidt, now in a fifth edition and available as an iPhone app. The cards, each of which offers a challenging constraint, were aimed at helping artists, especially musicians, to overcome creative blocks, but have been used in other fields, such as graphic design (Nassisi, undated). One of the card's creators, the musician Brian Eno, says,

> *The cards evolved from me being in a number of working situations when the panic of the situation… tended to make me quickly forget that there were other ways of working and that there were tangential ways of attacking problems that were…more interesting than the direct head-on approach. (Eno, 1980)*

In section 4 below we discuss how *Oblique Strategies* and other card-based design tools are supposed to work.

Following these early examples, we found two card-based design tools produced in the 1980s and 1990s, which also aimed to aid creative thinking. They are the *Creative Whack Pack*, a deck of 64 illustrated cards offering strategies for stimulating creativity, produced by Roger von Oech in 1989, which has sold over a million copies, and *Thinkpak. A brain storming card deck* by Michael Michalko first published in 1994. *Thinkpak* is based on Alex Osborne's (1953) SCAMPER idea trigger words (Substitute, Combine, Adapt, etc.). Michalko (2006) contends that Ray Kroc – the founder of

McDonalds – could have applied *Thinkpak's* principles to create his fast food business. For example, Kroc 'adapted' the fast food concept, originally conceived by the McDonalds brothers for their hamburger restaurants. Kroc then bought and expanded McDonalds involving methods of 'substitution', 'combination', etc. Michalko does not claim that Kroc actually used *Thinkpak*, but demonstrates how its methods could be used to generate successful ideas.

The 1990s also saw the emergence of several card-based tools for participatory user-centred design, especially of computer systems, notably CARD (Collaborative Analysis of Requirements and Design). CARD is a card game to enable designers and users to analyse and redesign task flows in software systems to make them easier and more efficient to use. CARD has been used by major companies, including Microsoft, to improve their software systems (Tudor, Muller and Dayton, 1993). An improved tool, Layered CARD, was developed at Lotus Corporation and used to help design a system to enable its software designers to collaborate more effectively (Muller, 2001). Another development of CARD, PictureCARD, is a means of collectively building an understanding of how people do their work and any improvements they would like. PictureCARD was used by Apple to help design a computer system for Indian rural health workers (Tschudy, Dykstra-Erickson and Holloway, 1996). Card sorting is another tool developed in the 1990s for identifying users' mental models of a digital system's information structure. In this technique users sort elements (e.g. of a website's topics) displayed on cards into groups they find most comprehensible (e.g. Neilsen, 1995).

After 2000 there was an upsurge in the number and variety of card sets produced. Many more creativity card sets were produced. A major field of interest, building on the early CARD techniques, was in card-based tools for user experience (UX) design aimed at helping designers to create user-friendly websites, apps, screen interfaces, etc. One of many examples is nForm's *UX Cards*, which provide a menu of methods and techniques to help design usable and attractive digital products and services.

Related to the UX sets were card-based tools for human-centred design more generally. The most widely used example of the latter type is the *IDEO Method Cards*. These comprise 51 cards of human-centred design methods, which provide ways to empathize with people in design projects. The card set was originally compiled for IDEO's own design teams and to encourage other designers to try methods for making products, services and systems useful, useable and delightful to people.

Other card-based tools were developed to help designers in specific domains, including designing computer games and graphic design, and for specialised topics such as designing for sustainable mobility. Additional areas for card-based tools were as aids to team building and collaborative working and cards to stimulate and inform futures thinking.

3 Reviews and classifications of card-based design tools

Given all these card-based tools for different purposes, there have been several attempts to review and classify them in order to help designers decide which they might use.

One such attempt is that by Miemis (2012) who lists 21 card sets which she categorised into:

- (Design) Principles & Processes (e.g. *Oblique Strategies*)
- (User) Experience & Game Design (e.g. *The Art of Game Design*)
- Communication & Learning (e.g. *Service Design Tools*)
- Visioning & Foresight (e.g. *Drivers of Change*)
- Ideation and Brainstorming (e.g. *Thinkpak*)

Other online reviews of card sets include those by Donaldson (2010), who lists what he considers the ten best card decks to aid user experience (UX) design, and Baldwin (2011), who reviews his five favourite decks for creativity, human-centred and UX design. Anderson (2012) lists 38 card-based tools classified into eight groups, including less common ones like Psychology+Design and Social

Design, and including a Miscellaneous category reflecting the difficulty of classifying the large number of tools by then available.

One of the most comprehensive reviews is that produced for the website Deckaholic (2014), which provides details of 81 card decks in its Library in five categories: Diagnose; Ideate; Learn; Play; Present. However, by inspecting of the stated purpose and content of the decks, via the Library and their websites, we identified only 32 that could be considered as design tools, the rest being cards to help or provide information in areas such as personal growth, travel and sustainable living.

3.1 A comparative analysis of card-based design tools

As shown above, there are several online lists and reviews of card-based design tools and attempts to classify them. However, a literature search only revealed one previous academic paper, by Wölfel and Merritt (2013), that provides a comparative analysis of a sample of these tools. These academics analysed eighteen card-based design tools according to their purpose, function and characteristics.

They identified three broad types of card-based tools (column 1 in Figure 2):

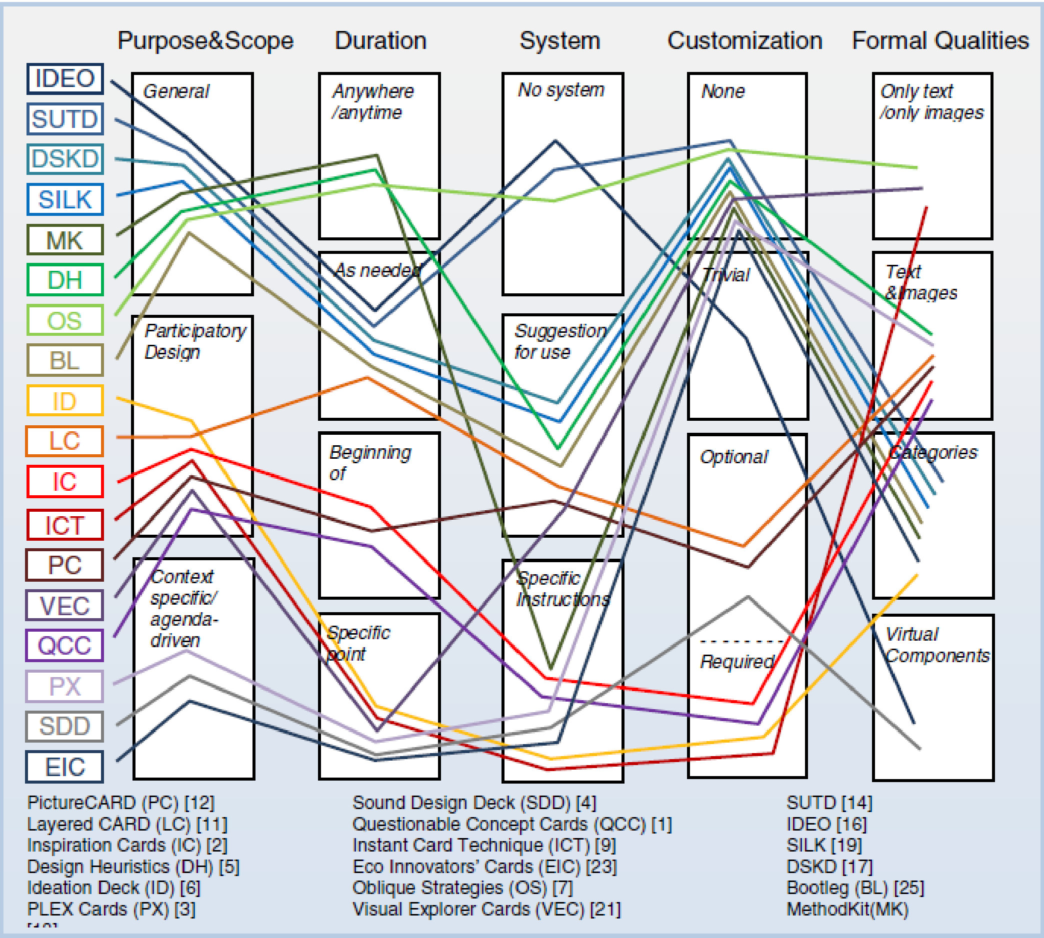

Figure 2 Classification of method cards for design. source: Wölfel, and Merritt (2013, p. 483)

General/Repository tools, some of which provide inspiration and challenge designers to take another point of view. An example is the *Oblique Strategy* cards, which can be engaged with at any time to increase creative thinking and stimulate design problem solving in general. Other tools in this group function as 'methods repositories' and offload the task for designers of remembering the many available design methods. Examples of this type offered by Wölfel and Merritt are the *IDEO Method Cards* and the *SILK Method Deck.*

Participatory Design cards, which seek to develop empathy for the context, and engage designers and users in the design process. Some, such as the *Ideation Deck,* are designed for better communication between users and designers.

C*ontext specific/agenda-driven* examples. This group includes cards focused on a particular design agenda such as the *Eco Innovators* cards, which focus on designing for sustainability or the *Sound Design Deck* for acoustic expression in computer games.

Because Wölfel and Merritt only suggest three categories, classification issues arise. For instance, the *IDEO Method Cards* and the *SILK Method Deck* are classified as General/Repository tools, but it may be argued that their main purpose is to suggest methods for Participatory design. Conversely the *Ideation Deck* might better have been included as a creativity tool in the General/Repository group.

3.2 A new classification of card-based design tools

In order to produce a less broad-brush classification based on a larger sample of card sets than Wölfel and Merritt's, we tried to obtain as complete an inventory as possible of card-based design tools. We compiled this from several sources: our historical survey; the Deckaholic library; the five reviews mentioned above; our own collection; and papers discussing individual card sets (e.g. Golembewski and Selby, 2010).

We then analysed this inventory of 72 card-based design tools. We did this by again consulting the lists and reviews of, and any websites for, the tools in order to identify their main function and content. This led to the following classification. It covers most of the card-based design tools developed since 1952 (although we are aware that there are some that we missed).

Systematic design methods and procedures (7 tools). General purpose methods, approaches and techniques to find, analyse and tackle design problems. This category includes procedures or representations for different stages within the design process in order to help designers to work systematically from problem or brief to detailed solution (e.g. *Meta Cards*; *SUTD-MIT Design Methods Cards; Service Design Tools; iD Cards*).
Creative thinking and problem solving (16 tools). Cards which could be used to help solve any type of problem, including design problems. These sets tended not to be addressed at any particular design field and many of the sets were dominated by cards that aimed to promote creative thinking generally (e.g. *Creative Whack Pack*; *Zig Zag Creativity Cards; 75 Tools For Creative Thinking; Design Heuristics, Intúiti Creative cards*).
Human-centred design (21 tools)*. C*ards which aim to help focus on designing for the users of a physical or digital product, service or system considering their needs, wishes and requirements *(e.g. CARD; Questionable Concepts; Method Kit for Web Designers; Design Axioms; Innovating for People).* (This was a separate category, rather than being included below in *Domain-specific methods*, because of the number of card sets that aim to facilitate this approach to design.)
Domain-specific methods (16 tools). This category provides methods, information or checklists for specific domains, such as game design, graphic design, designing products or services for ecological sustainability or for children (e.g. *Game Seeds*; *Sound Design Deck*; *The Design Deck: A playing-card guide to graphic design; Design Play (Eco Innovators) Cards*; *DSD Cards: Developmentally situated design of products for children*).
Team building and collaborative working (9 tools). A category that concentrates on providing guidance to facilitate collaborative working, participatory and co-design that could be used to create effective design teams (e.g. *Totem cards*; *L+D Leadship + Design; Surviving Design Projects*).
Futures thinking (3 tools). This category deals with awareness of change and scenario planning, often based on identified trends or from fact-based analyses. The cards may also be used for creative problem solving within future constraints or scenarios (e.g. *Drivers of Change*; *S-T-E-E-P Foresight cards*).

3.3 Validation of the new classification

Since the above classification was based on most of the card-based design tools we could find, we considered it to be fairly robust. Nevertheless, in order to check its validity, we selected a sample for more detailed study.

For this analysis we selected 15 card sets that appeared in all, or most of, the other lists (e.g. *IDEO Method Cards*) or were in our own collection (e.g. *Meta Cards*). We only chose cards available in print rather than those just available as apps or online. The selected card sets were obtained from their authors or printed from their websites.

We then examined the content of every card and discussed whether and how the individual cards and each card set fitted our above classification. This revealed that all the sets fitted one of our six categories, but some individual cards within the sets better fitted other categories. This is shown in Figure 3, in which the main category of each set is shown in the upper segment of the circles and any sub-categories that particular cards from the set fitted are in the lower segments.

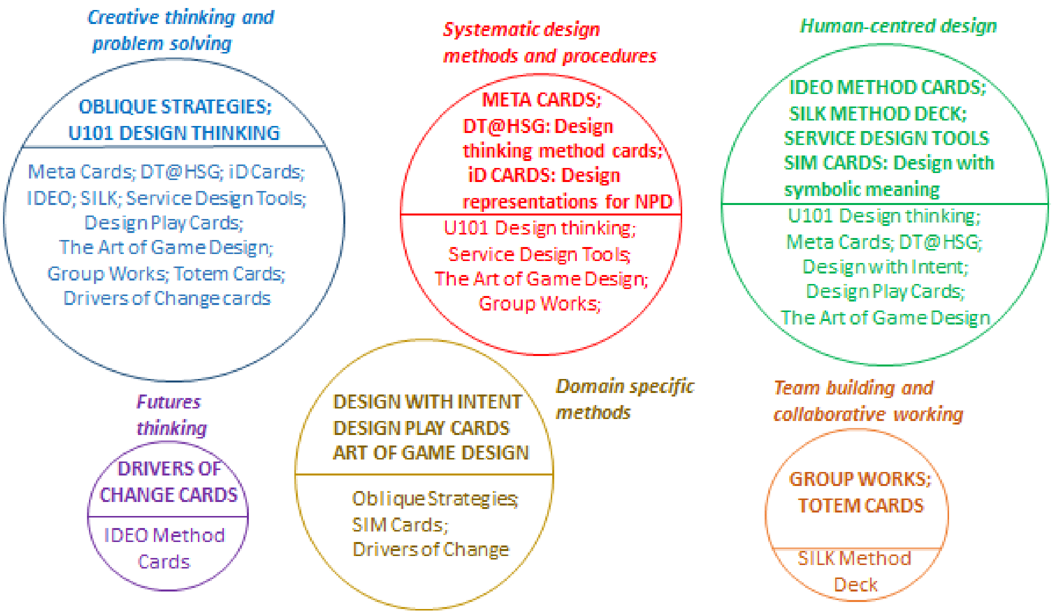

Figure 3 The 15 selected card-based design tools classified by their main function (upper segments) and sub-functions (lower segments)

Our detailed examination also showed that that some of the card sets are similar in function and operation. For example, the *DT@HSG Cards* appear to be an updated version of the *Meta Cards*, while the *Service Design Tools* overlap to a considerable extent with the *SILK Method Deck*.

4 How are the card-based tools supposed to work?

Examining the selected card sets and individual cards in each set, together with any accompanying instructions, also provided an understanding of how the tools are supposed to work. There were several different types and mechanisms.

4.1 Card sets that provide direct, cryptic or random prompts to stimulate creative thinking

The principle underlying these types of cards is that individuals or groups can be triggered out of their normal thinking patterns by, sometimes unusual, associations, suggestions or actions written and/or illustrated on the cards.

For example, some of the *Oblique Strategies* cards offer relatively straightforward suggestions e.g. “Look at the order in which you do things” or “Turn it upside down”. Others contain more cryptic ideas e.g. “Cascades” and “Gardening not architecture”. According to the card’s instructions, “They can be used as a pack …or by drawing a single card from the shuffled pack when a dilemma occurs in a working situation. In this case, the card is trusted even if its appropriateness is quite unclear.”

The *U101 Design Thinking Cards* also provide a number of prompts with images – based on what is known about creativity – to aid innovative design thinking, such as “take a walk”; “be playful”; “unexpected is good”; “change the scale” and “let chance decide” (Figure 4).

Figure 4 U101 Design Thinking: Creativity for the 21st Century cards. Developed for an introductory OU design course. source: Open University (2010)

4.2 Card sets that provide useful information and knowledge in summary form

These cards provide summaries of potentially useful information for specific design tasks in a handy, shareable and combinable form, such as information on accepted good practice in web or game design. For example, in *The Art of Game Design* the “Lens of visible progress” card advises that in a computer game “players need to see that they are making progress when solving a difficult problem” and provides questions to check a game for effective player progression.

In the Futures thinking category, the *Drivers of Change: Water* card set includes a “Water consciousness” card that provides information on water scarcity and use per capita in various countries and provides suggestions for reducing household water consumption by redesigning toilets, appliances and showers.

4.3 Card sets that provide summaries of design methods

These cards provide summaries of design methods, which might be generally applicable or specific to particular domains, in a handy and combinable form.

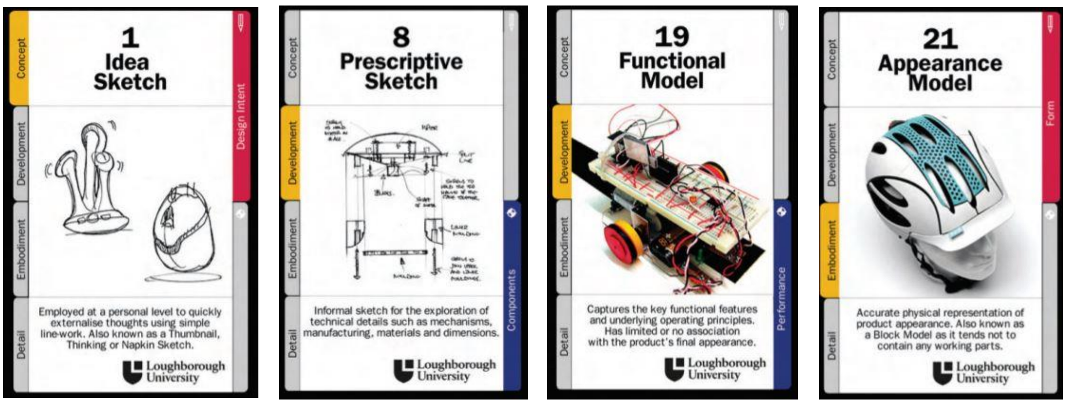

Figure 5 Four of the iD Cards which provide summaries of different representations suited to different stages of the design process. source: Evans and Pei (2014)

The *iD Cards*, for instance, provide images and descriptions of how a new physical product may be modelled and represented as it is developed from idea to detailed design (Figure 5). For example, card 8 is “Prescriptive sketch. Informal sketch for the exploration of technical details such as mechanisms, manufacturing, materials and dimensions.” Card 19 is “Functional model. Captures the key features and underlying operation principles. Has limited or no association with the product’s final appearance.” The *ID Cards* also provide guidance on which representations are best suited to the concept, design development, embodiment design and detail design stages and so could also be considered as providing summaries of a general design method for new product development.

Another example, of this type from the *IDEO Method Cards* is “Empathy Tools”, which suggests using devices like clouded spectacles and weighted gloves to allow designers to experience how people with disabilities experience using products and systems in order to design new or improved versions. IDEO used this method, for example, when designing a home health monitor for people with reduced dexterity.

4.4 Card sets that provide ideas and solutions for specific design problems or domains

An example of this type of tool are the *Design with Intent* cards, which provide ideas and solutions for influencing human behaviour through design to improve usability, safety security, health or sustainability. Figure 6 shows two cards from the 101 in the set, which offer examples of designs that guide people to operate a product correctly.

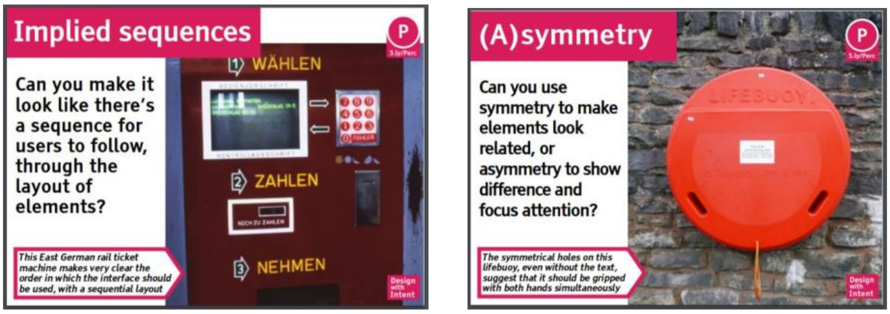

Figure 6 Two of the Design for Intent “Perceptual lens” cards.
source: https://www.flickr.com/photos/sludgeulper/4188746062 CC BY-SA 2.0 and Dan Lockton

Another card of this type from the *Design Play Cards* for facilitating eco-design is “Easy Disassembly”, which notes that laptop computers can be designed to be disassembled to increase the likelihood of repair and recycling, facilitated by having standard screws and labelled materials.

5 Do card-based design tools actually work?

This is clearly an important question, as there is arguably little point in producing these tools – apart from making money for the authors who sell their card sets – if they don’t help produce better designs.

Most of the card sets have been created by university academics or by design/management consultants or consultancies. This means that the university produced card sets have generally been trialled by their authors in educational or experimental settings; while the consultant produced tools have tended to be used by the consultants themselves or when working with their clients. Some of the pre-2000 tools (e.g. *CARD*) were created by developers in computing companies which they applied themselves to obtain user information for software design. Few independent, controlled trials have therefore been conducted.

This means that it is hard to establish whether the card-based design tools actually help to produce better, practical design outputs. Moreover, design outcomes depend on a variety of factors other than the use of a particular tool. The evidence that does exist is mainly based on trials of the tools being used by students or professional designers, and from cases provided by the consultants or designers who produced the cards, or from anecdotal reports on card use, often by other consultants. The sections below summarise selected sources of such evidence that we found.

5.1 *Student trials of academic card-based design tools*

(a) Bornoe, Bruun and Stage (2016) tested the use of different cards with 44 Danish undergraduate informatics design students given the task of redesigning a soccer team web-shop. Different groups used Fabrique's *inSights* web cards, which provide detailed information on good design practice; the *MethodKit for Web Development,* which only offers brief requirements to be considered; or no cards. Afterward, three web developers assessed the quality of the student teams' suggestions.

The authors found no obvious connection between card type and the quality of the redesign suggestions. Even a control group with no cards provided one of the best suggestions. Nevertheless, the findings indicated that the design cards helped to generate ideas, provoked participants to consider aspects other than personal knowledge and preferences, kept the groups focused, and helped progress discussions during the ideation phase. However, the cards did not compensate for the students' limited design experience. Especially, understanding the value of the cards and how they could be implemented was found to be a challenge.

(b) In other educational trials, 77 *Design Heuristics* cards were tested on first year American engineering and industrial design student groups given the task of designing a portable solar-powered cooking device given a sub-set of 12 cards (Daly et al., 2012; Yilmaz et al., 2012). Design Heuristics are prompts that encourage divergent exploration of the design space by providing ideation patterns used by expert engineering and industrial designers. Each of the cards describes a heuristic e.g. "Apply existing mechanism in a new way", gives a brief explanation of the heuristic and two examples of an innovative product application.

For the engineering students, the results showed that concepts created without *Design Heuristics* cards were less developed, and were often replications of known ideas or minor changes to existing products. Concepts created using the cards resulted in more developed, creative designs, although it was noted that practicality of the designs were not tested. Some students readily applied the heuristics, while others struggled to understand how to apply them (Daly et al., 2012).

Likewise for the industrial design students, the results indicated that using *Design Heuristics* cards helped students generate more creative, diverse, concepts. Concepts with heuristics evident were more complex and offered additional features, such as considering the context of how the product would be used. Concepts without heuristic application were often minor modifications to existing products (Yilmaz et al., 2012).

The authors of these two controlled studies conclude that *Design Heuristics* cards, given a brief instruction on heuristics, offer a sound method in ideation for novice designers leading to the generation of multiple designs judged more creative and diverse.

5.2 *Practical trials of academic card-based design tools*

(a) The authors of the above student trials also tested the *Design Heuristics* cards in a company with professional engineers who applied the cards to their current project – an (unspecified) new outdoor product for the consumer market – in an innovation workshop. The authors conclude that the trial:

> *…provides evidence for the success of heuristics in generating novel solutions and overcoming design fixation. The designers reported that they felt the cards stimulated novel thinking even though they had been considering these product designs for many years. After the study, the design team stated they felt the heuristic cards were effective, forced them to stay on track, and helped to focus their attention on one topic at a time. (Yilmaz et al., 2011)*

(b) Watson (2013) provides a case study of the use of the *DOC Method Cards* developed (with reference to the *IDEO Method Cards*) by the Designing Out Crime research centre (DOC), University of Technology, Sydney. The project concerned finding ways of reducing assaults, etc. in a Sydney crime hot-spot. Methods summarised on 14 DOC cards were employed to address the problem. These included "Theme analysis" – the dominant themes were that partygoers weren't looking for trouble, but an exciting night out; "Frame Creation" – if the area were treated like an event space the problems associated with large alcohol intake and absence of infrastructure would be addressed; "Design Exploration" – the exploration, subsequently adopted by the City of Sydney, generated concepts for street wardens, portable urinals, free water, integrated transport, chill-out zones, and more. Following from this project "a comprehensive research and policy design process has now been conducted by the City of Sydney, to explore in detail the workings of the late night economy".

5.3 Use of card-based tools developed by human-centred designers

The creators of *CARD* used the tool at Bell Communications to improve two software systems – a source code maintenance and a graphical layout system – by obtaining feedback and ideas from users. A post-project survey found that:

> *Users had high confidence that CARD supported them in making effective comments, and in communicating their views to the analyst. They also believed that the cards helped them to check the analyst's understanding of the users' views. Finally, users indicated that they had found the sessions interesting, valuable, and enjoyable, and that they would like to participate in them again. (Tudor et al., 1993 p. 52)*

According to its authors, the *CARD* tool seems to have allowed more effective communication between users and developers than the previous informal methods used in the company.

5.4 Use of consultant's card-based design tools

(a) Each of the 51 *IDEO Method Cards* provides a short example of how IDEO applied the method in a real project. An example, outlined earlier, is "Empathy Tools". Another example, "Behavioral Archaeology" suggests looking "for the evidence of people's activities inherent in the…organisation of places and things…to reveal how artefacts and environments figure in people's lives…" This method showed that people organised multiple work tasks by stacking papers in piles on their desks, which led IDEO to design a new item of office furniture. The existence of many examples of application, at least by IDEO itself, could be viewed as good evidence of the practical value of this tool.

(b) Another card set, now online, that seems to have value for designers are *UX (Trading) Cards*, which like IDEO's cards, are a set of practical design methods in this case for user experience design. Giola (2014) describes how one of the long-established methods, "Card Sort", was used for interface design of a supermarket self-service checkout. Users sorted a large number of cards containing names of different foods into groups to identify the best food categories for the checkout's screen.

Baldwin (2011), a UX designer, writes,

> *…when I was struggling for ways to approach a workshop with a client or for ideas on how I could solve a problem, nForm's UX Trading Cards were often a point of reference... Just pulling a random card and talking about the method can spur ideas when a team is having a hard time determining an approach. Grouping or combining cards…is also a good way to map out a set of project steps and approaches. Another use is in explaining what you're planning to do with clients or stakeholders. Rather than just saying you're going to create a concept model, you can hand them a card showing what a concept model is and why it is used.*

(c) Arcila (2013) is a games designer who writes about the practical value of *The Art of Game Design*. The "Lens of Visible Progress" card, for example,

> *…was very useful when I was designing my game miniQuest: Trials. I noticed…that I wasn't clearly conveying the progress the player was making…thus making players confused about their expectations. That's why I designed a playable level selection screen where you could unlock doors, and why I also changed the colors of each floor to make the progress more visible.[…] After several years of using these cards with*

students in classes and workshops I've found that it's an excellent tool that sharpens your ability to look further as a game designer.

6 Conclusions

Numerous card-based design tools have been produced. The first few, produced from the 1950s to 1980s, mainly aimed to stimulate creative thinking. Then in the 1980s and 1990s a few card-based tools were created to facilitate early forms of participatory software design. An upsurge occurred after 2000 when many more card sets began to be produced, especially to provide methods for user experience (UX) and human-centred design, but also for specific purposes such as eco-design and graphics and to provide guidance on systematic design methods and teamwork.

Several authors have attempted to classify the tools by their main function based on relatively small samples, notably Wölfel and Merritt (2013) and Miemis (2012). We have produced a new classification based on our more comprehensive inventory of 72 card-based design tools and validated it by a detailed examination of individual cards and sets in a sub-sample of 15 tools (Figure 3). While there are similarities between our classification and those of others, given our larger sample, we consider our classification to be fairly robust, while recognising that the system is based on judgement. The largest number of card sets aimed to facilitate human-centred (including UX) design, followed by tools for creative problem solving and for domain-specific design. The detailed check of the sub-sample revealed that while most card sets fell into one of our main categories individual cards in the sets often fitted another category better. Understanding these categories, and where sets may fit within them, can help designers decide which tool might be most appropriate for particular tasks.

We also found that there were a number of different ways that card-based design tools are supposed to work; ranging from providing prompts to stimulate creative thinking, or handy summaries of design methods, to offering concepts and solutions for specific design problems.

It is argued that card-based tools have many advantages over other media for helping to design (e.g. Möller, 2014; Rothstein, 2012). The evidence and feedback from trials and applications of the tools indicate that their advantages stem from certain characteristics of cards. They are tangible and engaging objects; summarise information, methods, or good practice in a handy form that designers can absorb and act on; they can be arranged and combined in multiple ways; serve as a common reference in teams of designers, users and others to facilitate discussions; can provide structure to a design process; and offer words and images to prompt people to think beyond normal patterns when tackling problems (Tudor et al., 1993; Wölfel and Merritt, 2013; Deckaholic, 2014; Bornoe et al. 2016). Thus an important benefit of using physical cards is their being a tangible artefact and the way that people can interact with them. The importance of physicality also helps explain why a significant amount of effort has often been invested in their graphic design to make them attractive to own and use. The use of a physical tool can be viewed as 'going against the grain' of everything digital, although, perhaps ironically, many card sets aim to help to design digital products and systems. Hence unsurprisingly, some of the tools are now also available as apps or online for viewing on digital devices.

Do card-based design tools actually work? Trials of some of the tools for stimulating creativity do seem to enable both novice and professional designers to generate more numerous and more creative ideas, but the practicality of the concepts or designs produced is unproven. Novice designers, especially, sometimes struggled to use the cards and good instruction or facilitation seems to be essential (Daly et al., 2012). The evidence available indicates that card-based tools that are most likely to lead to practical design outcomes are those which summarise domain-specific design methods, or good practice guidelines, which designers can apply to real world tasks. However, often these tools are used by the people – academics, in-house designers or consultants – who developed the cards, or after training, facilitating or working with other designers or stakeholders to use them.

Thus more work needs to be done, by those not involved in developing the card sets, in assessing these tools in independent, controlled trials, as well as to check the validity of the examples and cases of real-world products, services or systems said to be the result of using the tools.

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DRS 2018 Design Research Society 2018 Catalyst

University of Limerick
25th–28th June 2018

A Co-Experience Toolkit: investigating the issues of the pavement environment and the relationship with elderly pedestrians

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doi: 10.21606/dma.2018.328

Pedestrian pavements play an important role in assisting or restricting the quality of walking. Poorly designed and maintained pavements may pose a challenge to the walking experience of older adults. This research aims to investigate pavement problems and their effects on elderly pedestrians. An empirical study was conducted in London with 41 older people aged over 60 who were fit to walk. In this study, we classified 16 influencing factors of the pavements and four adverse effects of them and identified 13 behaviours that elderly pedestrians displayed when they encountered the pavement factors. In addition, 17 recommendations were proposed in order to improve the pavement environment based on the requirement of the elderly pedestrians. Taking a step further, we developed a co-experience toolkit that could be used by researchers and professionals involved in the study of pavement design and urban planning to assess and improve the pavement environment with older adults. This toolkit is designed to encourage the users to understand the relationship between pavements and elderly pedestrians better.

pedestrian pavement, older people, behaviour change, built environment, design tool

1 Introduction

According to Shrestha (2016), older adults have a higher frequency of walking compared to driving or taking public transport. This form of transport has drawn the attention of many researchers examining how the built environment can influence the walking experience of elderly people (Frank et al., 2010; Ewing & Cervero, 2010). For instance, pavements have been recognised as an important factor to encourage walking and to increase the amount of walking activity (Choi, 2012; Lo, 2009). Publications, such as the 'Manual for Streets' by Department for Transport (2007) and 'Pedestrian Comfort Guidance for London' by Transport for London (2010), have highlighted key issues of the pavement and created design guidelines for the pavements. For example, pavement conditions and barriers of both static and moving obstructions can influence the level of access, which in turn have implications for pedestrians' safety and their quality of walking (Rackliff, 2013).

Some research approaches and tools have been designed to evaluate and monitor the quality of the pavement and to collect the feedback of pavement users. For example, local authorities in London have set up a web page for residents to report the problems of roads and pavements ("London Borough of Hillingdon - Report potholes or damage", n.d.). Volunteers have been recruited as "Street Champions" to record and detect the conditions of pavements ("London Borough of Hillingdon- Street Champions", n.d.). Tools, such as an 'Audit checklist' (Curl, 2016), help to evaluate the risks of older adults when walking along pavements, such as falls.

Although the existing studies and approaches cover general information about outdoor walking, they do not investigate how the pavement conditions influence the walking behaviour of elderly pedestrians. In summary, the relationship between pavements and older adults' walking experience is decidedly less discussed regarding the impacts of pavements on elderly pedestrians especially their physically behavioural aspects. The perspective of older people to the pavement is also less understood. To investigate this further, we set out three main research questions: (1) what are the factors of the pavement environment influencing the elderly pedestrians; (2) what are the behavioural changes of the elderly pedestrian walking on the pavement; and (3) what is the relationship between the pavement environment and elderly pedestrians.

2 The empirical study

An empirical study was organised to investigate the factors of the pavement that could influence the walking behaviour of elderly pedestrians and collected the requirements for improving the pavement. 41 older people (9 for stage-one and 32 for stage-two) from London were recruited to participate in the study. There were similar ratios of male and female participants (22 females and 19 males) who were either retired or semi-retired. The participants were needed to be above 60 years old and fit to walk. The pavement environment in Hillingdon, Ealing and Camden of London were chosen for the research because a large number of senior residents whose walking significantly engaged in the pavement lived in the vicinity.

Table 1 Methods of the study.

Stage-one (n=9)			
Aim	Research techniques	Duration	Collected data
Investigating the influencing factors of the pavement	Interviews	45 minutes	Personal opinions of the participants
Exploring the behavioural changes of the elderly pedestrians	Observations	Two rounds: 30 to 60 minutes per round	Findings beyond the perspectives of the participants
Collecting the recommendations for improving the pavement	Cultural probes	3 to 7 days	Covered information reported by the participants
Stage-two (n=32)			
Aim	Research techniques	Duration	Collected data
Quantifying the collected data	A mix of interview and questionnaire	60 minutes	The priority of the collected data

In stage-one, the data collection was carried out with 9 participants using a set of interviews, observations and cultural probes to gain insights into their walking experience and their perspectives about the quality of the pavement. Additionally, the participants' behavioural changes and the pavement problems in the surroundings of their residence are observed and recorded using photographs. The interview was used to fully understand and record the in-depth views of the participants (Silverman, 2010). A question book was offered to the participants investigating the pavement issues and their particular experience on the pavement. In the observation, the hazards to the participants on the pavement were identified, and their actions beyond their perspectives were captured (Gray, 2014). The cultural probe known as a self-reporting tool was used by the participants to record the phenomenon that was exposed when they were walking alone (Arthur, 2012). It consisted of a diary booklet, a disposable camera, a local map and two pens which enabled the participants to photograph, mark and report the information. At the end of stage-one, plenty of data was received, while the significant findings needed to be further verified with a more substantial number of samples. Therefore in stage-two, a mixed method of interview and questionnaire was employed to specify the priority of the findings by quantifying the data efficiently (Ravitch & Carl, 2016). This combination assisted the participants to understand the study enquires better, therefore, generating valid data (Hussein, 2009). Finally, 32 participants filled out the questionnaires, and all the questions were completed with valid responses.

To analyse the substantial data, descriptive coding was used to categorise and generalise the scripts into words and short phrases (Miles, Huberman & Saldana, 2014). The collected results were then grouped into 16 influencing factors of pavements, 13 associated behavioural changes, 4 categories of adverse effects and 17 recommendations to improve the quality of the pavement environments.

2.1 *Findings and discussion*

Table 2 Influencing factors of the pavement and their adverse impacts.

<table>
<tr><th colspan="2">Factors of the pavement environment that influence the walking of elderly pedestrians</th><th>Adverse effects of the pavement factors</th></tr>
<tr><td>1</td><td>Uneven pavements</td><td rowspan="16">• Increasing the risk of falling and being tripping
• Increasing negative physical impacts (tiredness and pains)
• Limiting one’s walking (limiting one’s walking activity or behaviours)
• Limiting one’s view (affect one’s view of the pavement surrounding or condition)</td></tr>
<tr><td>2</td><td>Overgrown plants
(overgrown bushes and trunks, overhanging branches and ruderal)</td></tr>
<tr><td>3</td><td>Slippery obstacles
(slippery paving surfaces, liquid, ice, snow, fallen leaves, and moss)</td></tr>
<tr><td>4</td><td>Broken pavements</td></tr>
<tr><td>5</td><td>Moving objects
(bicycles, mobile scooters and skateboarders)</td></tr>
<tr><td>6</td><td>Temporary obstacles
(rubbish and temporarily placed objects on pavements)</td></tr>
<tr><td>7</td><td>Street infrastructure and furniture
(poorly planned or maintained street lights, cable boxes, street signs, bins, benches and bus stops)</td></tr>
<tr><td>8</td><td>Manhole and drain covers
(contributing to uneven and slippery surfaces)</td></tr>
<tr><td>9</td><td>Parked vehicles</td></tr>
<tr><td>10</td><td>Constructions
(safety barriers; build and repair works of road, pavements and street buildings)</td></tr>
<tr><td>11</td><td>Narrow pavements
(the paving width of pavement is narrow, or pavements are occupied by obstacles)</td></tr>
<tr><td>12</td><td>Absence of pavement
(no paved path for pedestrians)</td></tr>
<tr><td>13</td><td>Street stores
(commercial objects; tables and chair; and booths)</td></tr>
<tr><td>14</td><td>Confusing paving patterns
(messy paving slabs)</td></tr>
<tr><td>15</td><td>Tactile paving areas</td></tr>
<tr><td>16</td><td>Stepped and sloping ground</td></tr>
</table>

Table 2 shows 16 key factors that influence the participants' walking and records the negative impact such as the risk of falling. In consonance with Oxley and Hern (2016) and Wang et al. (2016), this study also found that slippery, uneven and poorly maintained pavements, and pavements with missing slabs, and kerbs, and inadequate street lighting were common hazards which would increase the fall risk. Our participants additionally reported that protruding tree roots, street infrastructure and drain covers would contribute to the risk of slips and falls. Besides, they indicated that narrow pavements made them have difficulty in navigating along the path. Furthermore, the pavements would be narrowed by permanent obstacles and further affected older people walking on the road (I'DGO, n.d.). Contrasting colours of ground patterns were sometimes mistaken for changes in the ground level (Pollock, 2012). Some participants also claimed that they experience physical discomfort when walking on poor ground surfaces. For example, the unevenness of pavements resulted in pain in their ankles and the overgrown tree branches compelled them to bend down and led to neck pain. Moreover, they experienced tiredness when they had to spend extra energy to walk up and down on the slopes. Although tactile paving is designed to support the walking of people with visual impairments, it can be a hazard as it can create slippery and uneven surfaces (I'DGO, 2010); therefore, it made older adults fall and unstable and further initiated pain in their hip and ankles.

Table 3 Behavioural changes of the elderly pedestrians.

Behavioural changes of the elderly pedestrian	
1	Adopting cautious steps
2	Walking around
3	Adjusting paces
4	Walking slowly
5	Giving way to other pedestrians
6	Stopping walking
7	Walking on the outside of pavement
8	Walking on the road
9	Crossing to the opposite side
10	Lowering one's head
11	Raising steps
12	Facing oncoming traffic
13	Swerving one's body

Table 3 presents 13 main behavioural changes that the elderly pedestrians adopted when encountering the influencing factors of the pavement. For example, they usually walked with careful steps to cope with the pavement issues. Sometimes they intentionally walked away from the obstacles; adjusted their pacing more often; walked slowly; raised their steps higher; and gave way for other pedestrians to mitigate the risk. This is in line with previous studies that show that they slowed down the pace of their steps when facing potential hazards (Spirduso, Francis & MacRae, 2005); and those who encountered irregular surfaces often adopted a more conservative gait pattern to negotiate the uneven ground (Mitra, Siva, & Kehler, 2015). Walking on the outside of the pavement was also a main tactic of the participants when the width of pavements was comprised of environmental obstacles, such as overgrown plants and inappropriate street furniture. Furthermore, the participants were compelled to walk on the road or to cross to the other side when the pavement was in severely slippery and broken condition; when a pavement was not available and when there was no designated footpath. At the same time of walking on the road, they usually faced oncoming vehicles so that they could observe the traffic flow. In fact, facing oncoming vehicles could reduce the number of injuries caused by traffic (Luoma & Peltola, 2013). At times, the participants would stop to observe before deciding how to deal with a situation to avoid the risk involved. For example, they stopped walking before stepping onto a slippery surface or when a cyclist was approaching. Besides, it was observed that the participants had to lower their head while avoiding the overhanging branches; or to look down on the pavement and observe the ground condition.

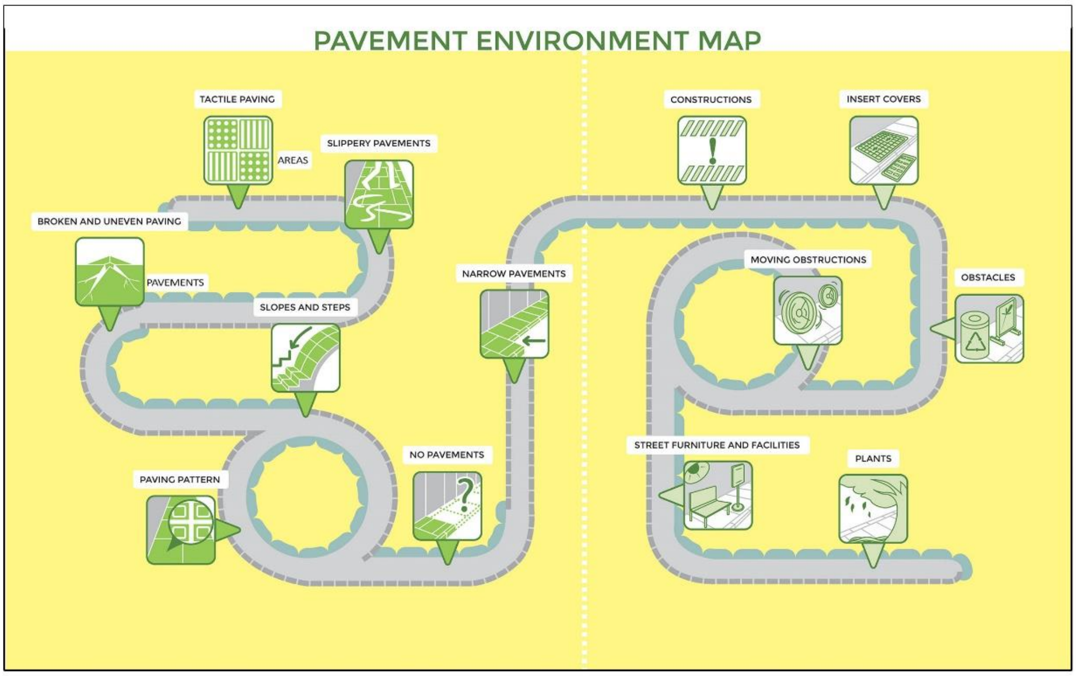
In this study, recommendations were also collected to improve the quality of the pavements. We also took on board the resources from the government publications and standards to pavement design, such as HD 39/16 (DMRB, 2016), Manual for Street (DfT, 2007) and Pedestrian Comfort Guidance for London (TFL, 2010), and references from other notable studies, such as Bayliss (2015) and Rackliff (2013). In summary, the recommendations include having:

- even and smooth paving surfaces
- wide pavements
- non-slippery paving materials
- well-maintained pavements
- clear pavements free from obstacles, such as temporary obstacles and parked cars
- well-constructed and organised street infrastructure and furniture
- a well-defined pedestrian route separated from constructions or vehicle roads
- fewer step and slope ground or they are built on a small gradient
- well-cared plants and right kinds of plants
- low kerbs
- pedestrianized pavements and plan the pavement for different users, such as scooters and cyclists
- taking away the temporary obstacles immediately or managing them well
- functional markings indicate the problems of pavements
- clear paving patterns in a uniform design
- well-maintained manhole and drain covers
- street stores make more space for pedestrians
- tactile paving planned for appropriate size and in appropriate locations

3 Concept development

The result of the data collection was concluded and embodied into a database with infographic displays. In addition to the database, a decision was made to develop a tool that could be utilised to assess and improve the pavement environment. This toolkit is designed to encourage users to gain a better understanding of the relationship between pavements and elderly pedestrians. For the first phase, we analysed existing approaches and tools which were designed to do reports and monitor the issues of the pavement. For example, FixMyStreet application ("FixMyStreet", n.d.) allows users to report the local problems like graffiti, fly tipping, broken paving slabs, or street lighting with photographs and descriptions. It then sends the organised reports to the local council and presents the problems on a digital map. Based on the ideas, we developed the concept including an analysis map and a demonstration card-pack which were used to probe the pavement environment. The analysis map was in a neutral design layout, and it was simulated as a pavement environment in which problems could be identified with the 'locating icons' reprinting different pavement issues. Users could assume the map as a local pavement environment and marked significant building and street names on the map. Then they could use the locating icons to demonstrate pavement hazards like the uneven pavements, narrow pavement and plants. Further discussions would be generated based on the map and elicit more relevant findings. In addition to the map, the card-pack includes 16 foldable cards which reported the significant findings of the empirical study: (1) the description and photos of different pavement factors, (2) the impact of poor pavements on elderly pedestrians, (3) changes to their walking behaviour; and (4) recommendations for built pavements. Users could use the analysis map to investigate issues of the pavement, and then turn to the card-pack learning the relationship between the pavement and elderly pedestrians.

Analysis map with locating icons



Card-pack

Figure 3 Design concept of the tool

3.1 *Expert interview*

In the concept stage, we invited seven academics to an interview to seek their feedback based on their different expertise such as accessibility, design methodology, inclusive design, behavioural science and civil engineering. During the interview, we discuss the information and design of the concept; application of the design concept and potential users; and recommendations for the tool.

3.2 *Comments on the design concept*

The academics declared that the tool was important and original and it provided new information in the certain research area and demonstrated a clear relationship between pavements and elderly pedestrians. It was useful in providing a better understanding of elderly people's perception of the pavement. Specifically, the analysis map highlighted the issues in a specific location. It was useful to do the investigation, and the sign planning contributed to decision making. Moreover, the card-pack was useful to provide a lot of specific content and universal solutions, and it was easy to use. The information shown on the cards urged people to look into details and to make them think about more. For example, they would consider the solutions to the pavement issue concerning its impacts on elderly pedestrians. Different information on the card showed the relationships between the pavement and older pedestrians for different users. However, personal preference to use the card would induce the miss of the information. Overall the whole view was easy to follow even though the connection between the map and card-pack could be made more explicit.

The tool would contribute to the users who are interested in the identification of the pavement issues while unfamiliar with the pavement environment. They may apply the finding in their work or use it as a checklist. They would be designers, researchers, local councillors and general public groups who worked on pavement design, environment design, urban design, place making, and community development. Moreover, the result and concepts may have a potential to be applied in academic projects. School students may use the map and card-pack to explore neighbourhoods. Lecturers can use them as a teaching tool, using it to generate guideline for an observation study and co-design.

In terms of the further development of the tool, firstly, the academics indicated that it could be used as a document or investigation tool. But if it is an idea generated tool, less information and data should be given. Secondly, the interactive process of the tool should be well designed. A tool in the physical format would be good to use practically for older adults in the real world. Thirdly, colour coding was recommended in the tool design. For example, the pavement factor could be distinguished by different colours. Fourthly, the user flow should be simplified in clarifying the information of the task that users need to complete. Finally, the tool should explain what it is, why and how it is used, and display the information that users need. It needs to deliver efficient results for people to report, produce and write something.

4 Co-experience toolkit

Based on the previous findings and discussion, a co-experience toolkit has been developed. It provides an opportunity for older adults to indicate their perspectives of walking on local pavements. Meanwhile, it assists people who work on designing, maintaining and monitoring the urban walking environment to assess and improve the pavements. Apparently, the users are made up of two groups of people who are 'researchers' (pavement designers, city planners and road engineers) and 'participants' (older adults who are fit to walk). This toolkit allows one researcher to conduct a co-study with up to six 'participants' every time. They could identify the problems and impacts of the pavement, and explore older pedestrians' behavioural changes to the pavement issues. In addition, they could propose recommendations in order to improve the quality of the pavement environment. In the co-experience study, participants would discuss and share their ideas in an interactive way, and consequentially the researcher could collate and model the results into the desired direction (Battarbee, 2003, cited in Fan & Lu, 2017, p. 4).

4.1 Components and usage of the co-experience toolkit

The toolkit is designed in a physical format in consideration of facilitating the interactive activity and efficiently seeking for the opinion of the elder users. Matrix is the main design element of the tool, and it was used to assemble the data. Because the data in matrix could be interpreted and described straightforwardly; and the relationship in the data could be uncovered by identifying and comparing the similarities and differences in the cross-sections (Corbin & Strauss, 2015).

This physical tool consists of four components including (1) 6 groups of 16 'Pins' and 16 'Landmarks' that each of them shows the type of a negative factor in the pavement, and being coded with a particular colour and a distinct participant code (e.g. P1, P2, or P3); (2) 6 'Participant survey books' which are used by the older adults to indicate the pavement factors that affect their walking, to specify their behaviours and to also suggest recommendations to improve the pavement; (3) A 'Card-pack' that includes 16 cards that providing descriptions of different factors of pavements using photographs and description; (4) A 'Researcher recording card' that is used by researchers to compile all data from the co-experience exercise. The recording card is in the form of a booklet that offers user instruction and tables for the researchers to record information being discussed. The user instruction introduces the background, objectives, pre-requisite materials, exercises and components of the toolkit. An additional material which is a local map that would be prepared by the researchers and printed in an appropriate scale (size A2 and A1 are recommended) so that it can be easily read with clearly labelled street names and landmarks.

4.2 Test of the co-experience toolkit

To test the tool, we intended to find out if the tool shows information in a proper way; enables the users to know what they could do and how to do; provides an efficient way to collect data; ensures users do appropriate exercises; assists users to identify problems and get solutions; and enables the collected data easy to be used; or supports the researchers in their work field and expands their knowledge (Grinyer, 2016; the design guideline of "IBM Design Research | Resources | Toolkit", 2017).

4.3 Methods

The toolkit was evaluated by nine senior citizens aged over 60 in Hillingdon, as well as five doctoral students from civil engineering, design and ageing study to act as researchers. Each researcher was allocated to a group with two of the older adults as the participants, and overall there were five groups. The groups were asked to use the toolkit to assess and improve the pavement environment of Uxbridge town centre (London). Each group sat together with the map in the centre of the table, and the components of the toolkit were distributed among the group according to their role. Every participant got a group of 16 'Pins' and 1 'Survey book', and the researcher got the 16 'Landmarks' and a 'Recording card'. At first, the researcher collected the personal information of the participants in the 'Recording card'. Next, the researcher asked them to identify the factors of the pavement environment that would affect their walking by placing the relevant 'Pins' on the map. At the same time, the participants further discussed why they had chosen those pavement factors, and the researcher selected the significant ones based on the group discussion. Then the researcher highlighted the significant pavement factors with their corresponding 'Landmarks' on the map, and signed them in the recording card. Following that, the participants indicated the impacts of the highlighted pavement factors on them and, the behaviours that they would have shown when encountering with those pavement factors. According to the row heading of the matrix tables in the 'Survey book', the participants ticked off their responses. Finally, they made suggestions on how the pavement conditions could be improved according to a list of supplied recommendations in the 'Survey book'. At the end of the activity, the researcher compiled all of the responses from the 'Survey books' in the 'Recording card'.

After the exercise, further user comments were collected in a survey questionnaire that consisted of nine questions: (1) Is the tool easy to use?; (2) Is the toolkit efficiently designed?; (3) Does the tool include the information that you expect?; (4) Does the tool enable you to indicate your ideas?; (5) Do the objectives of the co-study were achieved using this tool?; (6) Did you obtain new knowledge from using the tool?; plus 'Does the tool enable you to collect and compile the data quickly and easily?'; 'What will you do with the results that have been collected using the tool?'; and 'How does the tool contribute to your work?' which were designed for researchers only.

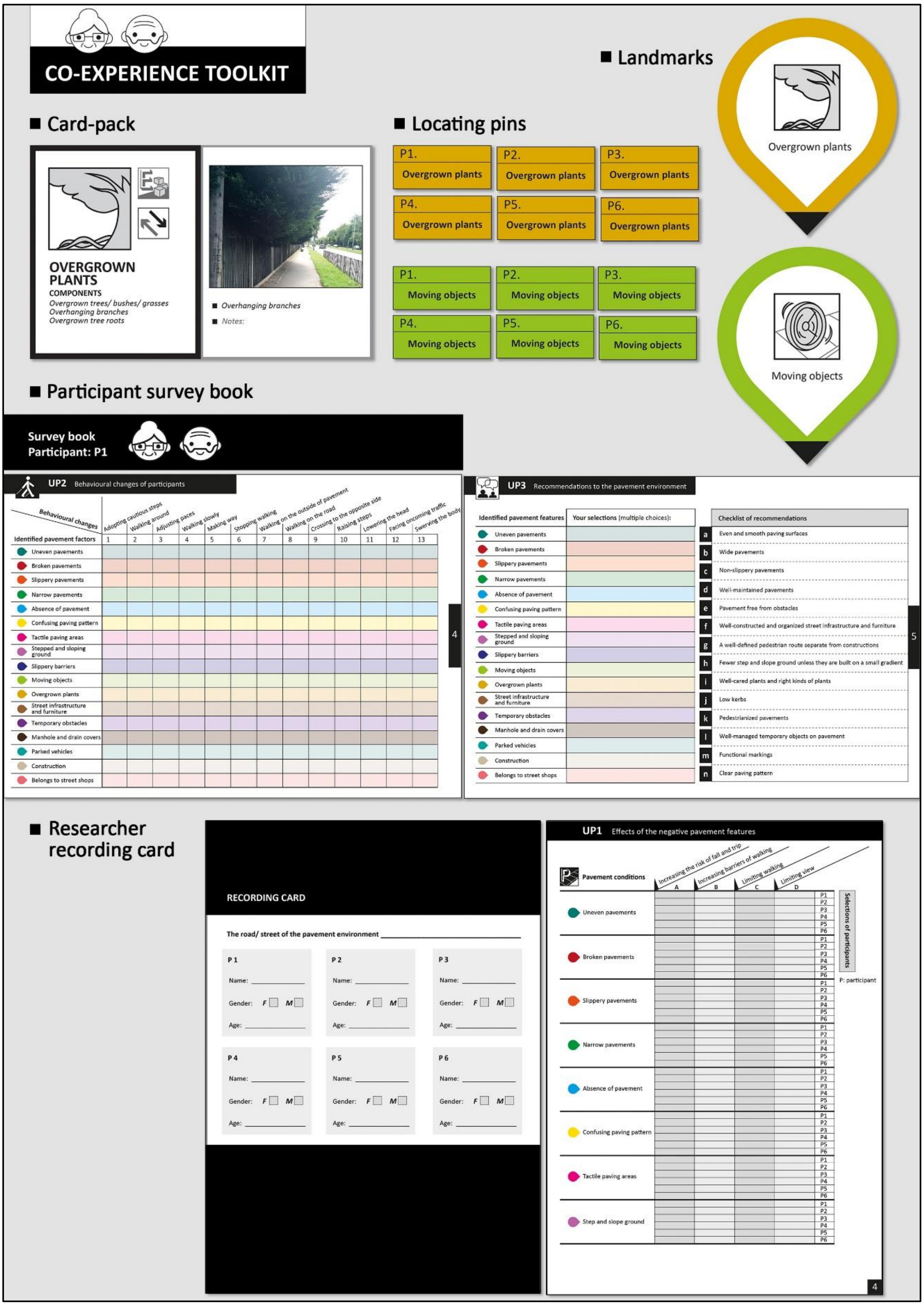


Figure 2 Components of the Co-experience toolkit

Figure 3 Test of the co-experience toolkit

4.4 Result and discussion

Each of the workshops took around 45 minutes, and we observed the significant phenomenon in the workshops. Additionally, we analysed the user feedback in questionnaires and discussed advantages and disadvantages of the toolkit and its components in aspects of usage, design and information delivery. In terms of the creation, most users agreed that the toolkit was user-friendly, highly straightforward, simple and well explained with a good layout and physical components, and the colours were well coded. However, a few users commented that the guidance and terms presented by the tool were slightly confusing and the matrix tables of the 'Survey book' were slightly complicated to use in the beginning. Moreover, the 'Pins' assisted the researchers to find out the priority of the pavement factors by exploring how many participants identified a particular pavement hazard in a specific location. However, they did not enable the participants to identify a pavement issue in various locations; thereby it limited the operation of the participants. On the other hand, the tool allowed the users to identify the problems of the pavement environment, the impact of the pavement and the behaviour changes of the older adults as it provided detailed and well-explained information. The tool also allowed users to arrive at the recommendations to the pavements by giving a comprehensive list. Even though one research student found that the relationship between the behaviours and pavement factors was slightly ambiguous, many users indicated that the tool could clearly demonstrate the relationship. In terms of the data recording, many researchers found it was efficient, easy and quick to compile the data on the recording card. However, one researcher also preferred a digital format rather than a physical layout as he believed it would be easier to compare the result.

As for the output of the tool, the researchers felted that it served its purpose and it had helped them to expand their knowledge regarding the relationship between older pedestrians and pavement. It gave them a better understanding towards the needs of elderly people and to suggest improvements to the pavement. Furthermore, the researchers would develop their work with the relevant response of the participants. For example, they would make a checklist or a guideline for designing inclusive environments for older adults, and relate the results to the body strength, health and other personal conditions of different participants.

In addition to their comments, we observed that even though the toolkit aimed to serve as a co-experience study, some participants did not cooperate with each other well in generating ideas and discussing ideas as expected. According to our analysis, this happened because of the design of the 'Survey book'. It efficiently facilitated the participants to have answers to the study questions. However, some participants were less likely to think about, or expand their responses, or talked to others in the group when they selected their preferences from the provided tables.

5 Development of the co-experience toolkit

According to the analysis result and user suggestions, we redesigned the toolkit by developing its design, form, usage and communication. In addition to the previous version, the new toolkit offers 6 participant code badges to be used to represent the participants with a number, such as "P1" (participant one). Moreover, it provides 7 user instructions (6 for the participants and 1 for the researcher) that introduce the components and a use flow of the tool. Furthermore, a new 'Card-pack' was created by integrating the function of the 'card-pack' and 'pins' in the previous toolkit. Each card set in the new 'Card-pack' was made up of a 'Folding card' and six 'Mini cards'. The folding cards are used to explain the pavement factor and to identify the hazards that influence elderly pedestrians' walking in a pavement environment. The mini cards are applied to further confirm the issues in particular locations of the pavement environment. Lastly, the improved version provides 17 group survey cards for replacing the individual survey books. The survey cards are categorised into: sixteen 'Survey Card (1)' are used to investigate the adverse effect of the pavement factor and explore behavioural changes of participants, and one 'Survey Card (2)' is used to collect the suggestions to improve the pavement environment. Besides the revised materials, the researcher would also be given a recording card that is kept in the same design as its former vision. What else remains is that the researchers must pre-prepare a local map of a pavement environment along with the new toolkit.

5.1 Improvements to the co-experience toolkit

Figure 4 displays the new version of the toolkit and shows the differences between the developed toolkit and the former one. First of all, we abolished the 'Landmarks' as the researchers declare that the 'Landmarks' had the same function as the 'Pins' while excluded some pavement factors that identified by the 'Pins'. However, all identified pavement issues should be further studied. Secondly, more pictures are used in the instruction enabling users to easily and quickly recognise the information and keep it in a longer-term memory (Dewan, 2015). Additionally, we modified the personal 'Survey books' to group 'Survey cards' in order to encourage discussions and idea generation among the participants. The function of the group 'Survey card' remains the same, although it has now been redesigned with a circle layout to ensure that all users could read it from different angles and to be fully involved in the group discussion and exercise. It encourages researchers to be more active to explore extra findings in the survey. To guarantee the data is collected properly in the group interaction, we additionally created 'Code badges' for the participants to distinguish their role when giving their responses. Moreover, the toolkit has also been revised to allow users to position the pavement issues in various certain sites with the commonly-used 'Mini cards' rather than using the personally-used 'Pins'. Comparing to the former version, the researchers can record the amount of the locations where presenting the pavement factor and the number of the participants who identified the factor on the 'Survey cards' rather than in the 'Recording book'. Therefore, the correlation between each pavement factor and the participants (elderly pedestrians) would be more clear and specific.

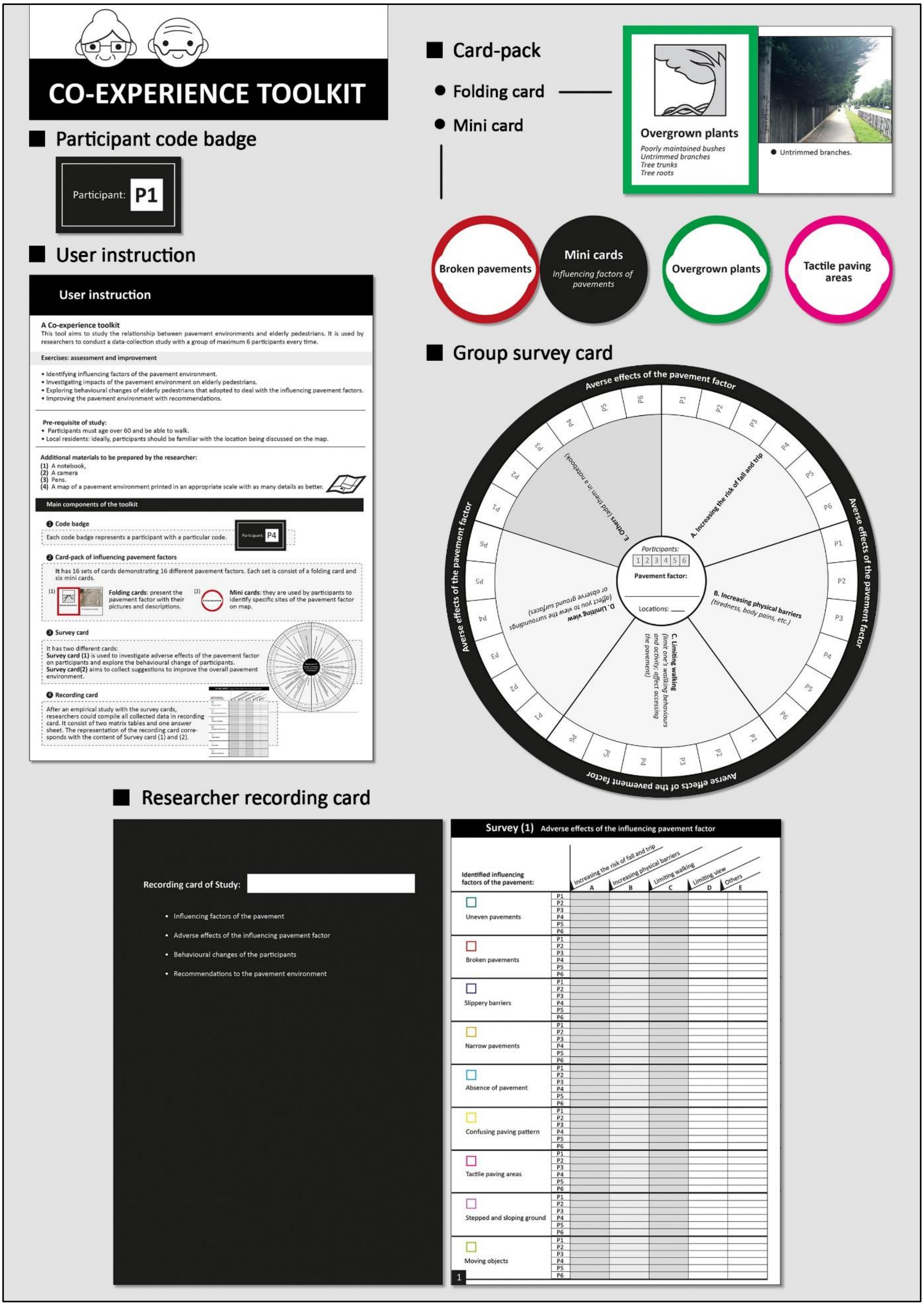


Figure 4 Developed version of the co-experience toolkit

6 Conclusion

From this study, we extend the findings of pavements and walking behaviour and develop a co-experience tool that not only identifies problems also provides practical recommendations to improve the pavement. The toolkit offers a new opportunity for researchers to listen to the needs of the elderly pedestrian. It is a heuristic tool allows users to participate in a co-experience study based on a localised area using a printed map for reference. Initial test shows that the toolkit has received a lot of positive feedback; even so, it has been further optimized. Although the studies used a small sample of participants, we have provided a representative result from each user group. In future works, we will involve broader user groups in the usability testing of the latest developed toolkit.

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DRS 2018 Design Research Society 2018 Catalyst

University of Limerick
25th – 28th June 2018

Mybias: A web-based Tool to Overcome Designers' Biases in Heterogeneous Design Teams

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doi: 10.21606/dma.2018.445

Cross-cultural and interdisciplinary collaborations are increasing in all sectors, from companies to universities. As a consequence, design teams are becoming more and more heterogeneous; it thus becomes fundamental to improve teamwork for heterogeneous teams. Designer's interpretation ability is a fundamental skill, but it might be strictly connected to the designer's personal experience and can, therefore, be strongly biased. Are design students aware of this? If not, how can they be supported to manage diversity? In this paper, we first introduce our research that is aimed at better understanding the role of biases in the design process and in heterogeneous teams. We afterward present the development of a web-based tool designed to improve design teams' dynamics by making students more aware of their biases from the beginning of the design process. The results of the tool testing on 79 students of two different classes of a Design Studio Course are presented and discussed.

design tool, heterogeneous teams, biases, mutual understanding

1 Introduction

In today globalized and complex world, cross-cultural and interdisciplinary collaborations are increasing in companies, universities, and institutions. Design is also moving in this direction, both in the area of education and profession. Design teams are becoming increasingly heterogeneous; it thus becomes fundamental to inquire about how to improve teamwork for these teams.

Indeed, while common thought patterns and a better chance to understand each other exist amongst people sharing the same cultural background, heterogeneous groups of people are characterized by a high variety of viewpoints and, therefore, have complex dynamics that lead to major misunderstandings.

Being a group of design researchers of an international university, we teach in a multidisciplinary and multicultural environment and, therefore, have first-hand experiences of the effect of diversity in teamwork. As educators, we observed that the high variety of different viewpoints that defines the profiles of our postgraduate students can impact their teamwork to a point that require support.

In this paper, we present the tool we are now developing and testing to overcome biases in heterogeneous teamwork. The first testing activity was carried out in a Master of Science course, where students come from all continents and from different fields of expertise.

We acknowledged that, when the team members share many cultural patterns, it is quite easy to accept some assumptions for granted. It is natural to think that "*everybody in the team knows what this means or what this is*", but it is quite inaccurate to assume that some ideas are universally understandable. However, this natural attitude becomes problematic when the team is highly heterogeneous because personal meanings can differ considerably among team members. If not well managed, this lack of understanding can be frustrating. On the other hand, it can also be an effective way to experience the subjectivity of interpretations. Indeed, each designer necessarily filters what she observes (context, user, interactions) through a personal point of view and most of the time, designers have their preconceptions about design objects. As a result, teams' heterogeneity can be considered either as positive or negative for the design process because from one side it leads to a varied range of ideas, but it also leads to many misunderstandings.

All these considerations brought us to the following question: how can we ask students to "*think outside the box*" if they do not know in which box they are thinking in? Each person's mind-set is built on personal biases and first-hand experiences.

We verified the need to effectively manage cultural differences during the design process to enhance teamwork. We observed that design students do not exactly know where the limit of their interpretation of reality lies until they are confronted with a completely different one. Designers' interpretation ability is a fundamental skill, but it might be strictly connected to the designer's personal experience and therefore strongly biased. Are the design students aware of this? If not, how can we support them?

In this paper we introduce our research regarding biases managing in design education. This research started in 2016 and led the team to develop a web-based tool to overcome designers' biases. The research output described in this paper refers to the making of a latest prototype, tested in the current academic years started September 2017 in two parallel design studio courses.

2 Literature review

While setting the basis of our research, we investigated three areas of interest, from the more general to the more specific, all strictly connected with the issue of managing a design team. Firstly, a general overview on decision-making will be presented. Then, teamwork practice in the design field will be briefly discussed. Finally, the issues related to biases in heterogeneous design teams are presented.

2.1 Decision-making: is teamwork effective to overcome biases?

To make good decisions has always been by far one of the most important goals of the organizations; human behaviours within the decision-making process are therefore a crucial topic in the field of teamwork science. Consequently, in the early days of this field, researchers tried to describe cognitive processes behind the individuals' ability to make choices (Larrick, 2016).

Heuristic processes, which could be defined as a shortcut to memory, are identified as the main drivers of individuals' decision-making (Kahneman, 2011). In other words, the human brain usually relies on memory when it comes to making decisions. Even though heuristic processes frequently work well in everyday life, they can however lead to wrong assumptions when decision-making concern unusual problems. Moreover, the lack of awareness of the heuristic processes leads to the tendency of people to ground decision on a biased set of evidence (Larrick, 2016), which are called cognitive biases. Cognitive biases are defined as "the deviation of rationality in judgment, whereby situations may be represented in a subjective way" (Haselton, Nettle, & Murray, 2005). The extensive literature about cognitive biases in the fields of cognitive psychology and strategic management suggest that cognitive simplification and biases play a crucial role in strategic decision making.

The existence of cognitive biases explains the rising importance of teams in organizational management as well, because a group of people can have access to a higher variety of experiences and therefore to a wider range of data (Kahneman, 2011). In his review, Larrik (2016) suggests that the heterogeneous composition of the team improves the decisional process because of two principles. The first is that of error reduction, because the introduction of multiple viewpoints produces different errors that statistically balance each other. The second is the principle of knowledge aggregation; diverse people will bring up different knowledge which will allow a better understanding of a given decision (Larrick, 2016). For these reasons, in the recent decades teams have become the strategy of choice when organizations are confronted with complex and difficult tasks (Salas, Cooke, & Rosen, 2008). The team can be defined as a social entity in which two or more individuals socially interact (Kozlowski & Ilgen, 2016) and the decision-making can be defined as one of the main results of team's social processes (Larrick, 2016).

It is interesting to understand the socio-cognitive processes through which the team builds a shared conception of an issue. The shared cognition is built thanks to communication among team members and the crucial attitude to reach this goal is mutuality, which means that the team is in an environment where all members can potentially contribute and be listened to by others (Barron, 2000). In other words, each viewpoint brings value to the shared cognition building process. Hence this process is enhanced if all the members are willing to build a mutual understanding. Mutually shared cognition is developed when an agreement is reached around the co-constructed understandings (Van den Bossche, Gijselaers, Segers, & Kirschner, 2016).

In our research, it is assumed that processes to build mutual understanding and share cognition should be implemented from the very beginning of the team activities. This aspect is identified as a booster for teamwork efficiency because it leads to more respectful dynamics.

2.2 Teamwork and Design

Design can be described as a "social process of interaction and negotiation between different participants who each bring to bear their own 'object world'" (Cross, 2011). By using these words, Cross highlights the subjectivity of the design process which needs the participants' interaction and negotiation to succeed. Since design teams' dynamics are gathering a massive importance within design research, many socio-cognitive and behavioural processes related to design thinking have been analysed. Two of them raised our interest among the others: design-by-analogy and design fixations.

Design-by-analogy is highlighted as one of the most important processes that regulate designers' thinking. Designers tend to make analogies during idea generation, which means that they use their experiences to find solutions to actual issues. This process seems to improve creativity (Toh & Miller, 2015), but still there is a lack of understanding about how much those analogies are accessible in heterogeneous teams (Christensen & Ball, 2016).

The second fundamental aspect of designers' behaviour is design fixations.

> *Design fixation is a state in which someone engaged in a design task undertakes a restricted exploration of the design space due to an unconscious bias resulting from prior experiences, knowledge or assumptions. (Crilly & Cardoso, 2017, p. 6)*

Fixation is neither defined as something good or bad for the design process, but it seems to be unavoidable (Crilly & Cardoso, 2017). Moreover, it is described as an unconscious behaviour which is always present (Cardoso, Badke-Schaub, & Eris, 2016).

Both design fixations and design-by-analogy could be interpreted as the result of previous designer's experiences. These two socio-cognitive processes suggested us that the problem-solution framing within the design process could be highly influenced by self-constructed preconceptions. As much as cognitive biases are unavoidable factors in decision making, the pre-conceptual ideas, that we call in this research "biases", seem to be present and relevant in design teams' dynamics.

Indeed, according to Krippendorff (2005) the way designers understand the world is not different from the way in which other people are influenced by their subjectivity. Designers should develop the skill of understanding of others' understanding. We do advocate that this skill could be implemented first with co-workers, leading at the same time to the construction of the shared cognition and mutual understanding among team members. This practice could also improve an efficient communication in the team, which is highlighted as fundamental in design collective processes as well (Wardak, 2016).

However, the design teamwork research often focused on the observation of teams during the decision-making moments. Referring to the Double Diamond mapping of the design process made by the Design Council, decision-making mainly takes place in the convergent parts of the scheme (Design Council, 2007).

What is the role of divergent thinking in decision-making? This first stage of design thinking lays the basis for idea generation, because the designer is exposed to stimulus that later will possibly have a role in the analogical reasoning (Mougenot, Bouchard, Aoussat, & Westerman, 2008). Designer's subjective experience is a fundamental element during the discovery research (Mougenot, et al., 2008). We think that this leads to the unavoidable fact that designers' cognition acts like a filter during divergent thinking, while designer observes and tries to deeply understand the design issues. Divergent thinking is therefore necessary to shape the ground where decision-making takes place, it is thus a crucial phase for the team to build shared cognition because designers could have different perspectives and biases while observing users and contexts. It is therefore important for them to be aware about the subjectivity of their interpretations.

2.3 Heterogeneous design teams: the challenge for the future.

During the last decades, design studies moved from analysing the individuals to analysing homogeneous teams (D'souza, 2016). Recently, the interest is shifting on heterogeneous design teams, especially because interdisciplinary collaborations increased. Some principles to foster interdisciplinary teamwork could be summarised as (Maciver et al., 2016, p. 14-15):

- *Fostering appreciation and unifying activities*
- *Recognising, acknowledging and embracing difference in approach*
- *Challenging of assumptions*
- *Synthesising ideas via alternative forms of communication*

Indeed, the role of individual variation in background knowledge is vitally important for attaining a full understanding of the biases of team members, which influences the effectiveness of teamwork (Christensen & Ball, 2016). Consequently, research on knowledge-sharing in interdisciplinary teams has also arisen in the design field. The knowledge-sharing literature demonstrated that a potential for design teamwork exists in the exchange and integration of previously unshared domain knowledge (Christensen & Ball, 2016).

Nevertheless, Maciver et al. (2016) principles can also be effective in other kind of teams, for instance in cross-cultural and demographically diverse teams. Indeed, the internet and the globalization has transformed our world into an international marketplace. Even though teamwork science paid very little attention to culture in its early times (Zeynep & Gelfand, 2012), increasing globalization pushed the field to an era where culture research is becoming an emergent field of scholarly inquiry (Larrick, 2016; Salas, Cooke, & Rosen, 2008). Several design tools have been developed to manage divergent thinking to understand users coming from different backgrounds and contexts (i.e. IDEO.org, 2015). Nevertheless, cross-cultural research in the design field seems to be quite exclusively related to designer-user interaction (i.e. Plocher, Rau, & Choong, 2012) and is rarely discussed during design teamwork itself.

Some authors underlined the importance of cross-cultural collaborations in designer's education (i.e. Hoyos, Scharoun, & Poplin, 2015; Peña, Conesa, Hassan, & Ballester, 2009). The interest in this topic is rising since academic studies are becoming increasingly international. However, from the team members' point of view, most research does not provide practical insights aimed at solving the issues related to cross-cultural design teamwork in education. In her article Audra Buck-Coleman (2010) presents a cross-cultural workshop organized with students of graphic design coming from different universities across the world. The identified need was to inform the students on how traits such as religion, socioeconomic class and other differences can impact visual messages (Buck-Coleman, 2010). Therefore, the workshop deliberately challenges students to evaluate their beliefs, recognize the limitations of their knowledge to understand how preconceptions manifest in their design work.

In our case study - an interdisciplinary master course attended by students from different Countries - it was difficult to define if the observed personal biases were caused by different disciplinary backgrounds or different cultures. Therefore, we defined heterogeneous team as one characterized by a wide range of different biases and by a lower initial shared cognition.

Moreover, since the design activity performed by the students' team were intended to mimic professional practice (with a brief issued by a company), we agreed on the theory that the reflective practice about biases their selves could solve the identified issue.

> *It is argued that reflective practice can help practitioners to understand their own experience and knowledge, in turn assisting them as their expertise develops over their careers […]. Furthermore, in certain situations, effective reflective methods need to allow a person to reflect on the influence of others as well as themselves in the decision-making process. (Gribbin, Aftab, Young, & Park, 2016, p. 12).*

The repertory grid technique proposed by Gribbin et al. (2016) for designers is another example of a tool aimed at making design practitioners and student more aware of their tacit knowledge and biases, which is also our issue concerning heterogeneous teams. In particular, it is intended to uncover implicit personal constructs through building polar definitions of certain topics using exclusively words.

3 Designing a tool to share biases in heterogeneous teams

We decided to design a tool for designers aimed at reducing the negative effects of personal biases on teamwork dynamics. Since the wide variety of biases is the most important characteristic of heterogeneous teams, the tool should help designers to understand another designer's viewpoint from the very beginning of the design process.

The idea was to create a way to represent personal biases. Through this representation, designers should reach a greater awareness of their own biases and, at the same time, they have a chance to understand the mental models of their teammates. In this way, the tool can actively improve mutual understanding in design teams by sharing personal biases about the design object.

Before developing the tool, we searched for already existing ones. We acknowledged that most of the tools for teamwork are designed for the convergent phases, while the tools for the divergent phases are mainly related to designer-user interaction (i.e. IDEO.org, 2015). This lack of tools aimed at improving designer-designer's interaction during the inspiration phase reflects the attitude, already observed in literature, to allocate the shared cognition building process after the divergent phase. We furthermore reviewed some interesting research related to this issue. Most of this research gave us useful insights, but they referred to *ad hoc* workshop activities (i.e. Buck-Coleman,

2010). Other research presented interesting tools related to the reflective practice, for instance the already mentioned repertory grid technique (Gribbin et al., 2016). Nevertheless, this technique, which completely relies on words contraposition, also appeared inappropriate; indeed, since designers frequently communicate by using images, we believed that the tool should have been based on diverse communication modes.
This aspect of the tool and its other expected characteristics are presented and justified. Beside the communication modes, we also supposed that a web-based tool would have been the best solution to represent personal biases and to train students to reflective practice. However, we found a lack of web-based design tools for designers aimed at building mutual understanding regarding designer's tacit knowledge (Bernal, Haymaker e Eastman 2015).
To sum up, none of the tools we found seemed to fit our goal. Since our specific case-studies were two Design Studio Courses based on learning-by-doing, we needed an applied tool for the students to manage such diversity. We therefore looked for a repeatable activity, easy and fast, to be proposed to the teams at the beginning of the Design Studio project teamwork. The tool should be aimed at improving team dynamics by making students more aware of their biases from the beginning of the design process.

3.1 Fundamental characteristics of the tool

As anticipated, we defined some fundamental characteristics for the tool based on some assumptions deduced by our observation of the students and from the literature review. We will briefly introduce them because the characteristics definition was a fundamental step for the definition of the design tool.

3.1.1 Light cognitive load

According to cognitive psychology, we can define the cognitive load as the total amount of mental effort being used to accomplish a certain task. The tool aimed at recreating an everyday interaction which did not represent a heavy cognitive load. We wanted students to be relaxed while doing the activity, because we expected that an unstressed atmosphere among participants would have fostered the mutual understanding building process.

Also, observing the interaction between students in heterogeneous teams, we noticed that when they want to express an idea, they first try to use the English language. If they do not know some words, they take out their laptops or mobile phones and look for translations. They also rely on gestures to empathize what they are saying. To reinforce their references, they usually look for images on the Internet or they pick some stored images on their devices and social networks. This technology-based and internet-based interaction appeared to be faster and more effective.

The core of meaning-making process within design collaborations relies on the correlations between words, images and gestures (Wardak, 2016). We therefore assumed that all those communication modes should have been present in the tool, because they are necessary during the meaning-making process and because they ensure a right cognitive load.

3.1.2 Communication using images

Images are a powerful design communication mode and they are intensively used during the whole design thinking process. We hence supposed that participants should necessarily use some pictures to describe their biases.

Mougenot at al. (2008) observed designers during images selection of the discovery phase and they found that web browsing allows a wider range of inspirational pictures and consequently a greater range of outputs. Then they observed how refining keywords is crucial to find the correct images, especially when designers want to express abstract or feeling-related concepts. For example, to represent "Competition" a participant looked for Footwear first, then Footwear + Sport, then Footwear + Sport + Design (Mougenot et al., 2008). They finally observed that "today computational tools could allow more effective control, such that individual differences in information gathering strategy can be more effectively pursued" (Mougenot et al., 2008).

We consequently thought that the picture selection of the tool should have been internet-based to guarantee the widest range of images. Participants should be free to refine their research keywords until they find the right pictures. Therefore, an internet-based activity also ensured a high flexibility of sources, which is needed to show a wide range of subjective ideas.

3.1.3 Communication using a common language

The use of words is also important and the correlation between pictures and words is another sense-making factor. Keywords and storytelling are fundamental to make the images-words correlation explicit. Storytelling is very important because it leads to building deep connections between participants and talks and gestures are a fundamental step to building shared understanding (Wardak, 2016).

The course we refer to is in English, which is identified as the international business language (Harvard Business School Publishing, 2017) and the international academic language (Jenkins, 2014). Many other international organizations and companies tend to assume English as the language chosen for cross-cultural collaborations. This usually happens even if no one in the team is an English native speaker.

Language is a critical issue in heterogeneous collaborations since the team communicates using a certain language with different proficiency levels. This implies that each person will have different skills in expressing and sharing subjective ideas. Moreover, according to each different mother tongue, the translation could be easier or harder. Indeed, it is fundamental to consider the notion of linguistic distance, which refers to the relative difference between two languages. According to the models of the origins of languages, 'language trees', to explain the historical relations between 'families' or 'groups' of languages being structurally relatively similar, the structural closeness of languages can significantly vary (Lauring & Selmer, 2010). Regardless of individual fluency, it is thus more difficult to express a concept for people with a higher linguistic distance from English.

The tool should indeed be designed for multiple users who can be either non-native speakers or native speakers. Since the objective is to build mutual understanding, it is important to give the team members time to think about words to use and to let them explain *"what they mean with those words"*.

3.1.4 Standard format

We agreed on the need for a standard format which implies a defined quantity of information that must be used to describe the bias. The standard format has some important consequences on the activity. Firstly, everybody knows the format which leads to better understanding of others during the sharing phase.

Moreover, everybody has the same space to express subjective ideas. Indeed, personal attitudes can influence team dynamics and these attitudes can vary according to individuals' characters. We should guarantee equality among all the team member's biases and, of course, among team fellows.

Finally, the selection process reveals differences and common points. To select the most relevant aspect to describe an idea is a great exercise to show how differently people can create connections. This tool's feature is the one that contributes the most to understand the subjectivity of thought.

4 Mybias: a web-based tool to share designers' biases.

4.1 Aim

The aim was to create an effective bias sharing tool. Indeed, we believe that during their academic path, design students should develop positive behaviour during teamwork, especially when they face a high variety of biases. These include:

1. To be aware that own personal interpretation is biased
2. To respect the team fellows' viewpoints
3. To understand the team fellows' viewpoints

Thus, the tool enables to share personal viewpoints in a safe environment. This is a key step in heterogeneous teams to build mutual understanding because it leads to acceptance and respect of differences.

Mybias is a web-based activity for design teams where users can represent their biases about any topic using a standard format representation that is called bias card (see Figure 1). The web environment, specifically a web application, can be executed by any browser. Indeed, the only requirements for the Mybias activity are to have one device per team member (PC, laptop, tablet, mobile phone) and an internet connection.

Figure 1. two examples of bias cards, made by two participants during the preliminary test of the tool.

4.2 Process

Mybias activity is divided into two main parts: the individual part and the collective one.

4.2.1 Definition of topics

Before starting the activity, the team should decide the words that are more significant to discuss to create a shared knowledge. Within the activity those words are called topics.

4.2.2 Phase 1: individual task, the making of the bias cards

When the team knows the topic, the individual phase starts: the participants are asked to individually represent their biases about the topic by describing it using:

- Three pictures
- Text up to 140 characters

This personal brief description is the bias card (see Figure 1). To do this task, no requirements, restraints or rules are given. The participants are free to fill in the card as they please. Though a lecture was given to explain the tool purpose and application, and some examples were shown, as alter explained in paragraph 5. After this process, the team has one bias card made by each member about each decided topic.

4.2.3 Phase 2: team task, storytelling and sharing of understanding

In the collective phase, each participant explains her representation to the teammates, talking in English. The description should include subjective experiences that led the bias's representation process. The rest of the team should ask questions to better understand the presented bias.

This step is crucial to build mutual understanding. The asking-answering process is necessary to comprehend the viewpoint of the others and where it comes from (i.e. cultural biases, previous experiences, different backgrounds). Additionally, it is fundamental to understand the meaning behind the words and the pictures selected by the others.

4.3 Output

At the end of the activity, the team has a set of bias cards but, above all, has a shared understanding on what each discussed topic means to each group member. These outputs are very context-related, which means that they are valid to that team in the moment in which the activity took place. The cards can become part of the research material of the team and they can possibly be useful for following parts of the design process (i.e. brainstorming, idea generation). Nevertheless, these implications are not discussed in this paper.

5 Testing the tool

Between March and May 2017, a prototype of Mybias was designed and preliminary tested during two short workshops involving 6 postgraduate students. The qualitative analysis of the preliminary test showed the potential of Mybias. Moreover, all the participants of the preliminary tests gave us positive feedback on the tool. However, we only simulated the design teamwork within these short design workshop and we therefore needed to test the tool. Yet, the prototype required extra testing on a wider audience, therefore, a second testing was conducted with 79 students of two classes of the first year Design Studio of the Master course coming from different study paths and parts of the world (see figure 2).

The aim of the Design Studio is to develop an innovative design product from the conceptual to the engineering phase. Students work in heterogeneous teams of three to four students. This semester, the specific design brief was "*to design an innovative anti-theft mechanical device*".

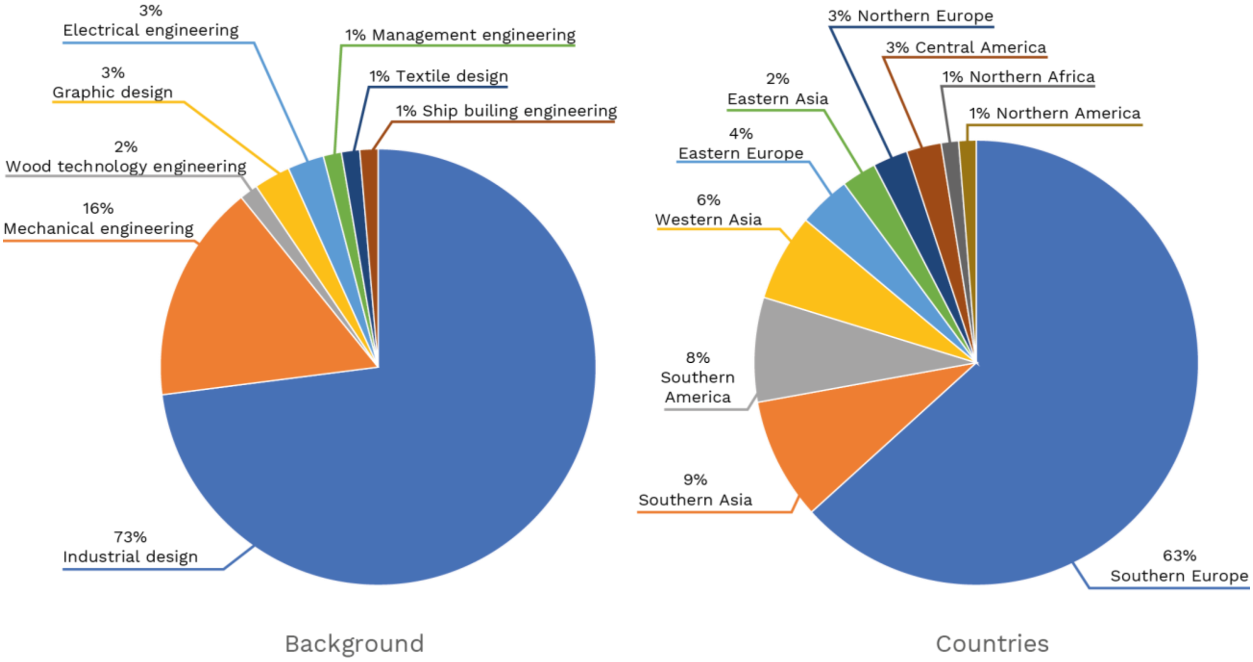

Figure 2. charts of the students' backgrounds and native countries.

Firstly, the students filled the initial questionnaire that was aimed at understanding the inclination of students towards teamwork, design teamwork and heterogeneous teams. Then, during a brief lecture, we explained how to use Mybias and we provided two topics, strictly related to the design brief: "*means of transportation*" and "*anti-theft*". The lecture aims were to clarify the practical use of the web tool and to guide the students before the bias cards making process. We therefore showed the tool, we provided various examples of several bias cards and we commented them. As a general rule, we explained that the bias card should be the representation of their genuine thoughts about the given topics. We prompted them to select the three images that would have first popped up in their minds while thinking of the topic. Regarding the text, the students were asked to give their personal definition of the topic at hand, according to their personal way of framing it.

The participants, divided in 21 groups of 3 or 4 students, did the activity autonomously off-class during the following week. To evaluate the impact of the tool, the students were asked to deliver a brief report of the use of the tool, particularly about the storytelling, and to fill a final questionnaire.

6 Results

The answers to the initial questionnaire were necessary to understand that most of the students perceived teamwork as very important in the design process, even if some of them do not really like it. Most of them also considered heterogeneous teamwork as an added value for the outcome, because of the wide range of point of views. Nevertheless, some of them highlighted that heterogeneity is often a barrier for mutual understanding during teamwork.

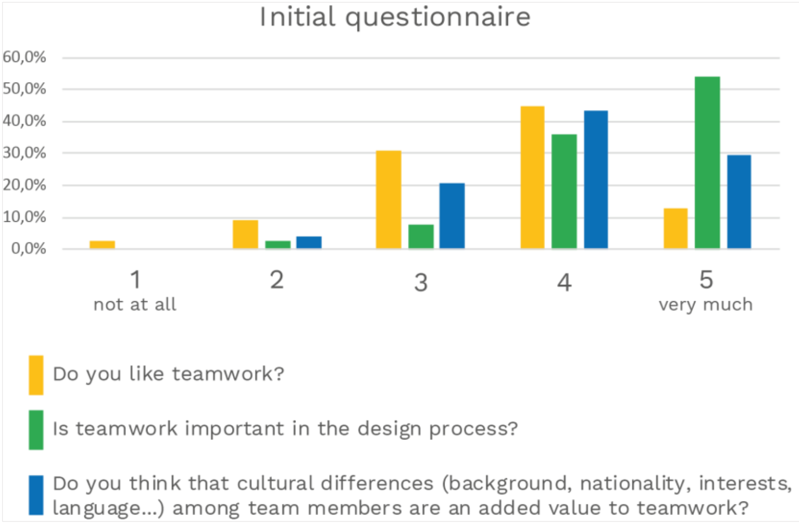

Figure 3. the chart shows the percentage of answers to the initial questionnaire answers. The students also justified the third answer (the blue one in the chart) by inputting a short text.

After using the tool, participants gave some important qualitative feedbacks about the use of Mybias in their reports. Firstly, several teams wrote that the use of Mybias stimulated students to build a shared knowledge

> *"All in all, the second topic (means of transportation) triggered more curiosity about the cultural backgrounds and, overall, the group discussed about their own experiences" (Class 1, Group 6)*

The students understood that, even though analogies in the definition of topics exist, the differences are always present, and they are fundamental to understand the world in its complexity.

> *"To sum up we can say that we have perceived this topic through different shades." (Class 1, Group 1)*

Mybias was also useful for them to acknowledge the importance of building a shared cognition within the team and therefore we expect them in the future to be promoters of this key process for teambuilding.

> *"With Mybias we could compare the different point of view, we understood the different thoughts of each member of the group and we also learned that a collective knowledge is more useful than a personal opinion." (Class 1, Group 7)*

Moreover, Mybias triggered some students' reflections about the language issue, which was also identified as one of the issues related to heterogeneous design teams.

"None of the group members' mother tongue is English, so there is a language barrier while communicating. Spending more time is important for the group to be sure that everyone is on the same page" (Class 2, Group 8)

Surprisingly, Mybias was triggering some interesting reflections about biases also in less heterogeneous teams.

"All the team members have a pretty similar cultural background: all of us come from the same Country indeed. This aspect came out during the talk among us; most of thoughts and outcomes happened to be really close to each other. This means that most of the pictures and biases were almost the same. […]. After the activity, we understood that what we take for granted in our everyday routine might be perceived as unusual by someone else. It means it is quite essential, to work successfully in a team, to listen to the opinion and to the feelings of every member. What sounds weird can be therefore accepted and, eventually, it can enrich the outcome of teamwork"

(Class 2, Group 2)

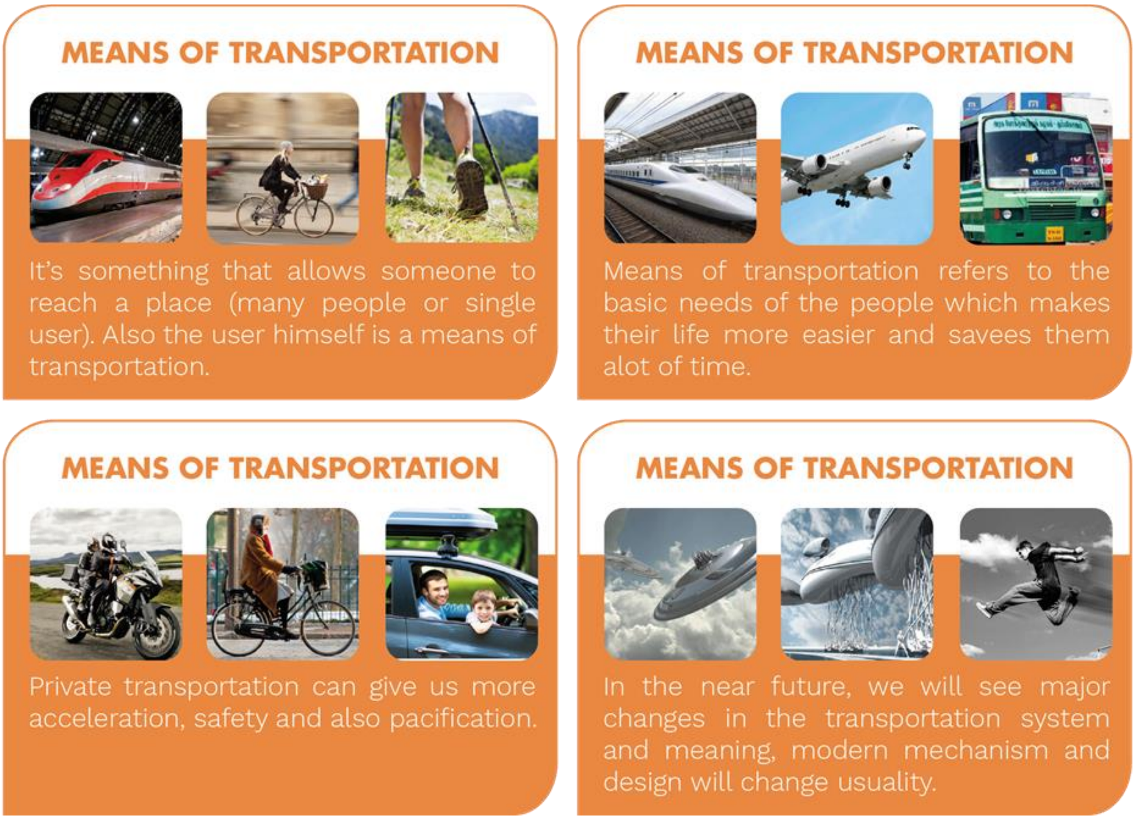

Figure 4. four examples of bias cards made by four different students with Mybias during the test.

From the final questionnaire answers the students confirmed that they personally found analogies and differences among their cards (see figure 5) and only few of them wrote that their cards were "not at all" or "very much" different from their team fellows 'one. We interpreted this data as a positive result because it means that the team members can build connections (analogies), but at the same time they experience a certain level of differences which stimulate the process of building a shared cognition. From their individual feedbacks we can infer that Mybias was useful for them to build mutual understanding among team fellows.

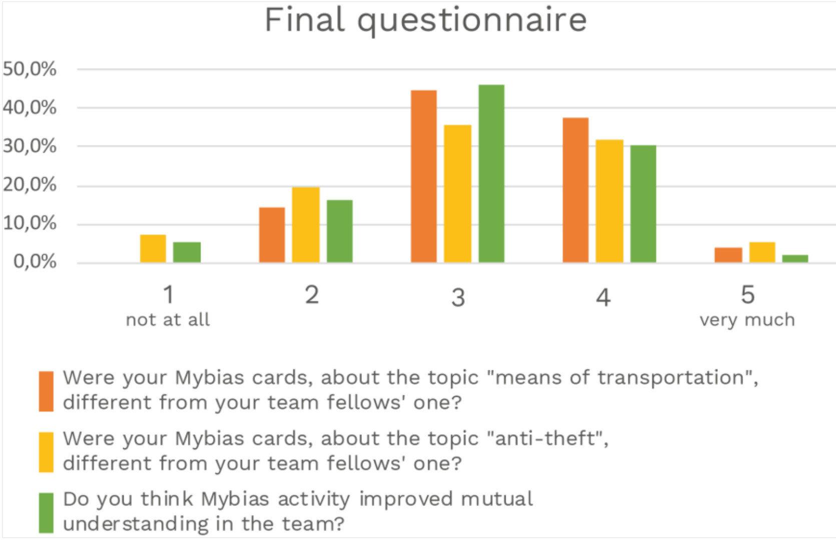

Figure 5. the chart shows the percentage of answers to the final questionnaire answers. The students also justified the third answer (the green one in the chart) by inputting a short text.

7 Discussion

The test revealed the potential of the tool. To share biases was a useful exercise for the majority of the participants. The observations confirmed that Mybias is useful tool to create a safe positive space for people to build connections and mutual understanding. The students' feedbacks highlighted how Mybias was effective to firstly acknowledge the differences among team member's viewpoints. The collective phase of the activity, which was divided into the storytelling and the discussion about different or similar definitions of each topic, was fundamental to understanding others. The results of their discussions can be summarized into some recurrent team attitudes:

- Agreement on some analogies in definitions
- Initial incomprehension of differences, followed by inquiry and collective redefinition
- Interest to make further research about some insights (analogies or differences)

The first two aspects observed are the symptoms of the shared-cognition building. It was interesting to observe that they were present also in less heterogeneous teams (i.e. Class 2, Group 2). Therefore, we suppose that Mybias could be an effective tool to inform students about the subjectivity of their interpretations. It is also highly positive that Mybias triggered curiosity in certain situations because it fosters deeper understanding of others, possibly leading to higher empathy and cohesion in the team.

Concerning the third aspect, it could add value to start the divergent thinking because Mybias can act as a divergence booster. However, it should be investigated whether these interesting insights could have some latent negative effects, for instance if they determine strong fixations for the team. The fact that the tool is web-based proved to be effective, because it let students work together when and where it was most convenient for them.

8 Conclusion and Further Development

The paper has sought to clarify the role of biases in the design process, with special attention given to their impact on heterogeneous teams' dynamics. The acknowledgement of some issues related to this context led us to the identification of the need to manage biases in the design thinking process. In this paper we presented the development and evaluation of a bias sharing tool, which enhance designers' reflective practice in relation to bias managing in heterogeneous teams. The tool is identified as a trigger to stimulate the building of mutual understanding among team members, especially in educational design Studios.

One of the main limits of this research is that during the described test, the topics were selected by us, but we do believe this degree of freedom might have an impact on the use of the tool.

Future research should examine the effects of the tool on the following phases of the design process, to understand its influences on the overall designing experience. Even though the use of the tool is positive for teamwork dynamics, future studies should clarify which is the effect of Mybias on creativity and idea generation. Indeed, the way a higher mutual understanding in heterogeneous teams affects the creative outcomes should be contextualised in the wider academic debate on creativity. Indeed, the authors believe it is necessary to verify the role of the tool in the design process, as regards for the creative aspects. Our actual ongoing testing is aimed at investigating this aspect. We are also exploring the use of Mybias by testing the tool on students coming from different fields of expertise (e.g. management and economics). Indeed, the tool could be used in other fields in which teamwork takes place, since biases and low mutual understanding are common features of the majority of heterogeneous team. These tests are now under investigation. Additionally, we should investigate the possible role of Mybias in professional design practice, to clarify the potential of bias-sharing practice for practitioners and companies. Data collected from a broader testing of the tool could provide novel insights on different ways used by people to individually and collectively conceptualise.

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DRS 2018 Design Research Society 2018 **Catalyst**

University of Limerick
25th–28th June 2018

Point of View Framework: describing the audience's emotional connection to information design artifacts

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doi: 10.21606/dma.2018.601

This paper introduces Point of View framework to examine design strategies for enriching the audience's emotional connection to information design artifacts. The framework consists of four thematic variations of point of view: perspective, person, mode, principle. The model is intended to accommodate the developing research agenda of exploring the emotional experience between the audience and the information design artifacts, which is becoming increasingly concerned with the wider impact of information products on people. Analysis of two information design cases are presented to demonstrate how the framework can be used to examine different kinds of design strategies in response to specific design problems.

point of view; user experience design; information design; design theory

1 Introduction

In the last two decades, emotion has emerged as an important theme in discussions of design. Central to this idea is the notion that emotion plays a critical role in the way that humans interact with information, products, and the surrounding environment. Human factor analyst Patrick Jordan argues that usability-based approaches are limited because they regard products merely as tools and users as cognitive and physical components of a system (Jordan, 2002, p.11-12). In addition, Donald Norman approaches emotions as human attributes from three different levels, which are visceral, behavioral, and reflective. His framework provides different ways of shaping one's emotional experience of a product and the implication in the creation of a product that can evoke specific emotional responses from the user (Norman, 2003).

Numerous studies focus on developing frameworks, techniques and methods for emotion research in product design and human-computer interaction. For example, Pieter Desmet presents a framework of product experience that can be experienced in human-product interaction as three distinct levels of experience of aesthetic, semantic, emotional (Desmet & Hekkert, 2007) and 25 positive emotions that people can experience in response to product design (Desmet, 2012). Hassenzahl et al propose Experience Design as an approach to discover pleasurable and meaningful moments of experiences by providing conceptual tools to help designers to model people's interaction with products through material and experience (Hassenzahl et al., 2013). Despite the increasing interest in emotional experiences in product design and interaction design, discussions of emotion focus on either the components or levels of emotional experiences or kind of emotions that are relevant to human-product interaction. In fact, proposed frameworks or methods can help a general understanding of one's emotional experiences with information or products, yet they do not provide a set of conceptual tools that help to explore and examine how the audience experiences various kinds of products and information in detail.

This research is motivated by a lack of substantive theory that would allow design researchers and educators to model the relationship among information artifacts, audiences, and designers in specific contexts. As the complexity of information design has increased in an inter-cultural and global environment, I argue that there is a room for a theoretical framework that will help design researchers, practitioners, and educators articulate the complex relationship between information and emotion. How can we describe the audience's emotional experience to information artifacts? How can we articulate design strategies that are often implicitly used by designers to create information artifacts aimed at enriching emotional effect for an audience? These are key questions to examining the relationships among information artifacts, designers, and audiences, and more specifically how they are emotionally connected one another.

In order to answer the questions addressed above, this paper presents Point of View framework that help design researchers and educators to describe the audience's emotional connection to the information artifacts and to analyze design strategies that enrich the audience's emotional experience in particular contexts. In addition, this research contributes to provide a metalanguage that allows design researchers and educators to articulate the complex relationship between information and emotion.

2 Point of view framework

Point of View framework is a descriptive framework to examine design strategies used for creating information artifacts in response to specific design problems. Concept of Point of View framework originally derived from Franz Stanzel's *The Typological Circle* that points out the inconsistent use of point of view in narrative criticism (Stanzel, 1986, p.9); but it has been modified to provide a framework that would allow us to describe and analyze the diverse use of point of view in the context of information design in which the narration can take the form of either verbal, written or visual narrative (Jun, 2014, p.412-414).

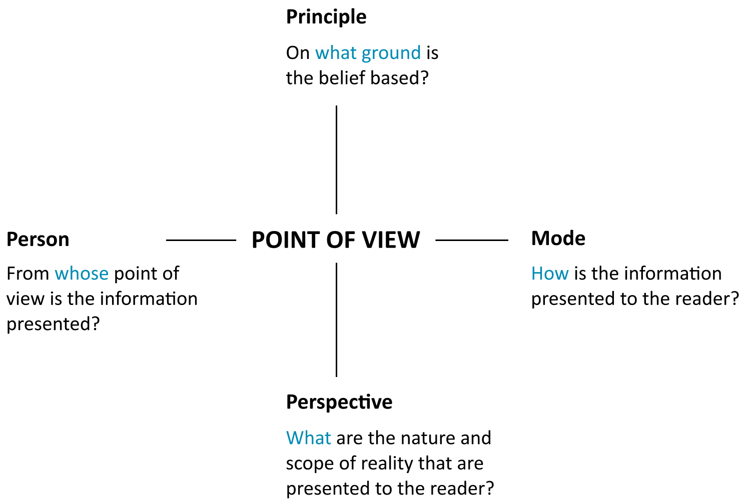

Figure 1 Thematic variations of point of view as mediacy of information design

Four thematic variations of point of view are proposed as mediacy of information design: perspective, person, mode, principle (Figure 1). This framework will help to broaden one's understanding of point of view in relation to its functional aspects that move beyond its focus on narrative person; it also will contribute to providing a framework that can develop design strategies through an inquiry into the following questions: 1) *What* are the nature and the scope of reality presented in information design? (perspective) 2) From *whose* point of view is the information presented? (person) 3) *How* is the information presented to the reader? (mode) 4) On *what* ground is the belief based? (principle). (Jun, 2014, p.415).

These four themes provide "places" or topics that consists of "a tool of inquiry" in the analysis, exploration, and generation of various forms of mediacy for information design (Buchanan, 2001, p.75). For example, point of view as *perspective* can be regarded *as* from which individual elements are structured and visualized while point of view as *person* can be understood as an identity, from whom information is perceived and interpreted. In addition, point of view as *mode* refers to by which information is reconstructed and experienced through the process of action in contrast to the *principle* in which one's belief or value is grounded.

The purpose of the framework is twofold. First, it offers a theoretical framework and terminology for investigating different uses of *point of view* as the mediacy of information design. In fact, point of view has been appeared to analyze the levels of meaning in images in visual studies and social semiotics (Kress & van Leeuwen, 1996; Unsworth, 2001; Rose, 2007). While these terms are still relevant to analyze the physical, social and emotional relationships between the viewer and the represented participants in the image (interpersonal), the use of point of view could be improved by the discussions of other kinds of relationships between an image and reality (ideational) or the relationships among the information components (textual) (Jun, 2014, p.416).

Second, this framework contributes to discovering a set of design strategies that have been effectively used in particular communicative situations, specifically in order to emotionally connect the audience to the information design artifacts. For example, one of the Stanzel's constituents, *person* in his Typological Circle proposes the opposition of *identity* and *non-identity* to whether the realms of existence of the narrator are *identified* with those of the fictional characters or not (Stanzel, 1986, p.111). While *identity* and *non-identity* explain the narrator's relation to the world in literary criticism, these would help to illustrate emotional distance between the narrator (or audience) and the fictional character as well as to examine different kinds of strategies that are applied to enrich the narrator(or audience)'s emotional connection to information design artifacts (Jun, 2014, p.416).

3 Example analysis

In what follows, I will examine two cases of information design artifacts in detail, which respond to specific design problems thorough the use of the thematic variations of Point of View as a conceptual tool for analysis. These two cases are chosen over the others because my emotional experience with them in person can be better described based on Point of View in addition to others experiences that are found online.

The first case is Titanic, the Artifact Exhibition that represents the story of the legendary ship by laying out the real artifacts that were recovered from the debris. Through the examination of *person* and *mode*, diverse information artifacts and the organization in the exhibit creates an intimate experience from the point of view of a character on board, and develops a story through the deliberate representation of scenes, sequences, and spaces.

Second, the *I Like Seoul Campaign* is a social campaign that fosters collective interaction to actively respond to the problems and issues about the environment. Through the employment of *person* and *principle* as the primary focus, diverse voices are created to foster open public dialogue, and irony is utilized to offer an opposing stance to the monolithic voice of the government.

3.1 Titanic, The Artifact Exhibition

Titanic, The Artifact Exhibition showcases actual artifacts that were recovered from a debris field 2.5 miles beneath the surface of the North Atlantic after the ship's wreck during its maiden voyage on April 15, 1912. The story of the Titanic has been retold in numerous books and movies; perhaps one of the reasons the story of the Titanic still attracts so many people nearly a hundred years after its occurrence is the dramatic element of human stories of those who were onboard this legendary ship. Thus the exhibition is not only a portrait of a famous unsinkable ship from its birth to death; it is also a compilation of stories of people who survived or passed away with the fate of the ship.

While books and movies focus on the story of characters involved in the event, the goal of the Titanic exhibit is to display real objects collected from the ocean floor surrounding the wreck site, thereby telling a story of the ship and the 2,228 souls who journeyed with her into history. While it is easy for books and movies to sustain an audience's attention as a story unfolds over time, designing an exhibit offers a different challenge to designers in that the experience of the exhibit is temporal and spatial. In other words, the exhibit allows visitors to navigate through the artifacts in the exhibit from their own point of view whereas the books or movies present a story that is told from one of the main character's point of view. Depending on the visitor's motivation or their personal interest in the story, their emotional experiences with the exhibit may vary. For example, when visitors do not have any personal interest in the event or are not familiar with the story, the exhibit may not evoke any emotional response from them, just as a person browsing old artifacts in an antique store. Although visitors recognize the fact that the artifacts they are seeing in the exhibit are real artifacts used in the Titanic nearly a century ago and that they are recovered from an ocean floor 3820 meters deep, these facts may not greatly affect the visitors' perception or experience of the exhibit.

Therefore, building some connection between the artifacts and the visitors is key to designing the exhibit. According to the interview with John Williams, principal designer for Titanic exhibition, he states his goals in designing an exhibition is "we recognize part of our role is to re-tell Titanic's story and preserve her legacy. We emphasize the Exhibition as a memorial and as an amazing platform to educate visitors on each part of her unfortunate tragedy." When creating a situation for the artifacts in which each object tells a story of people onboard or illustrates their experiences in the Titanic, the artifacts become meaningful to the visitors when each piece is seen in context, just as evidence in a crime scene reveals a whole story when all the pieces of evidence are in place.

In what follows, I discuss three design strategies used in the Titanic exhibit, based on the Point of View framework presented in the previous section. The diagram below shows how each strategy is related to the thematic variations (Figure 2). For example, person and mode function as mediacy for the Titanic exhibit, particularly in examining the artifacts or the design of the exhibit as it was created to enhance the audience's emotional experience in the exhibit.

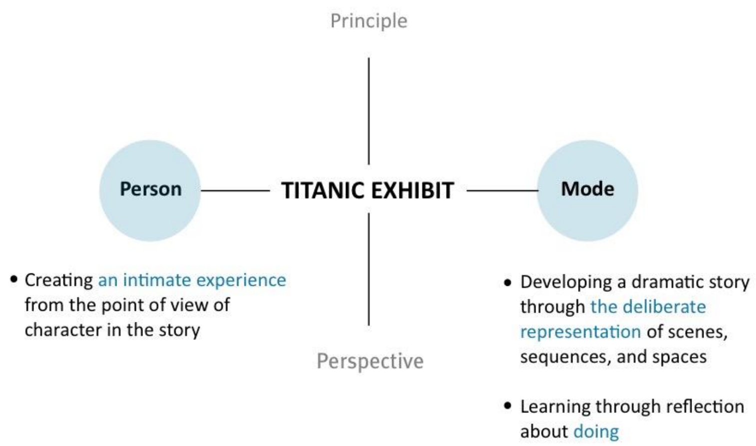

Figure 2 Design strategies in the Titanic exhibition

3.1.1 Creating an intimate experience from the point of view of a character in the story

What distinguishes the visitors' experiences in the Titanic exhibit from others is first found in the boarding pass given to the individual upon entering (Figure 3). Each ticket is a replica of a boarding pass for the ship and has a detailed description of an actual passenger on the back. These descriptions offer information about each passenger, from name, ticket class, number of people accompanied to the reason that he or she was onboard, along with additional passenger facts. For example, 38 year-old Miss Annie Clemmer Funk was returning to her family home in Bally, Pennsylvania from Janjgir, India on a second class ticket after receiving a telegram that her mother was very ill. Another example shows a story of a 48 year-old woman, Mrs. John Morgan Davies who was traveling with her two sons and two friends to Hancock, Michigan to live with her eldest son after being widowed twice.

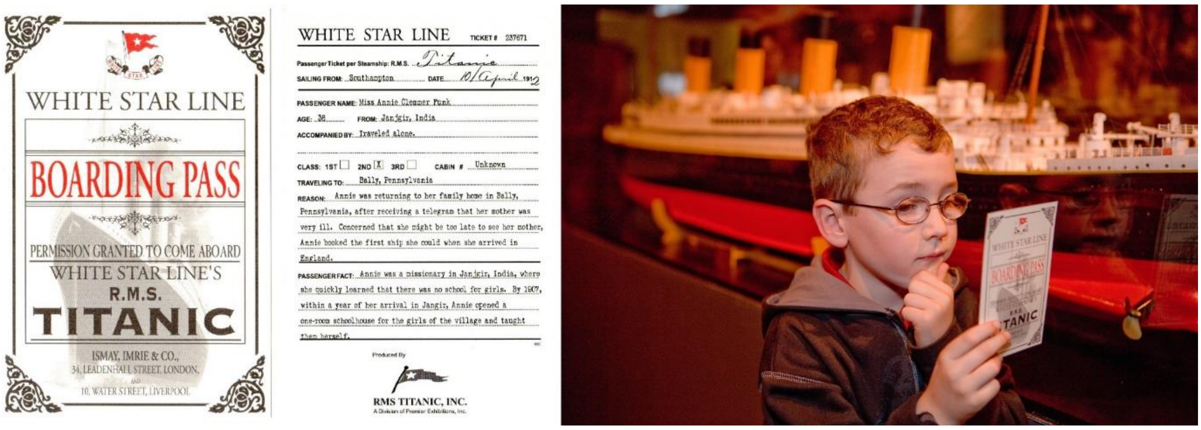

Figure 3 Boarding pass from the Titanic exhibition. Copyright © Titanic: the Artifact Exhibition

Instead of moving through the exhibition from a stranger's point of view, this information in this postcard-size carry-on is useful for visitors to track their passenger's experience on their boarding passes from his or her point of view. Consider the following quote from one of the visitors to the exhibit in the Denver Museum of Nature and Science:

> *Those boarding passes got all of us emotionally invested before we stepped foot into the exhibit. As we talked through, it was each to imagine and wonder if 'we' had been the owners of the artifacts displayed did we wear those glasses? Drink from those cups? And most of all, did we get into any of the lifeboats? (Tiffani, 2007)*

The boarding pass creates an impression that this is not just a story of a legendary ship but also the stories of the 2,238 people who journeyed in the ship. In this respect, each object becomes a piece of information that is meaningful and engaging when it portrays the experience of a particular passenger onboard or describes what the experience would be like in the Titanic. Simply put, the Titanic artifacts are not just physical pieces of evidence that demonstrate the veracity of the historical event; they are storied objects that elicit emotional experiences of the people onboard the Titanic.

In addition to the boarding pass, which first builds the visitor's connection to the actual passenger, another element that elevates this emotional experience is found in the Memorial Gallery, the exhibit's final display. Upon entering, there are three wall panels that list all the names of the passengers who were saved or lost based on their ticket class (Figure 4). At first glance, looking at the huge number of people who were lost overwhelms visitors, particularly in noticing the big difference between third class and first class passengers who didn't survive. Then, a feeling of astonishment turns into a sense of awe or deep sorrow as the visitors locate his or her passenger on the wall. This sentiment is illustrated in the following comments:

Powerful and awe inspiring, this exhibit allows the visitor to see, hear, and feel a small portion of what life and death must have been for the passengers and crew of the Titanic.(Tulsa, 2010)

This was my second time and I still am in awe and have a feeling of sadness for all of those families broken up and all of the sorrow. This is amazing.(Anonymous, 2010)

It is not only the connection between the individual visitor and his or her passenger that is built in this exhibit; the emotional connection is also strengthened by bringing the visitors together and allowing them to share in their experiences and the story in the exhibit. For example, a visitor recalls, “by the end of the exhibit, we all really felt like we were the people on our paper.”(Tiffani, 2007).

She further describes:

The Golfer. Oh, The Golfer (a third class passenger). I found his wife on the survivor list, but without his name accompanying it. He was so nervous as I searched and searched. I finally found it, along with his brother’s name, on the “Lost” list. I told him that he had most likely placed his wife on a lifeboat, and then stayed behind so more women and children could be saved. And then I started tearing up. I had no idea it would be so emotional by the end!(Tiffani, 2007)

After he checked the fate of his passenger, he also walked over to ask another visitor with whom he talked in the exhibit if his passenger survived or not. Sharing real stories about their passengers turn strangers into friends; it also creates a sense of leaving the exhibit with some stories to tell or feelings about the journey.

Figure 4 The Memorial Gallery in the Titanic Exhibition. Copyright © Titanic: the Artifact Exhibition

3.1.2 Developing a dramatic story through the deliberate representation of scenes, sequences, and spaces

What distinguishes one’s experience in the exhibition from the experience of reading a book or watching a movie lies in the difference between spatial and temporal experience. Walking in an exhibit develops the visitor’s navigation through the artifacts on display by controlling their pace and movement, yet it may not create an experience as immersive or vivid as events occurring within a moment in a movie.

In order to develop a compelling story through the visitors’ spatial navigation, the Titanic exhibit presents its story based on the chronological order of the event. The exhibit consists of four parts from its construction and departure to the memory of people, in which the life of the Titanic is told in a way that creates a deliberately organized pathway for the visitors. For instance, the construction and departure gallery in the first part, as well as the gallery describing the Titanic’s crash into a block of ice in the third part, are organized according to the temporal progression of events. The second part of the exhibit showcases various recreations of rooms with furniture, clothing, dinnerware and silverware, menus, and personal belongings that were used in each space (Figure 5, Figure 6). Displaying artifacts and furniture in context vividly describes the passenger experience along with the use of other kinds of informative pieces. For example, the Veranda café, one of the restaurants for the first class passengers, includes an actual recreation of the space with a display of china, glassware and silverware and demonstrates a contrast with the third class dining saloon displayed in pictures with their simple mugs and plates (Figure 6). Comparing the dinnerware between the first and third class provides a glimpse of the dining experience between different classes; the dinner menu hanging on the wall also offers detailed information about types of food served for each class. For example, Filet Mignon and Beef Sirloin are served to the first class diners whereas boiled chicken and bacon are the main dishes in the third class dining area. Representing the dining experience in diverse ways illustrates what it was like having a meal per each class in Titanic.

Figure 5 Room recreations: first class cabin (left), third class cabin and hallway (right). Copyright © Titanic: the Artifact Exhibition

Figure 6 Second class china (left), Third class plate and mug (right). Copyright © Titanic: the Artifact Exhibition

3.1.3 *Leaning through reflection about doing*

One of the goals of the Titanic exhibit is to provide education. According to Joanna Haas, the director of Carnegie Science Center, the Titanic exhibit “isn’t just about the historical aspects of the sinking of the Titanic. It also deals with the science behind what was hailed as a tremendous engineering feat that ended in disaster. Ninety years after the sinking of the Titanic, science played a role in developing ways to salvage artifacts from the wreckage area surrounding the ship.”(Haas, year unknown) In this respect, science as inquiry becomes the primary focus of the Discovery Gallery in which the process of artifact recovery and conservation is presented. In addition to a variety of hands-on activities, various documents are also available to download online from the link upon request, such as the Teacher’s guide or Educator’s information packet, which list of a variety of field trip activities and classroom lessons for different grades.

The educational impact of the Titanic exhibit is further enhanced through the presentation of scientific information within the stories of real people and real artifacts. Reconstructing the historical event from diverse perspectives, the Titanic exhibit becomes “a great catalyst for lessons in history, geography, English and Math” beyond science and technology. This is why the exhibit has drawn a wide range of visitors, from children to adults, and now continues to be held across numerous countries. Because of the richness and detail of the reconstruction of the event in its time, the exhibit provides something, from emotional experience to scientific knowledge that the visitors can take away from it. This is expressed in one of the visitors’ comments, “This is an *amazing* exhibit. I knew part of the stuff about the Titanic, but I never knew all of it. There are all these fiction/fact movies and stories about the Titanic, but you never get the *full* story, like you do here”(Richland, year unknown). Scientific facts, historical records, and social and cultural contexts can provide a fuller experience when they are woven together as a coherent story.

Figure 7 The wall of ice in the Titanic exhibition. Copyright © Titanic: the Artifact Exhibition

Another example of the design of the learning experience is found in the third section of the exhibit. In order to create a distinct experience from other sections, the emphasis in the third part is a description of the day of the ship’s sinking. This part is meant to enhance the visitors’ sensory experiences in diverse ways: through dim lighting, low temperature, and numerous sounds effects such as a low humming sound that mimics the ship’s engines. The highlight of this part is a large block of ice that stands in the middle of the room, which visitors can touch, feeling the coldness of the water that the ship’s passengers felt on that night (Figure 7). The following comments from two visitors describe their experiences with the iceberg wall:

> *The kids tried to see who could keep their hands on it the longest-no one managed longer than 8 seconds. Then we read that the freezing sea water was even colder than the fresh iceberg, and that most of the deaths occurred from hypothermia than drowning. We all sat in silence, imagining how cold it must have felt being totally submerged in the cold ice water, not just putting our hands on it (Tiffani, 2007).*
>
> *Touching the ice gave you a true idea of what they faced in many hours which would be their last (E.& D.K., year unknown).*

Providing visitors with diverse forms of hands-on experience was effective in making one’s learning experience direct and memorable. More than any realistic description or scientific evidence, touching the ice helps visitors to feel and imagine a situation that a huge number of passengers had to endure on that day. It is a unique experience that only the physical exhibit can offer to visitors in contrast to the experience of reading or watching an online experience.

3.2 I like Seoul campaign

The *I like Seoul Campaign (ILSC)* is a social campaign project that demonstrates the role of design in society, not only in its goal to solve problems in the surrounding environs, but also in its ability to raise issues to which the public can become aware and actively respond. The ILSC was initiated by a group called design group FF, which includes a small number of college design students and alumni. In one sense, their motivation for creating the *I Like Seoul Campaign* series came from their personal search for answers to the question, “why do I (we) like Seoul?” Thus, the ILSC began as a personal journey from the perspective of people who had grown up and lived in Seoul. However, we may consider the significance of this work from another perspective; it can serve as a model for critiquing a number of other design projects and internationally organized design events implemented by the Seoul Capital Government. Designing Seoul Campaign posters was just one of the projects among Design Seoul Campaigns which were placed all over the city, from subway stations and bus stops to newsstands (Figure 8). The goal of these posters was to promote new facilities and new services provided by the government, including daycares, public parks, saving accounts, and Wi- Fi internet services. Each poster advertises different facilities or services but contains the same message in the bubble: “I like Seoul” in Korean.

While the Design Seoul Campaign posters represent the voice of the Seoul Capital Government, the ILSC posters attempts to reflect the voices of multiple and diverse citizens, as the design group FF states:

> *There may be more than one answer why we like Seoul. Sharing and exchanging various voices enables people not only to seek their own answers but also to discover the true identity or the value of the place in which they live (FF, 2010).*

Their claim is that most of the Design Seoul Campaign projects attempt to promote the idea that new design is good, and tend to renovate the old into the new, yet do so without careful consideration of important issues, such as: sustainable design, protecting local cultures, and creating a harmony between old and new. This motivated the design group to launch a series of campaigns, including the I like Seoul Campaign in season 1 (I like Seoul Campaign Posters) and season 2 (G20 Seoul Summit Project).

Figure 8 Posters displayed at subway stations, on the subway, at bus stands, on buses

For the ILCS season 1 project, which transforms the “government monologue” into “open public dialogues,” FF adopted the idea of using bubble stickers as a communicative space through the *Bubble Project*, which was originally conceived by designer Ji Lee. The goal of the *Bubble Project* is to provide public “free spaces” that allow people to express their thoughts by filling in the blank bubbles with their own voices (Figure 9). In 2002, Lee printed 20,000 bubbles stickers and placed them on top of advertisements throughout New York City; later, he photographed the bubbles after they were filled in with various responses and published them in a book and an online forum in Figure 9 (Lee, 2006). FF also used bubble stickers as a primary means of communication, yet modified the idea in a way that it is relevant to the purpose and effect of the ILSC project.

Figure 9 Bubble Project (top); Bubbles filled with text (bottom). Copyright © Ji Lee

While the goal of *Bubble Project* is to provide the public with a way to express their individual voices against the corporate monologue in advertising, that of the ILSC is to inspire the public to search for the value and the true identity of Seoul against the monolithic message that is repeated in the "I like Seoul" campaign posters. In order to search for diverse yet collective voices to express why they like Seoul, FF gathered diverse opinions about "why I like Seoul" through social networking channels, including the project website, twitter, and me2oday. Afterwards, they printed each message onto bubble stickers and placed the bubble stickers with their new messages all over the city on top of the Design Seoul Campaign posters (Figure 10). Figure 11 shows how the message in the middle, "Seoul is dead. Seoul is now dying" contrasts with the original message, "I like Seoul" on the left and the right. While the former reflects one of the opinions generated by citizens, the latter represents only the voice of the Seoul Capital Government, which attempts to promote a variety of services and policies under the Design Seoul Campaign project.

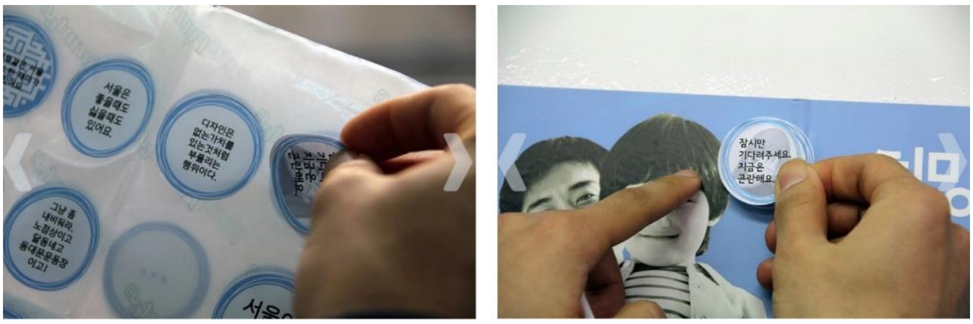

Figure 10 The process of the I Like Seoul Campaign Posters

Figure 11 Posters displayed at subway stations, originals (left, right), a poster with a new bubble (middle)

In what follows, I use the Point of View framework as a tool of analysis (Figure 12) to examine two design strategies found in the *I Like Seoul Campaign* posters, which are intended to foster open public dialogue and to employ irony as a means of communication.

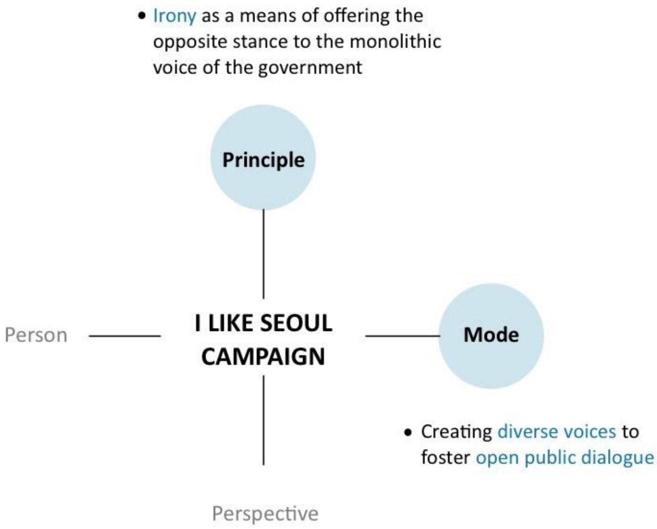

Figure 12 Design strategies discovered in I Like Seoul Campaign

3.2.1 Creating diverse voices to foster open public dialogue

The first design strategy found in the ILSC posters is to provide a means to convey *diverse* voices about what each citizen loves about Seoul from their points of view. These voices are individual, yet collective and powerful in that they arise from some shared understandings among the collected opinions. This is closely related to the objective of the ILSC in providing a means to collect and communicate these voices in a way that is widely accessible:

> *We have started to wonder why Seoul has been chosen as the World Design Capital in 2010. What distinguishes Seoul from other cities in terms of design? Why is it Seoul over other cities? We expected to find any answers to these questions in Seoul, where we live now. Therefore, we began our journey to search for these answers by reading books, meeting officials, designers, and citizens, and talking to a wide range of people, to discover something that is not apparent. However, the answers were already with us from the moment we began our search. We realized that they are not only ours, they also belong to all those people who live in Seoul.*

As described above, the idea behind this project is that each citizen differently values what it means to live in Seoul; sharing diverse opinions also fosters open public dialogue in order to discover other values, issues, or problems that were not realized before.

Diverse voices not only allow public dialogue about what it means each to live in Seoul, but also reconsider the common value, not merely as a city of the Design Capital but as an environment in which people live. What is the true identity of Seoul in comparison to other cities? What are the issues or the problems that are identified by citizens? These concerns are expressed in the bubbles by arguing that designing Seoul does not entail renovating every corner of the city without maintaining the identity of Seoul. For example, Figure 13 contrasts some opinions against the idea of changing the old to the new, such as “Does design mean to make something new? (left),” “Are you going to design ancient palaces, too? (middle),” or “Leave them as it is: street vendors, undeveloped community, Dongdaemun stadium (right).” Multiple voices presented in the bubbles shift the conception of Seoul, which elicits amazement by discovering a new way of connecting Seoul and the people who live in the city, from the World Design Capital to the real environment in which people live and interact. In summary, the ILSC challenges existing assumptions and preconceptions about the role that design plays in a society, specifically in response to the political and social changes happening in Seoul in 2010. The ILSC demonstrates the fact that designing for Seoul should mean designing for citizens who live in it rather than designing for the sake of design or for creating a new kind of policy.

Figure 13 I Like Seoul campaign posters with new bubbles

3.2.2 *Irony as a means of providing an opposing stance to the monolithic voice of the government*

Another use of point of view is closely related to the idea that *irony* offers “perspective of perspectives” from a critical stance. In rhetoric, the term *irony* refers to a figurative element of speech that expresses an idea as its opposite. According to literary theorist and philosopher Kenneth Burke, the role of irony as one of the four master tropes should not be limited to its figurative and literal usage. Rather, a more important application of the four tropes is to discover and describe “the truth” (Burke, 1969, p.503). The following passage illustrates Burke’s primary concern with irony, which provides useful insight:

> *Irony arises when one tries, by the interaction of terms upon one another, to produce a development which uses all the terms. Hence, from the standpoint of this total form (this “perspective of perspectives”), none of the participating “sub-perspectives” can be treated as either precisely right or precisely wrong. They are all voices, or personalities, or positions, integrally affecting one another (Burke, 1969, p.512).*

What is central to irony is to not just show seemingly contrasting ideas and judge whether they are right or wrong, but rather to develop and share many ideas as different possibilities so as to create a common ground that is agreed upon. This is closely related to the goal of the ILSC. Since irony is concerned with “resisting affirmation to locate alternate positions,” placing bubbles filled with multiple opinions on the existing Design Seoul Campaign Posters is more effective to show the gap between what Seoul citizens experience (middle, Figure 11) and what the Seoul Capital Government actually does (right and left, Figure 11), than recreating a poster that criticizes the constraints of the Design Seoul Campaign.

The emotional effect that is evoked by the ironic stance can also be discussed with *the sublime,* which is elicited when the idea of connected whole is discovered, particularly realizing the way we are all connected to one another. In the campaign, what connects individuals to Seoul is an awareness of the idea that we are citizens who are responsible for sharing ideas, raising issues, and resolving relevant problems. This would allow the public to explore alternative possibilities through active participation in a public dialogue.

The following examples (Figure 14, Figure 15, Figure 16) show a set of common issues and themes that arise from these diverse voices.

Sustainability

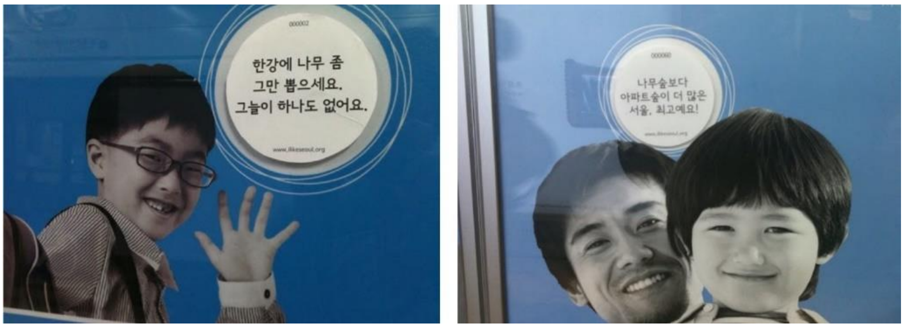

Figure 4 I Like Seoul Campaign posters with new bubbles

“Stop uprooting trees at Han River. There is no shade.” (left) “Seoul has more apartment jungle than forest. Wonderful.” (right)

Loss of Identity

Figure 5 I Like Seoul Campaign posters with new bubbles

“Wow. Seoul is turning into Seoul Land (like a theme park with a lot of attractions).” (left) “That’s just the way I like Seoul.” (middle) “Seoul-si, New York-gu, Paris-dong, London Apartment construction site." (right)

Goal of Designing Seoul

Figure 6 I Like Seoul Campaign posters with new bubbles

“For whom are we designing Seoul?” (left) “Seoul should be a space where residents feel happy rather than a city for display.” (right)

4 Conclusion

This inquiry stemmed from the problem of information design, particularly a lack of substantive theory that can encompass emotion and information design. Although the role of emotion has for some time been central to human communication and other areas of design, no theoretical framework has been developed that would allow design researchers and educators to model the relationship between emotion and information as part of examining the complex relationships among information artifacts, audiences, and designers in specific contexts.

This paper presented the Point of View framework as a mediacy of information design in order to uncover and analyze design strategies that are used in information design works. What distinguishes this framework from other descriptive frameworks is its breadth as well as the expandability of each of the four themes; person, perspective, mode, and principle as means for questioning and illustrating the use of point of view in the context of information visualization and other fields of design. Although the number of examples analyzed in this paper was limited but carefully chosen to cover diverse types, from posters to exhibitions and social campaign projects so as to examine diverse design strategies aimed at enriching emotional connection between the information design artifacts and the audience across various form and media.

Recognizing emotion in relation to action and experience as the central concern of information design, this research makes the following contributions. First, this study provides a theoretical framework that can examine the relationship among information artifacts, audiences, and designers in specific contexts. While the three components are not entirely new, the problem is the lack of a framework that models the complex relationship among the three. Therefore, presenting the Point of View framework would help design researchers and educators to understand the audience’s emotional connection to the information artifacts in particular contexts.

Second, this study provides a metalanguage that allows design researchers and educators to articulate the audience’s emotion connection to the information design artifacts; it offers an approach for uncovering design strategies that are often implicitly used by designers to create information artifacts aimed at producing a particular emotional effect for an audience. In particular, four thematic variations of point of view can be used as a tool for analysis with which an information artifact or a particular communicative situation can be better understood; they can be also used by practicing designers in the planning process when solving a design problem, and by educators in the class as a tool for critique.

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DRS 2018 Design Research Society 2018 Catalyst

University of Limerick
25th – 28th June 2018

Discovery DiDIY. An Immersive Gamified Activity to Explore the Potentialities of Digital Technology

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doi: 10.21606/dma.2018.616

Digital Do It Yourself (DiDIY), is a complex, rapidly evolving socio-cultural phenomenon, characterized by individual and social activity to create, repair, and modify objects through digital technologies. Thanks to the challenges opened by production and sharing technologies, DiDIY may create many economic opportunities and promote active citizenship. However, technologies can be also a hindrance to innovation because of a lack of skills, knowledge and awareness in using them. The objective of this paper is to describe "Discovery DiDIY" an activity designed to create immersive learning experience to make people understand how digital technologies can become economic and social opportunities. The activity has been designed following the 4 key phases from the Kolb's experiential learning theory – simulations, reflection and sharing perceptions, gaining knowledge, apply and experiment. Discovery is the first activity of the Immerse Step of the DiDIY co-design process, a process resulted from the 8 co-design workshops held within the framework of the EU project "DiDIY".

experiential learning; game-based collaboration; co-design process; co-design tools

1 Introduction

Digital Do It Yourself (DiDIY) is a current trend of self-production enabled and rapidly evolving thanks to the widespread social availability of affordable technological tools. It is a complex socio-cultural phenomenon, characterized by individual and social activity to create, repair, and modify objects through digital technologies. It typically occurs outside of companies and presents great opportunities for increase individual and collective creativity, helping citizens to acquire some of the skills they need in a digital world. People engage in DiDIY activities driven by personal satisfaction, a strong ethical motivation, interest in customization, or social reputation. In a context of industrialisation, that separates producers and users, DiDIY is a means for individuals to recover their autonomy by the productive and creative use of their skills and time.

1.1 DiDIY opportunities

DiDIY could contribute to change how individuals study, work, cooperate, express their creativity, solve problems, especially thanks to the widespread use of ICT, embedded in computers, smartphones, 3D printers, home automation systems.

Thanks to the challenges opened by production and sharing technologies, DiDIY may create many economic opportunities and promote active citizenship, while making the society more resilient, and playing a key role in realising sustainable futures. An inspiring example is the "Public Lab" project, (https://publiclab.org/) that is a DIY scientific community that investigate environmental concerns by using inexpensive DIY techniques promoting bottom-up and open research.

However, technologies can be also a hindrance to innovation because of a lack of skills, knowledge and awareness in using them. This often limits to apply the potentialities that grows form the profound connection between technologies and the social context.

1.2 Research methodology

Due to its complex nature, with implications in many different environments at different levels, DiDIY calls for a transdisciplinary research methodology and a bottom up approach to be investigated. Therefore, we have adopted co-design, a transdisciplinary research methodology and collaborative process where people are directly involved in the research and production of knowledge, as both an analysis method and a design process for DiDIY. Going to its essence, what characterizes co-design is the involvement of non-designers in collaborative activities: collaboration is then key element of the process and knowledge is produced and shared as a collective action.

With this knowledge in mind, we considered fundamental to understand what action could be done to exploit the more lasting, sustainable, and socially relevant opportunities of DiDIY. As design researchers and experts in creativity driven innovation through design, we aimed at contributing by facilitating the DiDIY creative process and, above all, by training and guiding people in the application of a strategic approach to the use of technology.

The two dimensions strategically embedded in co-design useful for analysing DiDIY are: 1-the social and rational idea of democracy that set the conditions for people participation, 2-the importance of eliciting participants' tacit knowledge (i.e. the practical and diverse skills that are fundamental to collective making). In this view collaboration through co-design might be seen as a collaborative process to implement the practices of DiDIY.

Starting from this theoretical ground, we designed an ad hoc co-design process and related tools specific for DiDIY that can help people to create an innovative digital solution in their professional field. The first activity of the process has been specially designed to make people understand how digital technologies can become economic and social opportunities.

To achieve this goal and face the complexity and volume of information to be transmitted, we designed co-design activities drawing from Experiential Learning Theories (Kolb 1984 and 2015; Fraser, 1995; Boud et al, 1985) and Game-Based Collaboration. Participants were immersed in a specific experience and guided through a structured activity by using co-design methods and tools described in section 4 of the paper.

1.3 The DiDIY project and its objective

The nature and potential long-term effects of this phenomenon has been widely studied within the framework of the EU funded project "Digital Do It Yourself" (www.didiy.eu), in which IDEActivity research group has created and experimented the DiDIY co-design process divided in four main steps: Immerse, Define, Ideate, and Build to Think, showed in Figure 1. Only the Immerse step is addressed in this paper.

This explorative activity called “Discovery” allowed the creation of a common knowledge establishing a point of view regarding a specific topic/issue, taking scientific material and structured research into consideration, and also considering the target user and the market.

A first specific objective that we aimed to reach was the emphatic involvement of people in the DiDIY environment, by organizing and providing residential and immersive experience.

A second specific objective was to help people in gain confidence and understanding of the DiDIY context. Through the collaborative analysis of some selected case studies people acquired knowledge of the DiDIY phenomenon identifying the DiDIY fundamental factors.

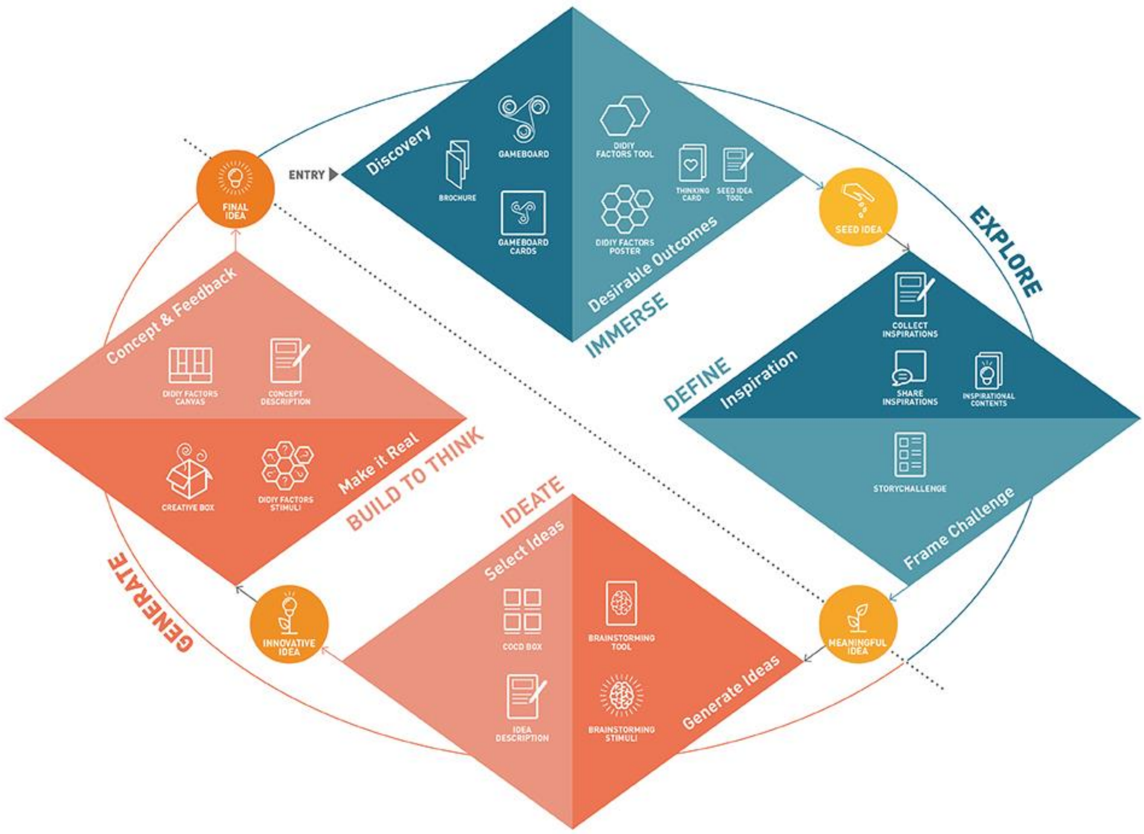

Figure 1. The DiDIY co-design process created by IDEActivity within the European project DiDIY

The objective of this paper is to describe the “Discovery” activity and related tools designed within the **IMMERSE step** of the co-design process (in Figure 1, it is represented in the blue rhombus at the top). Through an immersive experience, **the objective of this step is to dive people into the context of DiDIY to let them understand its potentialities and the business and social opportunities.**
To this purpose, section 2 refers about the preliminary research that led us to design an immersive experience to highlight the social aspects and the fundamental element of DIDIY. Section 3 will then describe the theoretical framework on which the experience is built and that will be carefully described in section 4.

2 Digital self-production as an opportunity for social change

The notion of DiDIY is here envisaged as a valuable tool for exploring the relationships between **emerging technologies**, **self-directed creativity**, and **social change.**

2.1 *The benefits of emerging technologies*

The contemporary concept of DiDIY can be understood as an amalgamation of different elements, politics, culture and arts enabled by digital technologies (Gauntlett, 2011). All these elements linked in turn in different ways constitute diverse making practices or contribute to the rising and diffusion of innovative projects. The spread of production and sharing technology has simplified the process of creation by facilitating the accessibility to tools and the connection of people.

On the one hand, emerging production technologies such as rapid manufacturing, allows the creation of products even at earlier stages of the acquisition of the required technical skills, to make the manufacturing process easier and cheaper, to realise artefacts valuable to human life, lowering prices and skipping various production steps (Hoftijzer, 2009). Technology allows for customisation of products based on human needs (Tanenbaum, 2013).

On the other hand, it is radically easier to interact with other people across geographical boundaries for collaborating and sharing knowledge. Digital technology is a way to break down borders and allows global expansion of different local communities' ideas and projects, readapting the solutions to meet their local needs according to their culture and geographical area of reference. This is the foundation idea of projects such as Open Source Ecology (https://www.opensourceecology.org/) which aim is to build an open enterprise that publishes blueprints for both physical artefacts and for all of its strategic, business, organizational, enterprise information, so that other community with similar problem around the world could learn and thereby truly accelerate innovation.

2.2 *New collaborative way for people*

In this sense**, digital technologies are intended also as social process facilitators** (Gauntlett, 2011). This is in our view the most significant meaning of DiDIY to transfer through a co-design process, i.e. ***the opportunity for people to acquire competences and trigger virtuous behaviours through and with others, in a collaborative way*** and often for the benefit of the local or global community (Salvia et al., 2016).

The establishment of the Information and communication technologies (ICTs) and social media has indeed contributed to the spreading of groups, i.e. communities (open source, peer-to-peer, etc.), who collaborate on a wider scale, for common purposes, contributing to a more community-oriented society. DiDIY is an environment where real/virtual, direct/mediated experiences are no longer distinguishable; online and offline activities meld and morph within distributed networks (DiDIY, 2017).

Collaborative and peer production has been envisaged as "an opportunity for more people to engage in practices that permit them to exhibit and experience virtuous behaviour" (Benkler and Nissenbaum, 2006). It is a creative practice through which **people may increase their self-confidence and empowerment by developing new skills and knowledge** (Salvia et al., 2016). This is a second important feature that motivated us to structure a process and specific activities which can support people in gaining knowledge about the phenomenon, and in applying its innovative features creatively.

With this ideas in mind, we truly believe that DiDIY practice has some potential features that could bring innovation to different fields of application. **It provides the opportunity to adopt technology not as the innovation itself, but as a vehicle for generating innovation that must be connected to other dimensions** (such as new scenarios, new product/service offering, new business model and so on). When we talk about innovation in the industrial field, we mean a change that is not only generating improvements, cost optimization, turnover and better performances. It refers mainly to the development of the right mindset, foster team building, introduce high levels of openness and cooperation in the working environment.

The general goal is to make people aware of the potentialities of this emerging technologies by let them: discover its innovative features, learn how to use them strategically, adopting a collaborative and creative mindset.

The next paragraph explains the theoretical framework and the learning theories on which the design of the “Immerse” step and the “Discovery” activity is based.

3 Discovery Activity: theoretical framework

"Problems are never technological" could be the claim *that summarizes the research on DiDIY,* as highlighted in the previous paragraph. It refers to the idea that digital technology doesn’t work itself and its adoption, without human thinking, doesn’t solve any (social) problem. In many fields, such as work and education, digital technologies aren’t often introduced because there is a lack of knowledge and skills on their applications and benefits. Nowadays, the role of digital technologies can be explained as “a necessary but not sufficient condition”: we cannot do anything without them, but technologies itself are not enough. To adopt them in projects or activities it’s necessary to have a strategic vision of how to use them and their potentialities and limits.

From this consideration, arose the idea of designing a step called “Immerse” as a starting point of the DiDIY co-design process, to allow people to understand how digital technologies can become an economic and social opportunity. A first deep reflection has been made on how to transfer the social concept of DiDIY by adopting learning and communication dynamics already experienced in other contexts. How can we handle the scientific knowledge in a practical and concrete way?

According to the theory proposed by Kolb (1984), the most effective methods involve experiential learning, such as hands-on or field-based practices, in particular intentional ones, associated with and linked to the real world. As the name suggests, experiential learning is “the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience”. “In this view of experiential learning, the emphasis is often on direct sense experience and in-context action as primary source of learning” (Kolb, 2015). This suggests that the active involvement of people in the co-design activities reinforces the acquisition of information and the consolidation of knowledge.

Kolb’s cycle emphasizes learning by **first experiencing something or bringing it to mind via a simulation of experience** *(Concrete Experience)*, **reflecting on that experience and sharing perceptions of the experience** *(Reflective Observation)*, **checking these perceptions against theory that helps to explain what happened** *(Abstract Conceptualisation)*, **applying what is thus understood to practice, and experimenting with new ways of thinking and working and being that generate a new cycle of this kind of learning** *(Active Experimentation)*. When a CE is enriched by reflection, given meaning by thinking and transformed by action, the new experience created becomes richer, broader, and deeper. (Kolb and Kolb, 2010)

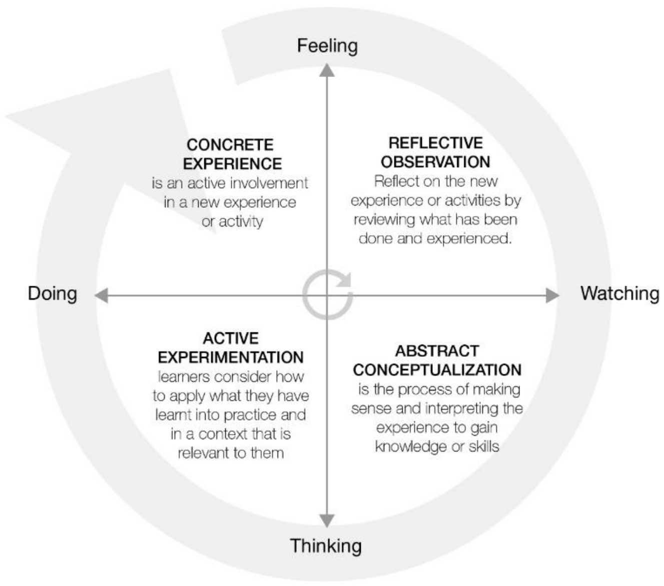

Figure 2. Illustration of the Kolb's cycle mapping.

Our fundamental objective was to offer an activity based on the concept of experiential learning of the DiDIY potentiality and the design process, designed to involve participants both emotionally and physically. There is no better way to understand the context of DiDIY than by immersing people in that context.

Therefore, **simulation** of experience, **reflection and sharing perceptions** of that experience, **gaining knowledge** from experience and finally **apply and experiment** what learned have been adopted as keywords to design the "Discovery" within the "Immerse" step of the DiDIY co-design process. Experimental learning theory has been adopted to involve people in an immersive experience that could transfer both a knowledge about DiDIY and a mindset related to the collaborative dynamics linked to this social practice. The experiential theory proposed by Kolb (2010) has a holistic approach and emphasizes how experiences, including cognitions, environmental factors, and emotions could influence the learning process.

"Discovery" is based on consolidated learning theories and on a framework in which game mechanisms are used to involve people in action and reflection. Gamified tools have been developed and designed to generate discussions, lead reflections and thoughts, collect and re-elaborate insights and finally actively propose implications in DiDIY.

In the design of the activity we have taken into consideration 5 points for its success:

- the **game-based/playful approach** to involve participants with different background and interests.
- Hold **provocative and emotional discussions** full of examples of real-life stories to facilitate reflection and understanding of what is being proposed.
- **Provide an easy-going environment**, where the participants are invited to relax and rethink their work or interest in relation to digital technologies, DIY mindset, collaboration and social impact.
- **Create and share materials to enable the participants** to experience and learn during the activities.
- Adopt **visual and verbal information**, emphasising the importance of creating, manipulating and combining mental images within the creative process.

3.1 The Game-based collaboration

The game is considered as *a field for the development of creativity* and an *element that stimulates the personality evolution and enhances learning*. It activates motoric, emotional, intellectuals and relational levels of people enabling a decision-making process.

According to Yu-kai Chou (2014), the biggest contribution that gamification can offer to people is human-centred design, rather than design focused on function. It is the use of game thinking and game mechanics in several contexts with the objective of improving participation and generating engagement and commitment from potential users. Gamification is applied as an alternative to traditional approaches, especially to encourage people to adopt certain types of behaviour, to get to know new technologies and to speed up their learning and training processes. Therefore, the act of playing has a meaning beyond entertainment. It presents its importance as a cultural element when: the game is more than a physiological phenomenon or a psychological reflection (Vianna et al., 2015).

In general, the application of gamification indicates situations that involve creation or adaptation of the user's experience to a product, service or process; the intention to awake positive emotions, explore personal skills or engage virtual or physical rewards to complete tasks.

The Games-based collaboration we have designed is all about leveraging the power of games to captivate and engage people for a specific purpose, such as to acquire and develop new knowledge and skills. It doesn't just "tell" the participants about the DiDIY as a lecture might do, rather it puts the participant right into the middle of things and lets him or her work their way around as an active participant in the events of the times. Games-based collaboration enables participants to undertake tasks and experience situations which would otherwise be impossible and/or undesirable for cost, time, logistical and safety reasons.

The "Discovery" activity focus on the use of a Gameboard tool that encourage collaboration among participants and active participation in defining the potentialities and limits of DiDIY. The gamified activity encourages reflection that is a crucial part of the experiential learning process. Dewey wrote that successive portions of reflective thought grow out of one another and support one another, creating a scaffold for further learning, and allowing for further experiences and reflection (Kompf and Bond, 2001).

A challenge for applying a Games-based collaboration approach is to design tools that can act as

> *"a skilled facilitator, that asking the right questions and guiding reflective conversation before, during, and after an experience, can help open a gateway to powerful new thinking and learning" (Jacobson & Ruddy, 2004).*

The tools lead participants to reflect and share their learning, interact with each other, with the facilitator building knowledge from other participants. The tools help also to create a shared language, appropriate to the context in which co-design activities take place, that could support information sharing and organization in a meaningful way.

3.2 Environment: a physical and emotional involvement

"The three factors related to the person, process, and environment interact to produce specific results. In other words, the quality of the creative product depends on the fact that people support certain processes within specific environments" (Puccio, Mance and Murdock, 2011). Numerous studies have concluded that an adequate space and environment should be designed to allow for exchange, dialogue and debate, by providing a dynamic and customizable environment and flexible enough to be able to adapt to people's changing needs. It should promote an open-minded attitude and the suspension of judgment, hierarchies and business roles.

Consequently, according with the idea that knowledge is continuously gained through both personal and environmental experiences (Kolb, 1984), it is important from the very beginning to consider the environment as an integrating part of the experience: a vehicle for the training itinerary able to effectively support the co-design process. This means not only managing the space, but also proactively managing communication.

During the activity, we have acknowledged the importance of setting up a space that allows for fluid and rhythmic sequence of activities where simulated experience, through case studies, or physical and mental pauses are essential elements for the retention of new information, their re-mapping and the emergence of new ideas.

The climate generated during the session is one of the factors that guarantee its success, as well as the right mindset to deal with the activities proposed during the workshop. Approaching the co-design session, one should be as open-minded as possible and try to avoid criticism of the ideas that are generated because this can cut off potentially useful ideas. A positive attitude is the strong foundation of a successful creativity session (Tassoul, 2011).

To foster a group of people and enable them to become a well-established and cohesive creative team they must become familiar with their surroundings and with all the components of their team. In this context, the transfer of know-how should be accompanied by short activities, such as energizers or icebreakers, designed to facilitate the generation of a favourable creative climate, which encourages team spirit and the sharing of objectives.

The activity designed by IDEActivity featured the emotional involvement of participants, a dynamic use of space, and visual representation.

4 Discovery Activity: designed tools

This paragraph describes the immersive learning co-design activity and the related tools designed to put theory in action through the active involvement and collaboration of participants. The 4 key phases from the Kolb's theoretical framework – *simulations, reflection and sharing perceptions, gaining knowledge, apply and experiment* – were used to let readers understand how we materialized theory.

"Discovery" guides participants through a process of identifying DiDIY potential and benefits that starts by exploring and interpreting a significant best practice in the field *(simulations).* The participants are led in their exploration of the case using activity cards, which show the task to be performed and a Gameboard *(reflection and sharing)* with specific aid cards *(gaining knowledge),* with which each group analyses the case. They will conclude this activity by choosing the benefits/potential that they'd like to bring with them to the next stage *(apply and experiment).*

4.1 Simulations

To quickly help the participants in understanding DiDIY essential aspects, some relevant information has been selected and presented in form of case studies. The selection of the case studies was based on the preliminary research carried out in different areas investigated by the DiDIY EU project such as education, open source, society, work, etc... They do not want to represent the best projects ever, but each of them is different, with marked social aspects, evidence elements of collaboration and motivational factors.

Five best practice have been selected (i.e FabAcademy, Open Source Ecology, Public Lab, Instructables and Imagineering) and represented in form of 50x70 cm foldable posters to provide an overview of the main elements of the project: objectives, participants, resources, main values, results, etc… (Figure 3). It is possible to consult them, as the whole set of tools presented in this paper, on the Co-design in the DiDIY scenario. Toolkit and guidelines (2017). On the front side of the poster were located the main information while on the back side were linked some in-depth information about specific features of the best practice. The information has been presented using images, text and by linking them to multimedia content (website and video) through a QR code. A multimedia presentation accompanied, supported and enriched each case study. Pictures, key words and in-depth videos were collected by using the Microsoft Sway program. The presentation allowed going in depth into some aspects of the case or understanding quickly the main points of reflection through pictures and key words.

Discovery activity begins with a preliminary immersion in the context of DiDIY by choosing one of the best practice brochure and consulting it for around 30 minutes (Figure 4). The combination of paper and digital material for reading the case study created methods of consultation that met the different types of users. Paper poster supported collaborative learning while digital presentation supported individual learning. Tablets and computers were therefore put at the disposal of the participants to make access easier to the multimedia contents.

Figure 3. "Open Source Ecology" poster brochure. Front side.

Figure 4. These images from workshops shows the combination of paper and digital material for reading the case study that meet the preferences of different participants.

4.2 *Reflection and sharing*

After the first moment of the best practice analysis, the activity moves towards a collaborative and structured exploration with the use of a gamified tool, designed ad hoc to improve participation and generate engagement and commitment from participants. Applying a successful gamification strategy is directly related to understanding the context where the user is inserted, and what their extrinsic (incited by the external environment) and intrinsic (self-motivated) expectations and constraints are.

Each collaborative analysis was supported and facilitated by using a Gameboard tool composed by a 70x100 cm poliplat graphic board (Figure 5, Figure 6) and 3 decks of help cards. The gameboard tool is designed to support and guide people in the exploration of the case studies considering three main aspects that usually enable a project: the people, the key components and the impacts that the project could generate. These three enabling aspects are visualized as three connected areas on the gameboard surface. The graphic board is a support that participants have at their disposal to complete and enrich with their reflections by using the Post-its. The activity's aim is to gather information and insight creating an understanding of them. This group activity is to be regarded as a moment of discussion to reflect and share different views and initiate a flow of ideas, to reach a common understanding among the working group. Working together in a multidisciplinary context, can better help people to discover how digital technologies can be used in new ways to design new social applications and practices. Multidisciplinary teams provide diversity, enabling the creation of new associations and interactions. In a group, the free flow of ideas can be stimulated by including open-minded group members, emphatic and creative people from different disciplines.

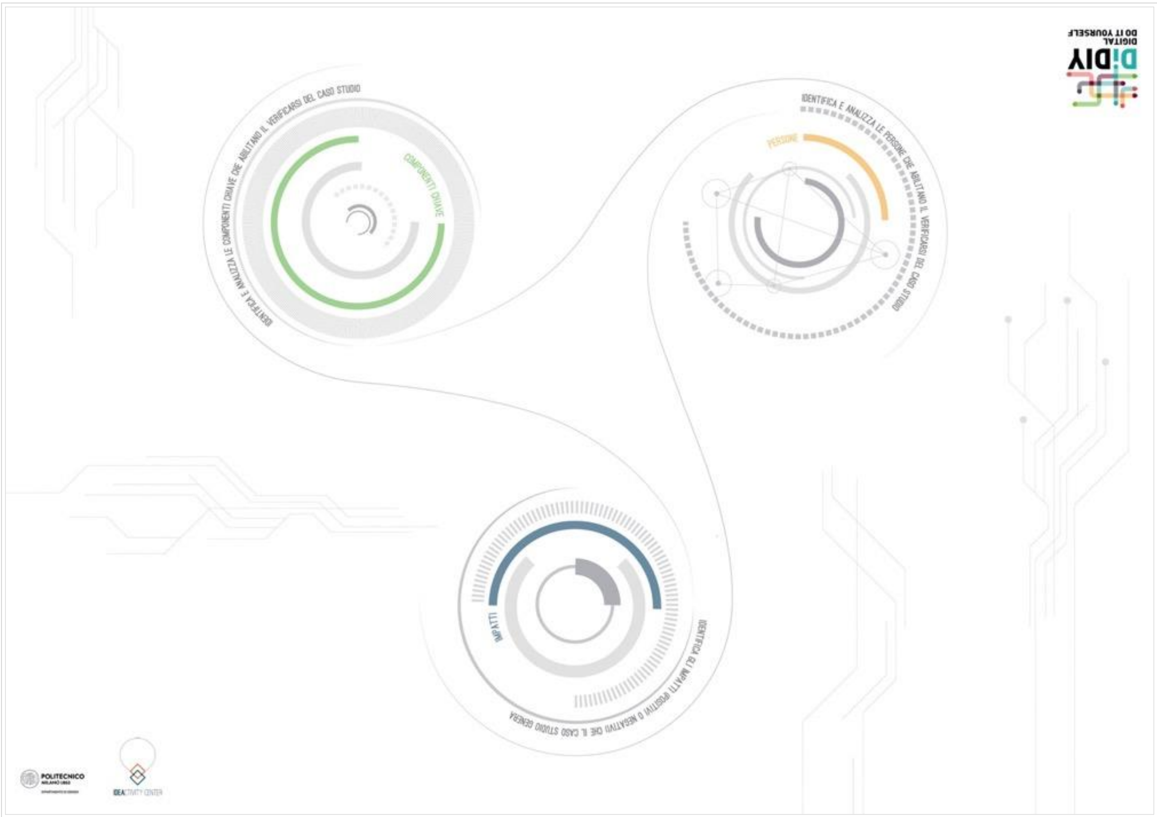

Figure 5. Gameboard tool. Graphic board.

Figure 6. Images from workshop: on the table there are the gameboard, the 3 decks of cards, the brochure of the case study, Post-Its and felt pens

4.3 Gaining knowledge

During the activity, the involvement of the participants and therefore their active thinking and learning is guaranteed by the introduction of 3 decks of cards that are part of the gameboard tool. The cards stimulate thinking and are the starting point for a rich flow of thoughts. Each deck is designed in relation to the 3 enabling areas illustrated on the graphic board. All the cards measure 9x9 cm and can be described as follows:

- People cards: the deck contains 4 cards whose aim is to identify and analyse Actors, Beneficiaries and Relationship that enable the develop of the case study. On the front side there is the topic to be addressed with the card and a specific question or stimulus on the back side that help participants to reflect (figure 7).
- Key components cards: the deck contains 3 cards on technologies with icons and descriptions on the front side and the questions to be answered on the back, plus 8 key components cards (e.g. activities, work environments, competences, etc.), each one with a specific question on the back. Both have the function of stimulating discussion, reflection and learning (figure 8).
- Impact cards: the deck contains 12 cards (e.g. social effects, business model, ethical aspects, etc.) with questions that help participant to reflect about the positive and negative impacts of the project analysed (figure 9).

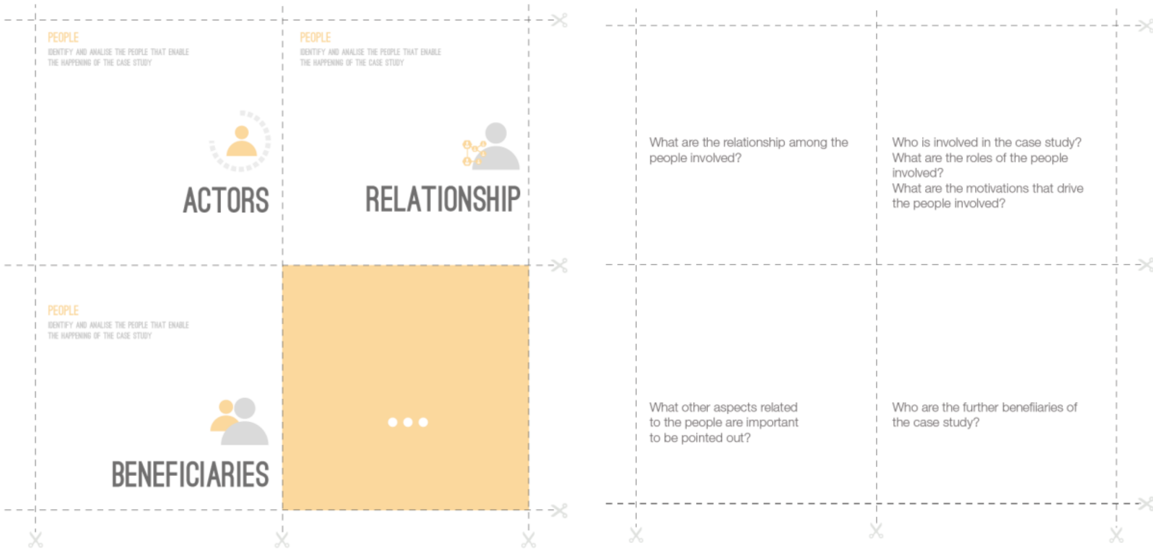

Figure 7. Gameboard tool. An example of people card, front and back side

Figure 8. Gameboard tool. An example of key components card. Front side

Figure 9. Gameboard tool. An example of impacts card, front side

Their use is mandatory, and they should generally be read in this order: people, key components and impact. Throughout the analysis, participants move through the three areas, reiterating, and placing relevant concepts on Post-its on those areas while discussing them. The cards can be used in different ways, according to the level of energy and involvement of the working team.

A Card Sort technique on which the card of the gameboard tool are based, is a quick and easy way to spark conversation about what matters most to people. By putting different cards, each with a word or single image or questions, in someone's hands and then asking them to reflect or answer the question, you'll gain huge insight into what really counts.

The use of the gameboard cards allows reaching an in-depth immersion in the context of DiDIY where connections between some aspects of the case and personal and professional experience of participants are likely to arise to enrich the contents. It is important to go beyond an impersonal analysis of the material, interpreting it with an open attitude. This activity is fundamental for both the expert and the people that are unfamiliar with the phenomenon because it allows a deeper understanding through analysis of the context from different points of view.

This explorative activity is considered divergent because it generates a vast mass of information (Figure 10). It becomes then necessary to organise the data visually, in order to indicate patterns that will help to provide an understanding of the whole and identify opportunities and challenges.

Figure 10. Images from workshop: Post-its with insight stuck on the gameboard, on the left image some toys to keep a playful atmosphere.

4.4 *Apply and experiment*

The divergent phase of the preliminary and the in-depth analysis is concluded with a convergent phase of clustering where the reflections that have emerged by similar aspects are grouped together to build a common understanding of the topic and above all identify the fundamental elements that underlie DiDIY. The final goal of the clustering activity is to synthesise all the information gathered into interesting findings, creating insights and inspiring future challenges.

The tool designed for this purpose is the “Technological star” poster measuring 100x70 cm with the representation of a star. This collaborative clustering activity produces from 3 to 5 factors shared and agreed by all the participants. The elements identified represent fundamental factors that must be taken into consideration when designing a solution in the DiDIY field. They are aspects that are present in most of the significant case studies in this phenomenon (Figure 11).

A star has been chosen to visually express the concept that only the intersection of all the fundamental elements of DiDIY at the same time can lead to innovation. It is important to highlight that it is not the single factor itself that generates a meaningful solution, but that the integration of all of them in a project creates the innovation.

The result of the Discovery activity is the collection of a series of factors which then, analysed by the research group and worked out allow creating the tool useful for the other steps of the DiDIY co-design process.

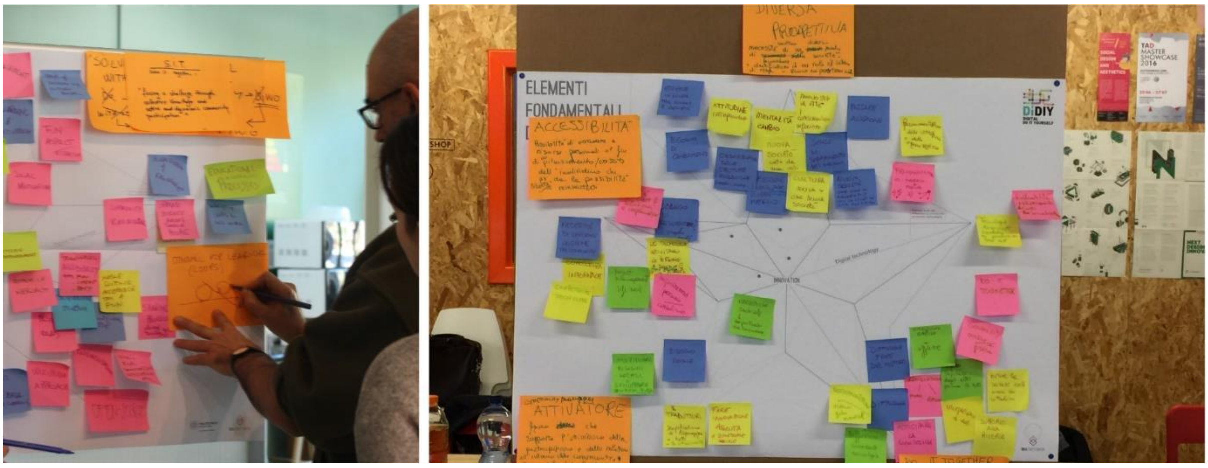

Figure 11. Images from workshop: the "Technological star" for the cluster activity to identify the fundamental factors to design solutions in the DiDIY field.

5 Conclusion

The activity’s main objective was to demonstrate how the co-design process - whose language is based on different forms of communication, and which makes use of specific game-based tools - represents an essential methodology in understanding the benefits of DiDIY. From this point of view, the designed activity has created a high added value satisfying the expectation of the IDEActivity research group and the participants.

As hypothesized from the research, the experience achieved through a game-based collaboration approach allowed to reach a deeper understanding of the complex socio-cultural DiDIY phenomenon in terms of economic and social strategic potential and of co-design process and mindset. The emotional involvement, the ability to freely move into the space, the use of images as a preferred channel of communication, has led participants to accelerate their learning and reflection process.

The experience clearly showed the value of adopting an experiential activity as a starting point of the co-design process that followed the 4 stages of the Kolb cycle: simulation of experience, reflection and sharing perceptions of that experience, gaining knowledge from experience and finally apply and experiment what learned.

The playful approach and the experience through a case study, are two important aspects that assumed an even more important role than expected. The activity in the relationship with space and with others, has amplified the involvement of the participants and the emotionality of the experience obtaining a very high level of attention from the whole team. The playfulness of the environment and the activity merged the group and made each participant aware of his own creative potential and the negative dynamics that could hinder the work. Moreover, it helped to create a fertile ground to activate the team's "lateral thinking" and activates the symbolic and imaginative thought of the right brain hemisphere.

Discovery has been tested and validated throughout 8 human-centred co-design workshops held in Italy and Spain by the research team of IDEActivity Center, within the framework of the EU funded project ‘Digital Do-It-Yourself (DiDIY). The workshops, have been repeated with the same structure in two countries focusing on 4 different thematic areas - Education and Research, Work and Organization, Creative Society, and Law, Right and Responsibilities.

Through co-design workshops the research team involved both laymen and DiDIY practitioners in the testing and refinement of the Discovery activity and the overall DiDIY co-design process, creating tools that speak in layman’s terms. Experts from the DiDIY field collaborate with professionals from the 4 areas, in order to identify the DiDIY enabling elements, according to their own experience and knowledge.

The repetition of the activity for 8 times with different actors allowed to: test and improve the activity, collect and elaborate those fundamental factors considered enabling for the DiDIY phenomenon. This are one of the most important results obtained from the Discovery activity. The DiDIY fundamental factors emerged from the participants have been transformed by the research group into one of the main tools to implement design challenges in DiDIY, to be used in the next steps of the DiDIY co-design process.

The experiences in each workshop have contributed to continuous experimentation, verification and implementation of project-building processes, and of specific activities and related tools, which have been utilized to produce the ‘Toolkit and Guidelines’ (IDEActivity, 2017).

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Annotated Portfolios as a Method to Analyse Interviews

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doi: 10.21606/dma.2018.510

This paper explores the use of annotated portfolios as a method to support the qualitative analysis of interview data about design projects. Annotated portfolios have so far been used to support artefacts with text in order to discuss them in the context of 'research through design' In this paper, we interpret the five-step method of McCracken and relate it to annotated portfolios to analyse interviews. We use a case study on design projects related to 3D printing and sustainability to illustrate the process. Five designers were interviewed to obtain a deeper understanding of the role of Additive Manufacturing in practice. These interviews were analysed in a visual process with annotated portfolios. The use of annotated portfolios is considered a meaningful approach to analyse interviews, because it leads to a more transparent analysis process: The visuals are rich in information, bring clarity to the data for interpretation and pattern finding and make this stage insightful for discussion with peers.

annotated portfolios; visual analysis of interviews; research through design; circular economy

1 Introduction

This paper explores the use of annotated portfolios as a method to support the qualitative analysis of interview data. We want to explore this in the context of design research, because it creates the opportunity to obtain insight about design objects and the process that led to these objects; data is approached differently, because visuals can be incorporated in the analysis phase. 'Annotated portfolios' is a research through design approach that shows a selection of annotated artefacts to analyse these artefacts. Annotations can be described as "the indexical connection with artefacts" (Gaver & Bowers, 2012), making them topical for discussions and comparison with other annotated objects. The annotations draw attention to aspects in the design that are not directly visible, but for example part of the ideas or system behind the object. The combined annotated artefacts generates the annotated portfolio, i.e. a group of artefacts that is described together to show a domain of design and its relevant dimensions (Bowers, 2012; Gaver, 2012; Gaver & Bowers, 2012). Annotated portfolios allow to translate particular aspects of artefacts into more generalizable theory. They can be seen as a form of intermediate-level knowledge, which indicates the space between the particular artefact and the general theories (Lowgren, 2013). We consider pattern finding in the interview analysis process as a form of intermediate-level knowledge. Therefore, including annotated portfolios in the interview analysis is expected to bring more transparency to the analysis process.

Although annotated portfolio is often mentioned in literature as a meaningful approach, only few examples exist of actual implemented 'annotated portfolios'. All studies have in common that the authors apply the method to describe their *own* design in order to make the design process, with all its considerations, more insightful. Some describe their design and insights in a paper, either directly linking annotations to pictures of their design project(s) (e.g. Srivastava & Culén, n.d.) or summing up annotations in the body of the text (e.g. Hobye, Padfield, & Löwgren, 2013). Others use the approach as a means in their process, for example for collaborative use of annotations to communicate between team members (Kelliher & Byrne, 2015). We consider it appropriate and interesting to describe the work of others with this method as well, especially in the context of qualitative interview analysis. The insights from interviews about the (design) process can be captured in annotations.

Applying annotated portfolios for qualitative data analysis has to our knowledge not been performed before. In this paper, we explore the combination of these methods with a case study on design projects related to 3D printing and sustainability. We first describe the case study in some detail, including the use of annotated portfolios, and then reflect on the use of the annotated portfolios.

2 Case study: 3D printing for design in a circular economy

The circular economy aims to accomplish sustainable production and consumption. Additive manufacturing, also known as 3D printing, could be an enabling production technology, because its production characteristics differ from conventional production methods: It is a digital and additive production process (Despeisse et al., 2017). We are particularly interested in the way in which designers can use additive manufacturing to support sustainable design in a circular economy. Therefore 'research through design' is the applied methodology, because it creates knowledge through the act of designing and in this way allows for the creation of theoretical, as well as practical understanding (Stappers, 2007).

Literature describes many potential sustainability advantages of additive manufacturing. However, it is still unclear how these aspects can be applied in practice. In previous work, literature about the sustainability of additive manufacturing was compared to circular design strategies in the context of five selected design projects (Sauerwein, Bakker, & Balkenende, 2017). The circular design strategies support product longevity and are described by Bakker, Hollander, Hinte and Zijlstra (2014) and Bocken, De Pauw, Bakker and Van Der Grinten (2016) . An example of such a strategy is 'Design for standardisation and compatibility', which can be explained as "creating products with parts or interfaces that fit other products as well" (Sauerwein et al., 2017).

The five design projects were selected, because the designs were produced with additive manufacturing and related to sustainable product design. In figure 1 each project is described. The designers of these projects were interviewed to obtain a deeper understanding of the role of additive manufacturing in practice.

'Standard products': Jesse Kirschner and Jesse Howard (2016)

Furniture is made from standard wood elements, with 3D printed joints. Therefore people can online adjust the furniture to their preferences. Further, they can choose to download the files, receive the printed joints or the complete product.

'BIOMIMICRY; soft seating': Lilian van Daal (2014)

Van Daal designed a seat fabricated in one print, but expressing different material properties through different local structures.

'Value Added Repair': Marcel den Hollander and Conny Bakker (2015)

Value Added Repair (VAR) extends the product lifespan of broken products not only through repair, but also through the addition of an extra functionality. In this way extra value is added to the product.

'Project RE_': Samuel Bernier (2012)

This project explores 3D printing as a do-it-yourself tool for reuse of products. The functionality of used cans and jars is expanded through the addition of customized lids.

'Screw it': David Graas (2013)

Graas designed connectors that transform old PET bottles and their lids into new user objects, e.g. a vase or bracelet.

Figure 1. Explanation of the five design cases.

3 Methodology

3.1 Interview design

Semi-structured interviews were conducted with the purpose to gain insight in the design projects related to 3D printing, sustainability in general and the circular design strategies in specific. The interview was divided into three sections with questions on:

1. The designer's experience of working with 3D printing
2. Sustainability aspects of the designs
3. The applicability of the circular design strategies and the relation to 3D printing.

All designers of the selected design projects accepted the invitation for an interview, which lasted between 40 and 65 minutes. Interviews were preferably conducted face to face, but due to time and distance constraints two of the five interviews were held through a video-conference over the internet. Three interviews were in Dutch and two in English.

3.2 Analysis

The interviews were recorded and transcribed for analysis. The use of annotated portfolios was considered a meaningful approach to analyse the interviews, because the design projects were the focus of the interviews. We interpreted the five step interview analysis method of McCracken (1988) and related it to annotated portfolios. The 5-step analysis provides a scheme to follow in the treatment of data. It describes the steps to take from data to knowledge contribution, each step representing a higher level of generality. The first two steps focus on the creation of observations. The third and fourth step translate these observations into themes. The final step seeks for patterns between the interviews (table 1). Our interpretation of the 5 steps for interview analysis with annotated portfolios integrates visuals from the start of the analysis process, other than just grouping text. Each step and our additions are described below. The work of Piercy (2004) helped us to better understand the 5-step analysis of McCracken. However, we did not always follow her interpretation.

Table 1. five step method and analysis for annotated portfolio's based on the 5-step analysis (McCracken, 1988)

	1	2	3	4	5
5-step analysis McCracken (1988)	Read transcript carefully to create observations	Develop observations	Examine interconnection of observations	Determine themes among observations	Determine patterns between interviews

Step 1

As described by Piercy (2004), the interview transcript is read carefully to identify the important material. She explains 'important material' as the predetermined focus or subject of the analysis. In our case we focus on interview data directly related to the artefact, i.e. the design project. Therefore, we highlighted all sentences that where directly related to the design project. The highlighted sentences create an observation (McCracken, 1988, p. 42).

Step 2

The observations have to be developed beyond their original form to exploit their full potential. Subsequently, they are related back to the transcript and examined, "one in relation to the other" (McCracken, 1988, p. 45). To further develop the observations, we summarized and translated them to English (if needed). These summarized observations were annotated to a picture of the design project to make the design project topical for examination. Throughout this paper we will indicate 'the summarized observations' as 'annotations' and 'the annotated picture of a design project(s)' as 'visual(s)'.

Step 3
McCracken (1988, p.45) describes these stages as follows: "Observations are once again developed on their own accord, and, now, in relation to other observations." In other words, the observations are examined to identify connections and categories (Piercy, 2004). The focus shifts from the transcript to the observations. We assigned colour codes to the annotations to cluster them into different categories.

Step 4
After examining the observations, the investigator has to seek for more general themes on the level of each individual interview. The developed observations are linked to compose a theme. (McCracken, 1988, p.46; Piercy, 2004). In our case a first evaluation on the level of the visual was made. We indicated the relations between the categories with dotted lines.

Step 5
The final stage seeks for patterns among the themes by comparing all interviews. Patterns are the predominant themes of the data and serve as answers to the research questions (Piercy, 2004). We repeated step 1 to 4 for each transcript. In order to enable comparisons across the visualisations, the same visual language was used for each design project (i.e. colour coding and dotted lines). This enabled the identification of patterns between the interviews. We created separate visuals to make these patterns more insightful, to "subject them to a final process of analysis" (McCracken, 1988. p. 42) and to complete the procedure from the particular details to the general observations.

4 Results

To illustrate the analysis process, we focus on the results of the interview about 'standard products'. The interview data contains knowledge to answer several research questions about 3D printing and design for a circular economy. This section shows the visuals that support the analysis of the relation between 3D printing and the circular design strategies, in particular design for standardisation and compatibility. The result of the analysis is not yet complete (it is part of an ongoing research project), but is shown here to support the explanation of the analysis process.

Step 1
The transcripts were read carefully and relevant sentences were highlighted. For example, in the interview about 'standard products', the following sentence was highlighted: "well, this standardisation and compatibility is really about the fact that there are these standard components and huge infrastructures behind them, so they are not going anywhere, so let's adapt to those"

Step 2
The process of summarizing observations into annotations can be illustrated by the sentence from the interview about 'standard products' cited above. This sentence was summarized into the annotation "standardisation: adapt to existing standardised systems, they will not disappear". All annotations were connected to specific parts of the design project as shown in figure 2 for 'standard products' to illustrate the written text. The demonstrated annotation above, for example, is attached to the connection between the wooden beam of the leg and 3D printed joint to illustrate that this annotations applies to this part of the design project. When the text is not directly connected to the object (e.g. "product attachment is achieved because of practical value), it means that the annotation applies to the whole product, or the idea or system behind it.

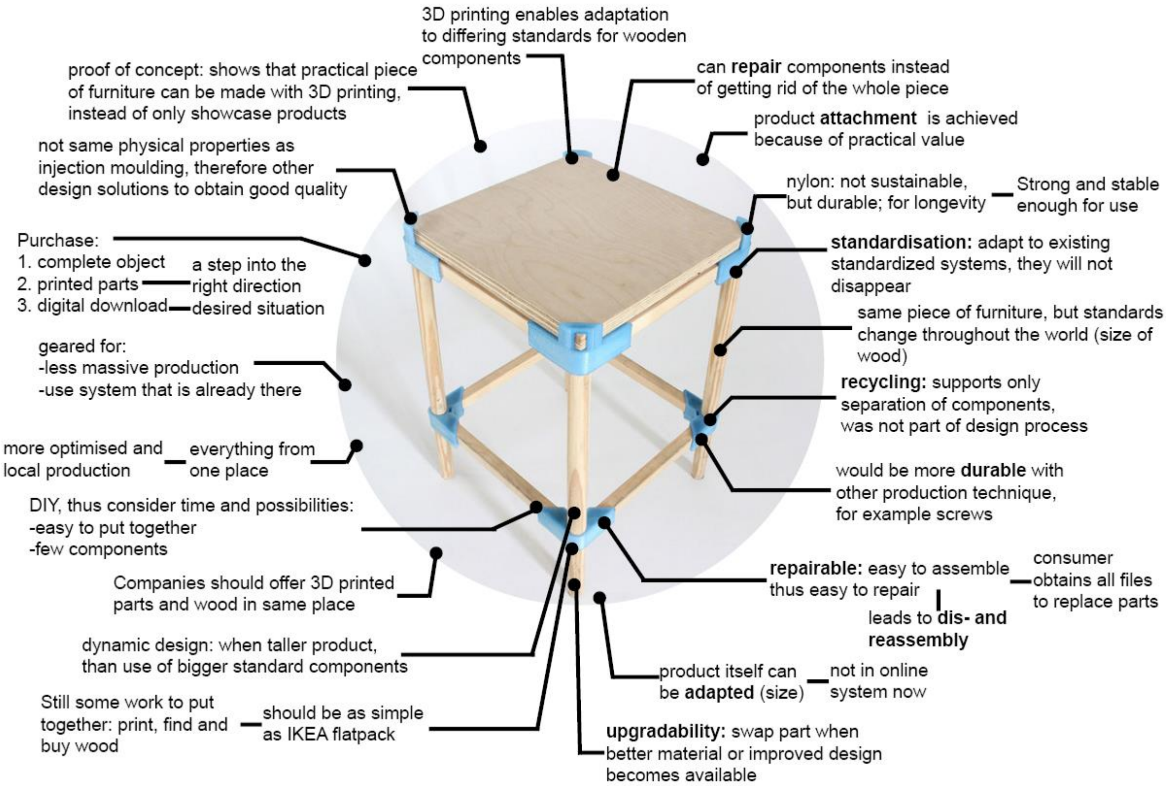

Figure 2. annotations made by 'standard products'

Step 3

The interview had three focal points: '3D printing', 'sustainable aspects' and 'circular design strategies'. These were used to categorize the annotations. From the transcripts two more categories appeared, i.e. 'future opportunities' and 'other aspects'. Below a description of each category is given:

- 3D printing: annotations in this category refer to 3D printing as a production technique. They cover its abilities and shortcomings, but also when a certain aspect could be realized because of 3D printing.
- Sustainable aspects: this category depicts when the interviewee assigned a certain aspect to sustainable behaviour/use/production or lack of it.
- Circular design strategies: this category is used when the circular design strategies are mentioned or when something is mentioned about the circular economy.
- Future opportunities: annotations in this category refer to the instances where designers talked about future possibilities of their design. This was either because they were inspired by the questions or had a future vision, which could not yet be realized.
- Other aspects: annotations in this category give insight about the design project, but do not belong to one of the categories mentioned above.

A colour was assigned to each category and these colours were used to highlight the annotations as depicted in figure 3. Each annotation can belong to one or more categories. The colours put the annotations in context and show the connections within the categories.

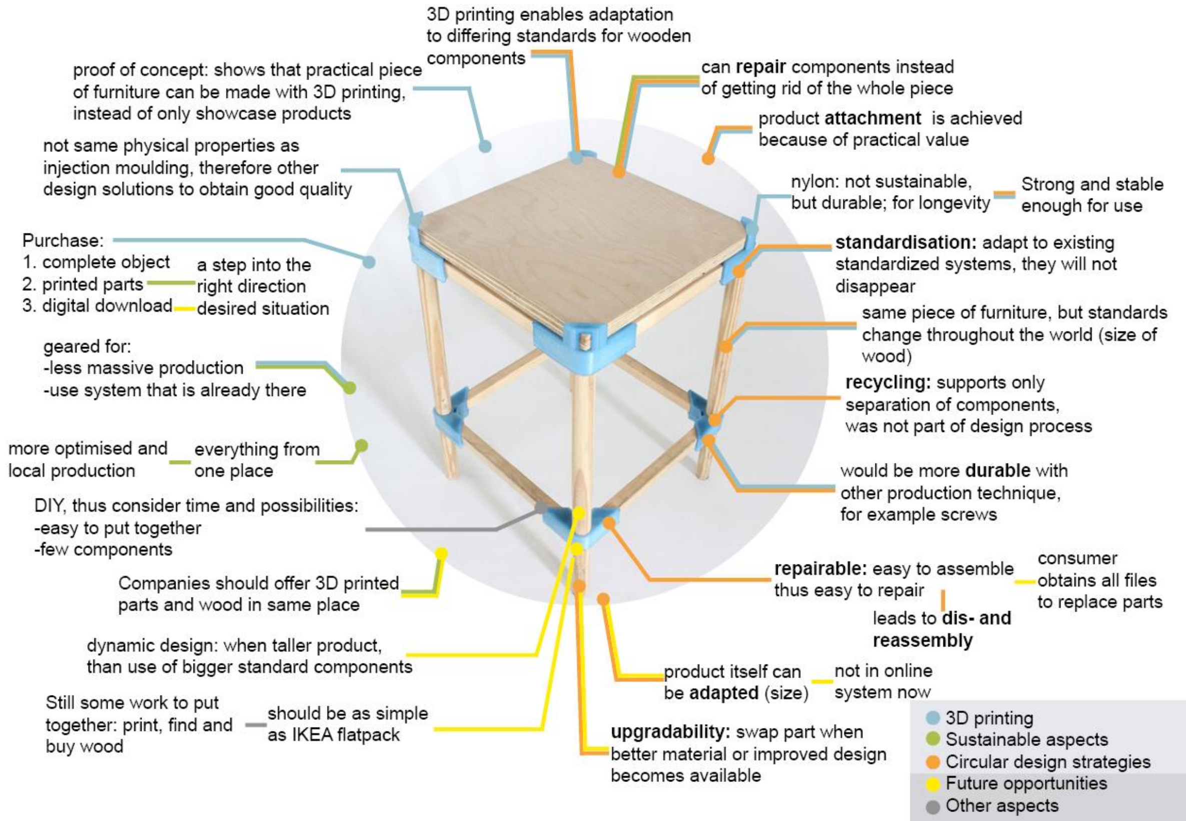

Figure 3. Coloured annotations

Step 4

Dotted lines were used to find patterns on the level of the design project. The size of the dots was increased with an increasing number of connections between and within categories (figure 4). This helped to determine the most prominent themes, to bring hierarchy to the themes and potentially eliminate redundant themes. Sorting the themes is valuable for support of the final arguments (McCracken, 1988, p. 46). Figure 4 shows that for the presented case the annotation on 'standardisation' (in orange) has the largest circle, followed by the annotation on 'optimised and local production' (in green). These annotations exhibit most connections with other annotations and therefore it is likely that they will play an important role in the final evaluation.

The connections help to interpret the annotations, because they show the relations between them. We illustrate this with an example about the relation between standardisation and additive manufacturing. We found that in this project, the use of standard dimensions for wood in combination with 3D printed joints is considered as a means to realize sustainable production. The following connected annotations led to this conclusion. The use of local standards optimizes the production process, because of the accessibility of parts. All parts can be produced in the same place on a local scale. Besides this, adopting local standards increases the reparability and the upgradability of the product: parts can be replaced instead of the whole product, because standard components are widely available. The user will obtain the digital files of the joints, so that he or she can reproduce them him/herself. Our interpretation of these observations is that the design of the object is universal, but local standard dimensions can be used, because of additive manufacturing. Standard dimensions differ throughout the world, making digital storage and adjustability key for successful functioning of this project. Without the digital characteristics, the result would be a too wide range of components to be stored.

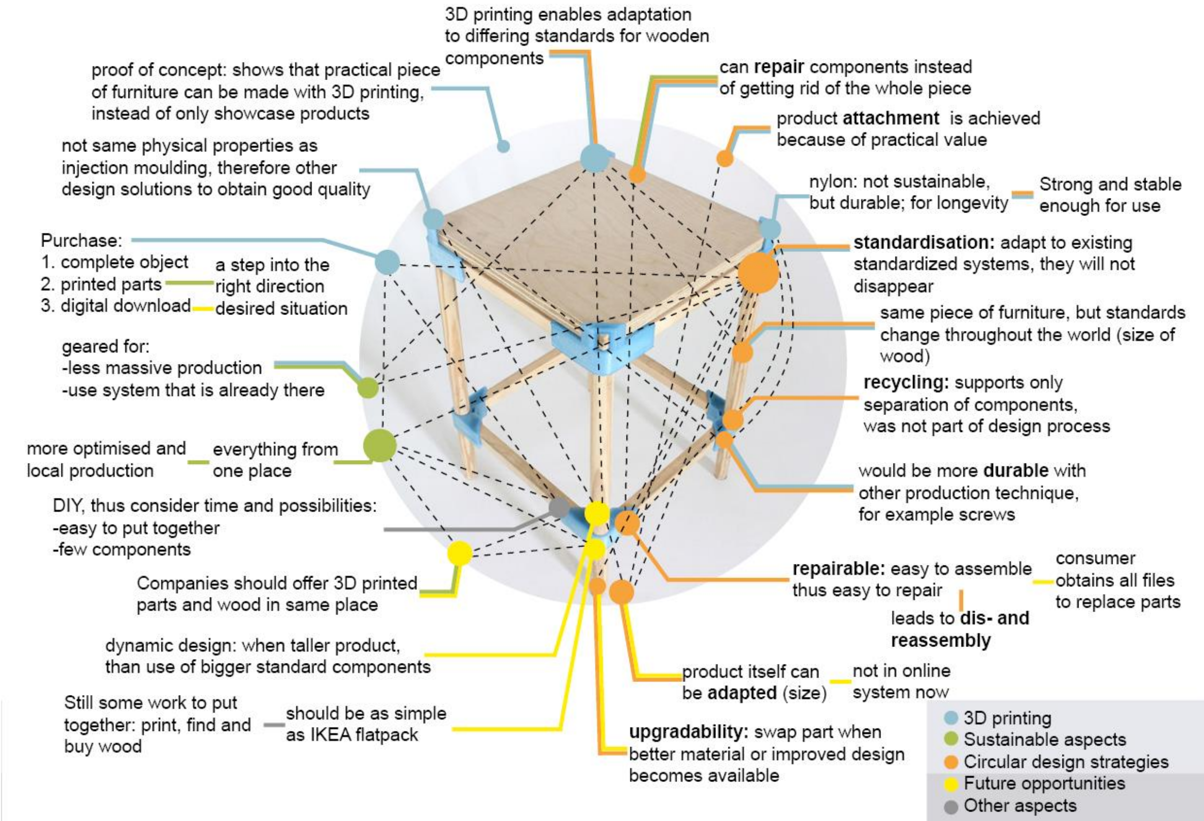

Figure 4. coloured and connected annotations

Step 5

All visuals together create the annotated portfolio. Figure 5 gives an impression of the result of the five design projects. The annotated portfolio allows for the particularity of individual objects, but also show the issues that join and differentiate them (Gaver, 2012).

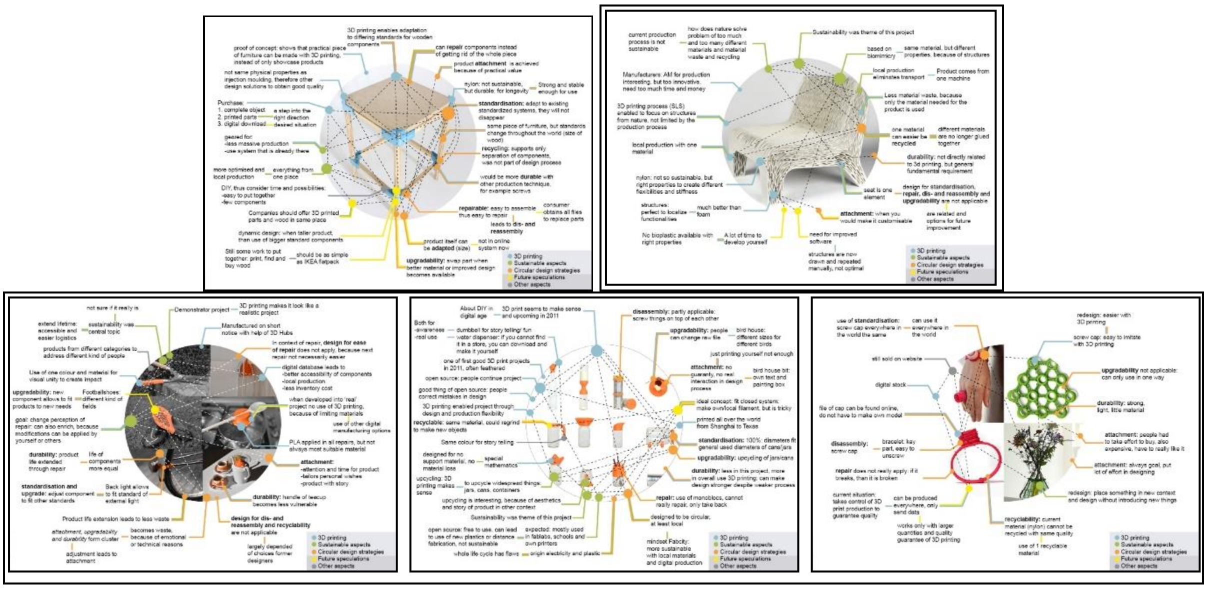

Figure 5. annotated portfolio for 3D printing for design for a circular economy

When establishing relations between the design projects, patterns were found, which in turn can be visualised. When looking for example at the annotations about the circular design strategy 'design for standardisation and compatibility', the explicit use of standardisation in combination with 3D printing to support sustainable production returns throughout the portfolio. In Figure 6 this is illustrated with a combination of all artefacts and the supporting annotations related to this pattern. This figure is the final step of the interview analysis and should therefore reveal the findings.

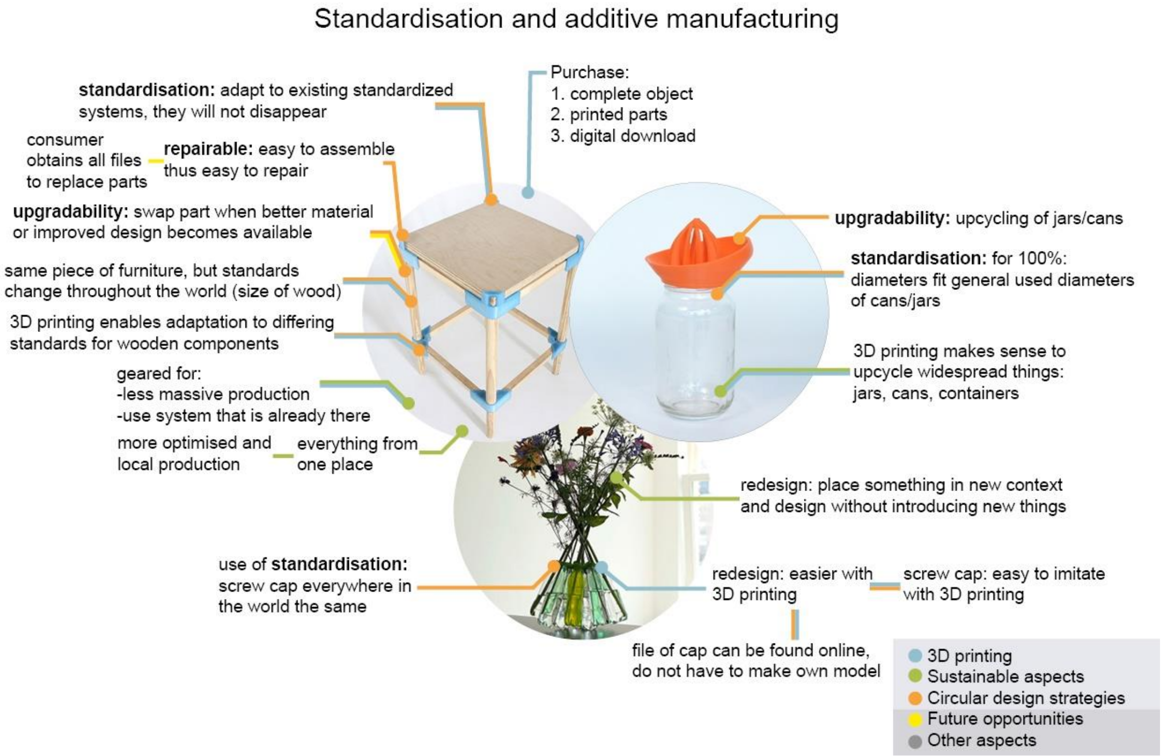

Figure 6. Visual representation of annotations about standardisation and additive manufacturing

In this case, the annotations about standardisation and additive manufacturing in figure 6 present a paradox. In general, it is expected that designers would neglect standardisation and embrace design flexibility with 3D printing. However, the interviewed designers embrace both and use standardisation in an interesting way. The design projects illustrate that additive manufacturing simultaneously enables both the adaptation to standards and the creation of unique solutions. For example, in 'project Re_' and 'screw it' (picture below) standard fittings are used to upgrade an existing product and extend its use. Thus, all three projects embrace the ability of 3D printing to digitally adapt the design to fit a specific context, while using standardisation to make it accessible all over the world. This could lead to product longevity and an efficient use of resources.

4.1 Visuals

The generation of the visuals can roughly be divided in three levels, that are respectively the result of step 1 and 2, step 3 and 4, and step 5. First, annotations are assigned to the product without further interpretations. Next, colours and relations are introduced to categorize the annotations and identify themes. Finally, new visuals are created based on the annotated portfolio, showing patterns that relate specific aspects of the design projects and annotations.

5 Discussion and Conclusion

In this section we reflect on our process and discuss the findings and limitations that we experienced. In general, we experienced that annotated portfolios support the data interpretation in interviews that focus on design projects and make the analysis process more transparent. Being a form of intermediate-level knowledge, annotated portfolios support verification during the analysis process, increasing the responsiveness of the investigator and therefore supporting rigor throughout the process (Morse, Barrett, Mayan, Olson, & Spiers, 2002). The visuals allow the communication of this intermediate-level knowledge to peers. Therefore, this stage becomes accessible for discussion, which increases the transparency of the process.

Besides communication to peers, it is also insightful during analysis process itself to visually show the steps needed to transform data into knowledge. Figure 2 to 6 clearly show the development from data interpretations to pattern finding; at first only annotations are assigned to the individual design projects, next meaning is given to these annotations and finally all design projects are connected through the annotations. The development of the visuals structured this process, which can be very fuzzy and therefore difficult to keep track of when analysing interviews. When coding an interview with analysis software for example, many layers of interconnectivity can be created. The amount of codes can be overwhelming. Although many software tools allow the creation of visuals (mind maps) to better understand the linkages between different observations, this is only possible after categories and themes have been assigned to the observations. The disadvantage is that it is not directly clear which observations have the most connections. Annotated portfolios, by contrast, allow the creation of visuals right from the start of the analysis process and connect the analysis to (specific parts of) the design artefact. The visuals directly show the amount of connections between annotations and therefore bring clarity to the data.

The visuals allowed us to apply as many layers of interpretation as desired. They could be adjusted according to the focus of the research question. The overall outcome was a visual rich in information, showing that many annotations belong to multiple categories. For example, the annotation 'companies should offer 3D printed parts and wood in the same place' belongs to the categories 'sustainable aspects' and 'future opportunities' (figure 3). Showing this in a visual representation can be seen as a unique advantage, when compared to other interview analysis tools. However, the final version of the visual is likely to have a very high density of information and might therefore be less understandable for outsiders. Therefore, we found it beneficial to create new visuals (figure 6) with a selection of annotations that belong to a certain pattern to make outcomes more insightful.

In comparison to qualitative data analysis software, the analysis with annotated portfolios needs an extra step of interpretation. Analysis software directly links the transcript to categories, but annotated portfolios require the creation of annotations; the observations are first summarized, before they are categorized. These summaries and short sentences are important to present an overview in the visuals. However, the investigator should be careful when summarizing, as this is the first interpretation of the transcript. The summary should be as literal as possible to avoid misinterpretations later on.

Further research is needed to develop this exploration into a more rigorous method. A possible approach could be to perform a comparative analysis between the classic qualitative data analysis and the analysis with annotated portfolios. The same data should then be analysed by two experienced research in two rounds, one first performing the classic method and then the method with annotated portfolios and the other vice versa. This approach would allow for analysis within and between the subjects.

To conclude, this study shows that annotated portfolios do not only have the ability to communicate the design process, but also to support the communication of interview analysis regarding design processes. Applying annotated portfolios to the field of interview analysis broadens the scope of this method. Our study shows that annotated portfolios are also suitable to give meaning to and evaluate the work of others, instead of only own design projects. We even expect that the use of annotated portfolios to analyse interviews does not have to be limited to interviews about design projects, but could be extended to all topics that can be visualized, for example systems or relations. The advantage of visuals is that they stimulate the detection of relations between annotations, as well as patterns within the bigger picture. Therefore, by introducing a visual analysis this approach has the potential to contribute to the toolbox of interview analysis, in addition to the current textual analyses.

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DRS 2018 Design Research Society 2018 Catalyst

University of Limerick
25th – 28th June 2018

Developing a Design Toolkit for the Internet of Things

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doi: 10.21606/dma.2018.447

In a future where products get smarter and networked, becoming part of the Internet of Things, the design discipline acquires an increasingly strategic and visionary role. In the business to consumer market, the successful products will be those that answer meaningfully to user needs. This paper describes the development process of the "MappingTheIoT Toolkit", an open source resource born to support multidisciplinary teams in the design of IoT products. The tools guide through research activities and different phases of the creative process, and can be used freely or in a structured way. This paper will outline the complete Toolkit development: initial research, scope definition, requirements and positioning of the tool in the Double Diamond representation, refinement process and final evolution of the Toolkit elements. The described process may be used as reference for developing other methodological design toolkits. Since the MappingTheIoT Toolkit is in its testing phase, this paper also attempts to get in touch with the scientific community and foster possible collaborations.

design toolkit; internet of things; design methods; product design

1 Introduction

The Internet of Things has received enormous attention. It is seen as an opportunity for organizations to evolve and to elevate their reputation and product offering (IoT WoRKS by HCL Technologies, 2017). The estimated potential economic impact forecasted by the McKinsey Institute (McKinsey Global Institute, 2015) is of $3.9 trillion to $11.1 trillion per year in 2025, for IoT applications in nine settings: home, offices, factories, retail environments, worksites, humans, outside, cities, and vehicles.

In the Business to Consumer market, the first waves of smart connected consumer electronics and wearables are progressively getting mainstream and more widespread (IDC, 2016). Gartner reported that in 2017, consumer applications represented 63% of the total IoT applications in 2017 (Gartner, 2017).

Although the IoT market is getting flooded by solutions, only few consumer products stand out. (Buntz, 2016). Among them, winning products will be those that succeed in understanding the needs of real users, offering clear value propositions and a coherent service component. In this context, the design discipline acquires an increasingly strategic and visionary role.

For developing meaningful connected devices, it is important to apply what Giaccardi and Fischer define as Metadesign approach (Giaccardi & Fischer, 2008):

> *Metadesign is a unique design approach concerned with opening up solution spaces rather than complete solutions (hence the prefix meta-), and aimed at creating social and technical infrastructures in which new forms of collaborative design can take place.*

This approach was at the basis of "Mapping the IoT", a research project activated at Politecnico di Milano with the aim of developing a methodology to support the product design of IoT products for the consumer market.

The project, originated by an MSc Thesis (Vitali, 2015), started with the selection, analysis and mapping of over 100 case studies of IoT products in the B2C market. As output, we were able to delineate product categories united by formal and conceptual features, and by technological and technical aspects. The data collected was represented infographically (Vitali, 2015) and was later used to design a connected object (Arquilla & Vitali, 2016).

From this case study research became evident that for many of these "smart connected products" the contribution of design discipline was extremely small or absent, especially regarding the whole value proposition and problem framing, rather than in aesthetics.

This lack of design discipline demonstrates that even at a time characterized by the democratization of design tools (Van Abel, Evers, Klaassen & Troxler, 2011; Raasch, Herstatt & Balka 2009), and of production methods (Rifkin 2011; Rifkin 2014; Von Hippel 2005) many products do not have a proper cultural and critical reflection upstream, but rather represent attempts that often don't succeed in the market.

In light of these first considerations, and having developed a demonstrator product that was selected, prototyped and exhibited during Milan Design Week 2016 within the project "Next Design Innovation" (Maffei & Bianchini, 2016) it was decided to further develop the MappingTheIoT research.

The specific goal of this second part of the project was to define an open source tool that would allow designers to develop coherent and meaningful products by guiding them through research and analysis (metadesign phase) and subsequently supporting the design process.

2 Steps from a theoretical framework to the "MappingTheIoT Toolkit"

The first step towards a viable tool was to identify a design-oriented Theoretical Framework able to summarize the peculiarities of IoT objects. The Framework covered some important aspects that need to be considered to build up mature and complete technological products. The six selected aspects were users and context, market, technologies, product design and identity, interaction, and user experience.

Designing for the Internet of Things means considering different levels of complexity, in which products are in a relationship with users, with each other and on a wider network. Without an exhaustive design process, it is easy to treat this topic superficially, and eventually develop tech gadgets with little perceived value, especially in the B2C market.

Given this complexity, we identified that both designers and non-designers felt the necessity of guidance during the design process of IoT products. From this need arose the opportunity to create a Toolkit based on the identified theoretical framework.

The steps followed to design the MappingTheIoT Toolkit were:

1. Research on the existing design toolkits and resources regarding the relationship between the design discipline and the Internet of Things;
2. Wider research on design toolkits and card-based toolkits in particular;
3. Definition of vision and mission of the MappingTheIoT Toolkit. Outline of the requirements and positioning of the resource in the double diamond representation;
4. First prototypes of the different elements of the Toolkit;
5. Test and validation of the Toolkit in a co-design session with experts during NordiCHI'16 (Vitali, Arquilla & Rognoli, 2016);
6. Further refinements of the Toolkit, development of the Activity Guides;
7. Test with students;
8. Release of the Open Toolkit on a dedicated website, new tests and involvement of the scientific community for further evolution of the Kit (in progress).

Since the Toolkit is in its testing phase, this paper will mainly focus on the first six phases here listed.

3 Toolkits and resources on IoT and Design

The term "Toolkit" can be applied to many forms of content and information, and identifies a set of tools arranged together in one place. The concept of Toolkit is not new in the design field, but is a consolidated practice that is increasingly common to overcome the lack of knowledge, methodology or of practical tools for different activities (Lockton, 2013).

Wölfel and Merritt (Wölfel & Merritt, 2013), with the aim of sketching out the panorama of card-based design toolkits defined "5 design dimensions" to classify them.
Toolkits can be distinguished for

- Intended use and Scope (e.g. repository, library of patterns, provocation, support for participatory design, methodology);
- Duration and placement in the design process (e.g. divergent production and brainstorming);
- System and methodology (e.g. the method can be used freely, it has a suggested use, or it has specific instructions);
- Customization of the toolkit (e.g. customization is optional, required, absent);
- Formal qualities of the toolkit (e.g. specific features like using images or only text to describe concepts).

The structure and shape of Design Toolkits may vary. There are cards-based Toolkits like IDEO's Method Cards (IDEO, 2013) and Toolkits that combine an online platform with a printable guidebook such as the "Design kit" (Designkit.org) and "The Field Guide for Human Centered Design" (IDEO, 2015). Other common Toolkit shapes are canvases like the Service Design Toolkit (Service Design Toolkit, 2014) or even games and hybrid solutions (for example the "IoT Service Kit", 2016).

Dan Lockton (Lockton, 2013) argues that

> *The toolkit metaphor may have reached design practice through the use of the term in computer science, particularly in HCI and interaction design where toolkits such as GTK+, Qt and jQuery UI comprise collections of graphical user interface `widgets', with the associated code, which can be used by developers to build a variety of applications, often cross-platform. A toolkit in this sense is directly deployable, providing an API (application programming interface) which can be called by applications, compared with interface design pattern libraries [...] which are more akin to collections of `ways to solve' particular common problems.*

In this sense, since the Internet of Things is first a technological evolution, it is only natural that most of the IoT toolkits are building blocks to support the development of the IoT infrastructure. The role of these toolkits is to support the creation of a network and to reduce the entry barriers for testing and prototyping both hardware (Moussette, 2007) and software (Koster, 2017). Therefore, these resources are not related to the product and service design discipline.

The increasing relevance of the IoT topic and its complexity is leading to the creation of a consolidated bibliography of resources that tackle the subject in an integrated and instructional way, presenting technological aspects alongside design methods (Biron & Follett, 2016; O'Reilly, 2015) and guiding the design process of connected products (McEwen & Cassimally, 2014; Rowland, Goodman, Charlier, Light & Lui, 2015).

Authors have been reflecting for years about the implications of having augmented products in everyday life (Sterling, 2005, Kuniavsky, 2010), and the debate is becoming increasingly less hypothetical and more contextualized (Rose, 2014; Semmelhack, 2013).

Initiatives like the IoT manifesto (Iotmanifesto.org) are directly addressed to the designers that will develop future smart products, making them reflect on the impact of the design profession in shaping the future. The IoT manifesto proposes a set of design guidelines to encourage paying attention to issues like utility, the whole product lifecycle, privacy and security, data ethics and transparency.

Other resources integrate design strategy and economical aspects, for example the IoT Business Model Builder (Bosch IoT Lab, 2015) developed by Bosch IoT Lab, that proposes a 4-step method to define successful IoT business models and identifies the existing design methods and tools that can support this operation. One of them is the "55 Business Model Patterns" (Csik, 2014) and its IoT expansion for "digitally charged products" (Fleisch, Weinberger, Wortmann, 2014) that introduces business models such as "physical premium", "digital add-on", "digital lock-in" and "product as point of sales".

The first resource that refers itself as "IoT Toolkit" and deals with the topic in a broad way is the IoT Toolkit by Postscapes (Postscapes.com). In this case, "Toolkit" means an updated repository of selected online resources to explore the IoT topic autonomously.

Two relevant toolkits directly address the relationship between products, service design and IoT: the IoT Tiles Cards and the IoT Service Kit.

The IoT Tiles Cards (Tilestoolkit.io) are the result of an ongoing research project at the Norwegian University of Science and Technology. The kit consists of 99 cards grouped in six decks. The kit has different roles. It is a participatory resource that can be used with game mechanics to engage users and non-experts in ideation sessions. It has an informative purpose and introduces the basic concepts about design and programming IoT architectures. It can be used as repository or brainstorming support.

Similarly, the IoT Service Kit (IoT Service Kit, 2016) by Futurice is a toolkit configured like a game, with a boardgame layout. It is made up of maps, 3D printed tokens and five kind of cards: Sensors, Interactions, Service Cards, Open APIs, and User Cards. Using the different elements, the aim is to imagine contextualized user journeys that integrate IoT services with both physical and digital touchpoints. The kit has a Creative Commons license and is useful to brainstorm in team sessions involving designers and different stakeholders.

The Method Kit for Product Development (methodkit.com) is another relevant toolkit even though not specifically linked with IoT. The Method Kit decks are repository of knowledge, summarized on illustrated cards. These cards can be used for divergent production (Guilford, 1984) and are designed as unstructured entities, to facilitate discussion and brainstorming with different suggested techniques.

Several Design Toolkits were examined other than those IoT-specific. The three cases that influenced the most the development of the MappingTheIoT Toolkit are "Design with intent"

(Designwithintent.co.uk), “The Art of Game Design: a book of lenses” (Schell, 2008) and the “Service Design Toolkit” (Service Design Toolkit, 2014).

Design with Intent is “*a collection of design patterns for exploring the interactions between design and people’s behavior, across products, services and environments, both digital and physica*l”. Design with intent means “*a design that’s intended to influence or result in certain user behavior*”. It is a card-based kit developed by Dan Lockton during his PhD (Lockton, 2013). The deck is organized in eight “Lenses”. Each card is phrased like a question in order to act as a provocation, and summarizes a good practice pattern to be followed to achieve a result.

The same concept of lenses is used in the guidebook “The Art of Game Design: a book of lenses”. The “lenses” are more than 100 open questions integrated at the end of each chapter of the book. Questions enable reflection on different themes and stimulate lateral thinking on new perspectives.

The last relevant kit is the Service Design Toolkit, an introduction to the methodologies of service design. The set is made up of several templates that can be filled in and printed. Each template is indicated for a different activity, like for example framing personas, creating user journeys, visualizing actors maps. This configuration makes the Service Design Toolkit a valuable resource for workshops and design sessions.

4 A Toolkit to support the Design Process of IoT products: positioning of the MappingTheIoT Toolkit

With the MappingTheIoT research, we observed the need of a specific design toolkit for IoT products, able to support the design process with a focus on the metadesign phase. We defined a broad and ambitious theoretical framework. We analysed the state of the art of existing toolkits and resources. At last, we reflected on MappingTheIoT Toolkit positioning as a resource.

To position the Toolkit we analysed the functions that it should offer during the whole design process. To stress out this aspect we used Double Diamond representation, a model developed at the Design Council (Design Council, 2005) to summarize the phases of any design process: it is a consolidated representation applied to the wider concept of Design Thinking and not only linked to the product design field.

The Double Diamond model is composed by four phases: Discover, Define, Develop, and Deliver.

The first is the Discovery phase, a divergent moment in which designers explore the design problem, search for inspiration, and analyse the user needs and the market. To support the design of IoT devices, in this phase there is the need of guidance for metadesign research activities such as case studies research, user studies, market research. There is the need of structuring the research correctly from a methodological point of view.

Going in the convergent Define phase, there is the need of visualizing and analysing the gathered insights, transforming them into usable knowledge and product specifications, for an exhaustive project brief. In this phase, pattern libraries could support the problem framing, presenting common patterns in the design of IoT products.

After the brief definition the Develop phase can start, a divergent moment in which to brainstorm and to delineate concepts. Here an IoT Toolkit could support divergent production, reinforcing the lateral thinking attitude providing stimuli and design provocations.

The last moment is the convergent Delivery phase, in which ideas are shaped and tested. For this phase, we identified the need of supporting the concept selection, and of having a repository of relevant aspects that need to be designed, in order to validate and deepen concepts in their initial phases.

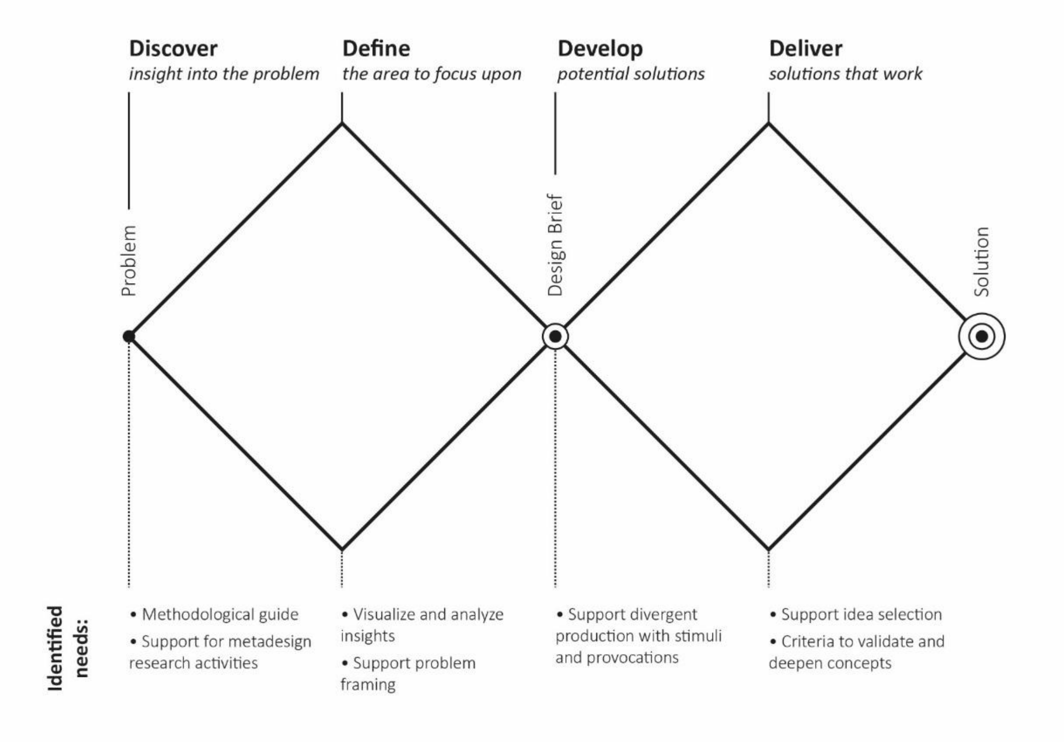

Figure 1. Design needs in the different phases of the Double Diamond model (Design council, 2005)

Having identified a set of activities that the Toolkit could perform in the different moments of the design process, we then delineated the characteristics that the MappingTheIoT Toolkit should have, following the five "Design Dimensions" (Wölfel & Merritt, 2013).

Table 1. Desired characteristics of the MappingTheIoT Toolkit according to the five "Design Dimensions"

Five Design Dimensions	Desired functions
Intended use and scope	Methodological guide, repository of knowledge, support during workshops and design sessions. For designers and non-designers, used alone or within a team. It will not focus on co-design with end-users.
Duration and placement in the design process	Support the design of IoT products, in particular during the metadesign phases and for problem framing activities.
System and methodology	The Toolkit should be flexible. Depending from the activities it should be used freely, with suggested use or specific instructions
Customization of the Toolkit	Customization is optional, but the elements may be expanded and updated with new content. The resource will be published with a Creative Commons license.
Formal qualities	The format of the elements of the toolkits will depend on the function. The card and canvas format will be explored.

5 Testing and Co-Design of the Toolkit

The first version of the MappingTheIoT Toolkit was tested during a co-design workshop at NordiCHI'16 (Vitali, Arquilla & Rognoli, 2016) with a group of professionals in the fields of design, interaction design, technology, and psychology.

The activities of the co-design session were

- Discuss the theoretical framework behind the Toolkit
- Test the structured research exercise provided by the Toolkit

There was a general appreciation towards the framework and structure of the Toolkit. The multidisciplinary panel of experts confirmed the need of having more support during the research phases of the design process, especially non-designers.

The Toolkit components were also tested at Politecnico di Milano with students at their first year of MSc in Design & Engineering. The students, organized in groups with both engineers and designers from different countries, used the Toolkit during their case studies research and for concept definition. The cards were appreciated in an evaluation survey, and the use of the kit demonstrated that a greater awareness led to the development of more coherent and mature products compared to previous years (well defined ideas, technical details of final projects, positive final grades). An interesting point that emerged from both tests was that while non-designers appreciated the structured elements of the Toolkit, designers preferred an unstructured use of the resource, to be kept as repository only when needed.

6 The MappingTheIoT Toolkit

The MappingTheIoT Toolkit (mappingtheiot.polimi.it) is an analogue kit that aims to support designers and multidisciplinary teams in developing successful and meaningful connected products. The kit offers a framework of relevant topics and specific questions. It highlights the key features that smart devices should possess and the aspects that cannot be forgotten while designing for the Internet of Things.

The elements of the kit are usable during different phases of the design process, supporting activities such as research, user studies, benchmarking, brainstorming, interaction design, UX definition, CMF, project evaluation and development.

The MappingTheIoT Toolkit is made up of three elements that can be used freely or for structured activities, alone or with a team. It is licensed under a Creative Commons License and is ready to be downloaded and printed.

The three elements of the Toolkit are:

1. The MappingTheIoT Deck
2. Analysis Cards & Feature Maps
3. The Activity guides

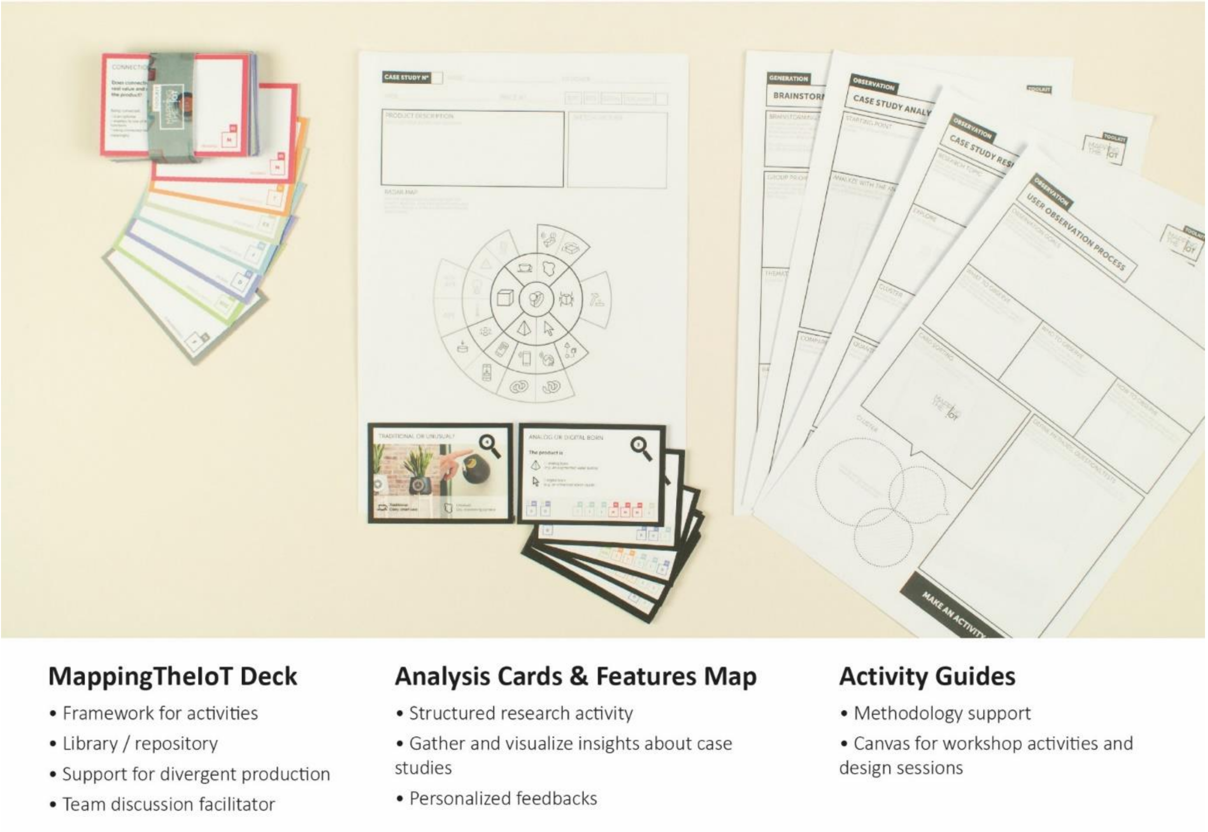

Figure 2. Overview of the Toolkit elements (Version 2.0)

The elements serve different functions and are related with each other. They can be used independently, but reach their true potential when used together. The Toolkit envisions a design methodology in which researching is the first step, followed by an immersive focus on the product. Therefore, the Analysis Cards & Features Map will be used first, and then the Deck. In this paper for storytelling purposes, the Deck will be introduced before the Analysis Cards and Features Map.

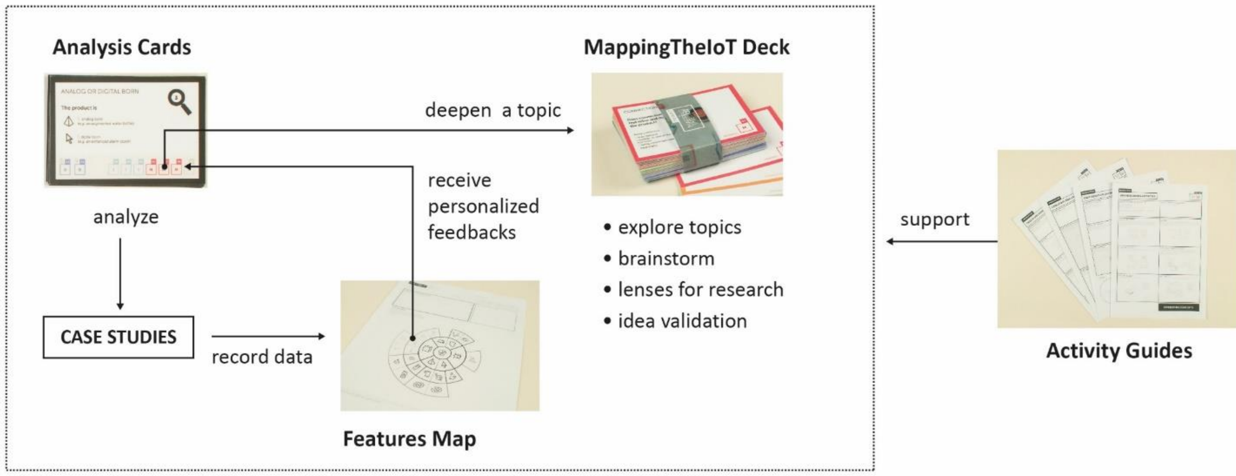

Figure 3. Relationship between the MappingTheIoT Toolkit elements and interaction flow

The three elements of the Toolkit will prove interesting along the whole design process.

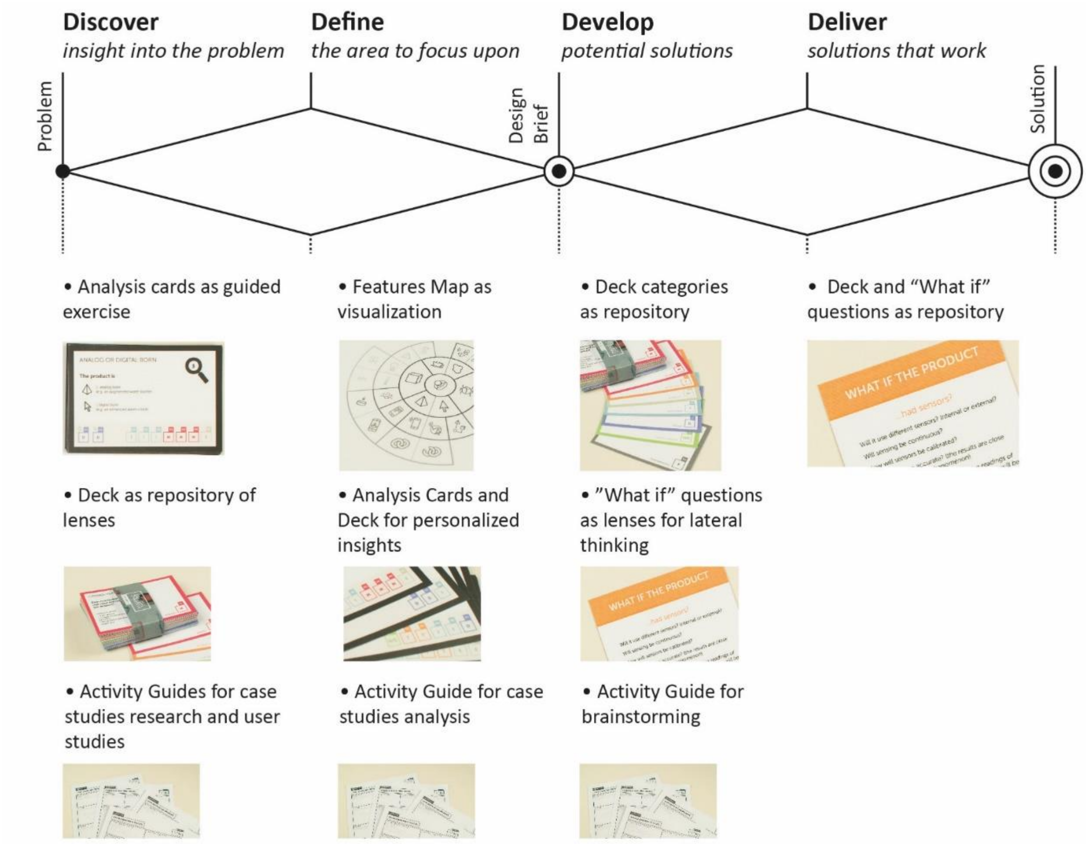

Figure 4. Positioning of the MappingTheIoT Toolkit into the Double Diamond model

7 The MappingTheIoT Deck

The MappingTheIoT Deck is an expandable resource currently made up of 78 two-sided cards organized in seven original categories. Since the Internet of Things is a hot topic of debate, constantly evolving, the Card format was preferred for flexibility, to enable further updates of the tool.

Figure 5. The MappingTheIoT Deck

The front and back of each card are different have a distinct function. The front is read horizontally and introduces a relevant topic through a title and a key question. Its aim is to allow a quick deck exploration for various activities. The back is read vertically and deepens the card topic with specific “What if” open questions, inspired by “The Art of Game Design” lens structure (Schell, 2008).

Both front and back are recognizable by a colour/pattern code and identified by a progressive number in the affiliated category. This to support a structured use of the cards in combination with the other elements of the Toolkit.

The seven categories are User & Context, Design, Technology, Interaction, “Fundamentals”, Experience and Material Experience, Meaning. This composition provides a framework for different activities.

Each category represents a key macro area that needs to be strategically designed, a point of view from which to analyse a product. Like for the Six Thinking Hats system (de Bono, 1986) the division in categories lets users experience different perspectives. The “What if” questions are designed to encourage lateral thinking (De Bono, 1990), that as De Bono highlights, differs from the traditional vertical thinking because “Vertical thinking is selective, lateral thinking is generative”, it is provocative, can make jumps and isn’t sequential. The cards embrace this concept, adding a layer of structure and self-assessment.

The Deck provides elements of reflection that question the cultural value of the design project. It proposes a strategic vision of the process and questions the role of design and designers.

Here follows the description of each category and a general idea of their value and function.

1. **User and Context Cards for framing problems.**
   “User and Context” cards let designers focus on how to better frame problems, needs and opportunities without being superficial. The cards are useful to support the user personas definition, and to explore ideal and extreme user scenarios in which to test new ideas and existing solutions.
2. **Design Cards to design the product**.
   These cards approach the design discipline with a wide angle, providing insights on different aspects of product design, from those related to shape and aesthetics (style, ergonomics, affordances…), design principles (design for all, modularity principles…), and strategic elements (product system, servitization, life cycle). The role of these cards is to aid in the design and strategic definition of the whole product system, with its complexity and constraints. The “what if” side of the cards is particularly useful during the divergent phases of the design process, since it opens up on many suggestions for product development.
3. **Technology Cards exploring the role and potentiality of technology**.
   These cards introduce some of the common features and components IoT products. The approach is not didactic; the cards are not a learning resource or repository of components but are stimuli to deepen the subject. Purpose of this category is to start a reflection on technical aspects, exploring standard and innovative components, features and technology transfer possibilities, keeping in mind the feasibility of the system. Technology cards may be used to identify constraints and opportunities, and as a discussion facilitator for multidisciplinary teams.
4. **Interaction Cards for meaningful interactions.**
   Networked products are phygital entities with a tangible part augmented by a digital avatar (Semmelhack, 2013) but in many smart gadgets tangible interaction is often left out and replaced by apps on smartphones. Interaction cards can be used to balance out tangible and intangible aspects, refining the complete interaction flow with the product. The cards focus on inputs and outputs of the different interaction touchpoints. These cards are especially supportive when designing objects augmented by apps or that need to display, use, and generate data.

5. **“Fundamentals” Cards about market opportunities and business models.**
   These cards represents the “fundamental” information that cannot be missed while analysing any product case study. The cards offer objective questions about the reference market in which the product is positioned, branding and naming details, communication channels, marketing choices, and funding options.
6. **Experience and Material Experience Cards investigating user perception and the role of materials.**
   This section is divided in two to better focus on the different components that contribute in creating a meaningful User Experience. The Experience cards introduce some of relevant topics such as the perception of trust and security. The five Material Experience cards instead guide through a material analysis of existing products. Starting from the Material Description, they focus on the Aesthetic Experience, Meaning Experience, Affective Experience, and Performative Experience that materials elicit in users. The cards were developed on the basis of the Materials Experience framework (Karana, Pedgley & Rognoli, 2014; 2015, Giaccardi & Karana, 2015) and can be used alone as a guided exercise.
7. **Meaning Cards for a Strategic and critical perspective.**
   These cards provide critical questions to evaluate and rate ideas, helping into being more objective and aware of their real value. These lenses add a great value to the Deck, because as Verganti (Verganti, 2017) states talking about the current design scenario in which ideas are overcrowded “Amid this wealth of opportunities, value comes from envisioning which direction makes more sense. It does not require more ideas, but one meaningful vision”.

7.1 Role and functions of the MappingTheIoT Deck

These seven “suits” of cards provide a framework for activities. The MappingTheIoT Deck categories can be explored freely without order, or combined with the other Toolkit elements for structured processes.

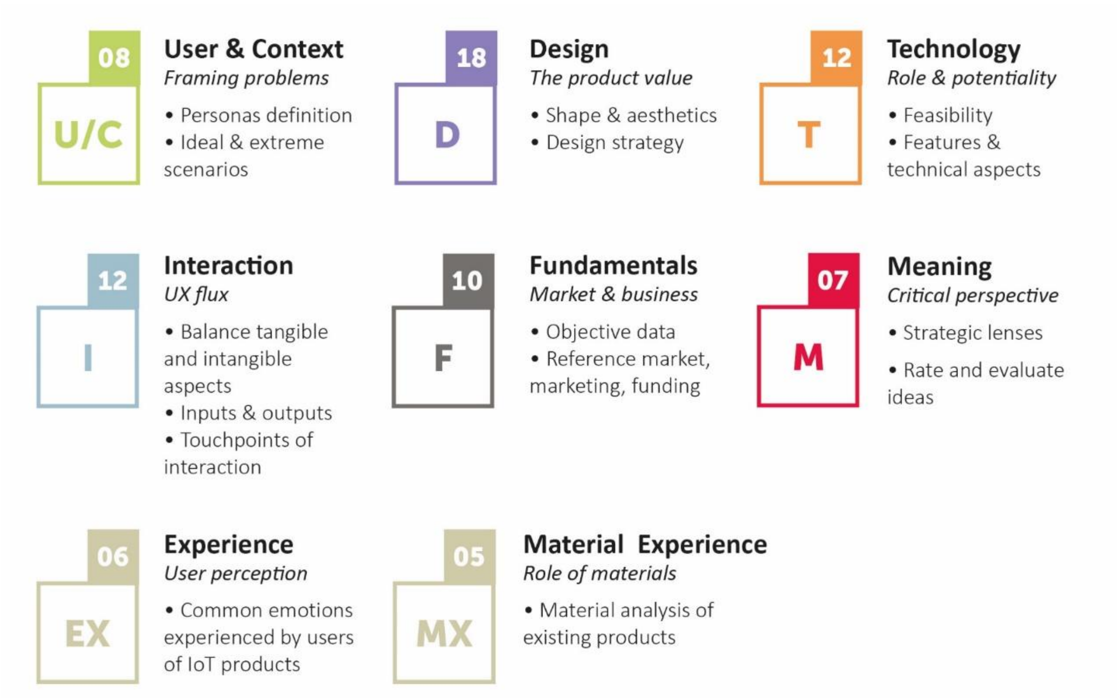

Figure 6. Categories of the MappingTheIoT Deck

In general, the deck is a divergent resource that, with its “What if” questions, encourages confrontation and openness towards new possibilities. Alone, this element is more useful in both the divergent phases of the double diamond representation of the design process. It is a “Library”, a repository of contents, and a facilitator for divergent production and team discussion. In the

Discovery phase, the categories serve as lenses to analyse existing solutions with more awareness. In the Develop phase, the cards can assist brainstorming, idea selection and aid team discussion. In the Deliver phase the “What if” questions can support idea evaluation, testing and self-assessment.

Cards can be used as a provocation, combined randomly to receive unexpected stimuli, used for time-controlled idea generation exercises, addressed by topic to deepen a specific aspect, and used for card sorting exercises to pinpoint relevant themes when working in a team.

The MappingTheIoT Deck can expand with new cards and topics added thanks to professional collaborations and user-generated contents. On the he backside of the cards there is a dedicated space to add new questions, to foster this idea of personalization and evolution of the Deck.

8 Analysis Cards and Features Map

Unlike the MappingTheIoT Deck, the Analysis Cards and Features Map are two elements designed to perform a structured research activity. The two resources will accompany the Toolkit users in a guided meta-design activity: analyse and map case studies to gather useful insights.

Figure 7. Analysis Cards and Features Map

The Analysis Cards are 15 “black cards”, different from those of the Deck. On the front, there is a simple question with two or fewer possible answers, identified by a logo. On the back, there are two photographic references to explain the logos and better identify the most fitting answer. The same logos are the central element of the Features Map, a canvas-like fillable form.

The Cards and the Map propose a research exercise. Once a relevant case study is selected, the idea is to analyse it by answering the questions proposed by the cards. The Features Map can record the answers and highlight the features that the product possesses. On the Map, there are also dedicated areas in which to write down positive and negative details about the examined case study. This way it is simpler to gather insights and comparable data on each case. By filling one Map for each analysed case study it is easier to spot common aspects and compare them: the Toolkit contains different versions of the Features Map, that guarantee different levels of comparison of the gathered data.

Once users have collected data, the Analysis Cards offer another functionality: on the bottom of the cards, there are specific suggestions that point out to a personalized selection of cards of the MappingTheIoT Deck. It is like a hyperlink. For example the Analysis Card number 2 “Wearable: can the product be worn?” is directly linked to the Design Card number 7 (Wearable shape), to the User and Contest card number 4 (Which are the direct and indirect users of the product?), and to Interaction Cards number 4 and 5 (Time and frequency of interaction. When does it take place? For how long?). These connections provide an overview of key aspects regarding one given topic, establishing a process of guidance and value creation. In this way, the MappingTheIoT Deck gets more structured, offering not only general stimuli, but also targeted content.

A further evolution of the Toolkit foresees the realization of a digital version of this whole process, with the creation of an online database, able to collect and map case studies suggested by users, implemented with dynamic data visualizations and a system of personalized feedbacks.

8.1 Role and functions of the Analysis Cards & Features Map

This structured exercise finds its position along the first diamond of the Double Diamond representation (Discover & Define phases). It is in the Discover phase because the Analysis cards lead users to perform a structured research. It is in the Define phase because as well as leading users to look for case studies, it tries to give shape and meaning to the collected data, facilitating its interpretation.

Analysis cards and Features map are elements suitable for use during short sessions and workshops with multidisciplinary teams (like hackathons). In general, during this kind of activities, there are strict timetables and many groups tend to start working without properly analysing the topic/brief, nor performing any research activity. By using the 15 Analysis Cards and Features Map is possible to have a quick visualization of the features of case studies.

The analysis exercises proves particularly efficient when analysing case studies with the aim of redesigning the same product, because it gives direct insights and personalized feedback for framing the problem.

9 Activity Guides

The last element of the toolkit are a set of guides that explain how to perform some design activities with the support of all the components of the Toolkit. Therefore, the Activity Guides are an instructional resource to assist Toolkit users into reaching their design goals.

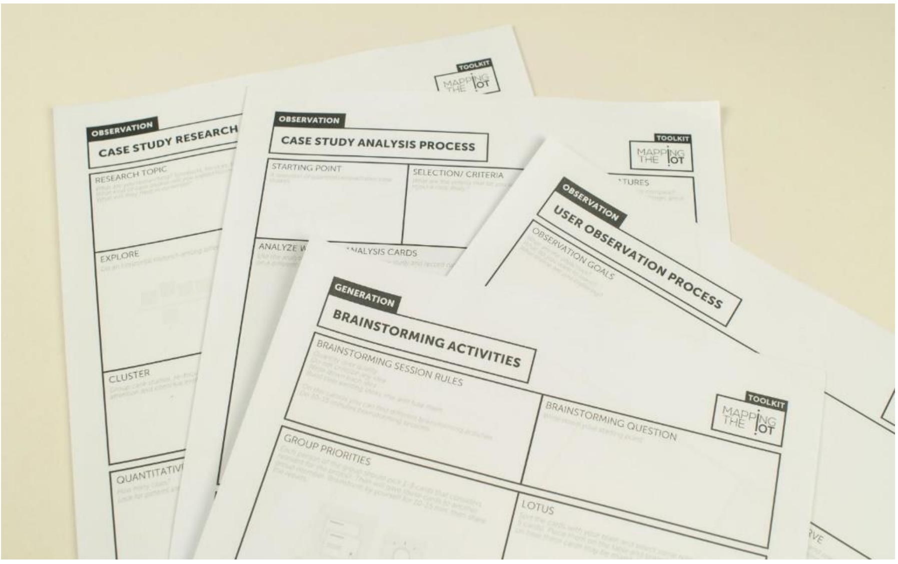

Figure 8. Activity Guides

The Activity Guides were developed following the feedback gathered after the co-design testing of the Toolkit during a workshop held at NordiCHI'16.

From the test emerged that while designers preferred a more unstructured and informal use of the Toolkit elements, non-designers (e.g. professionals within the psychology or tech field) felt the need of receiving more guidance for performing activities. For example, they perceived the Analysis

Cards/ Features Map exercise as clear and with an explicit value, but were uncertain about the usage possibilities of the MappingTheIoT Deck.

The Activity Guides aim to overcome this lack of knowledge about the design methodologies. Their structure is like a walkthrough. They present the different steps to carry out activities autonomously. Currently the Toolkit includes four Activity Guides: "How to plan a user observation", "How to do a case study research", "How to analyse case studies", "Different techniques on how to brainstorm using the MappingTheIoT Deck".

9.1 Role and functions of the Activity Guides

This element wants to mitigate the knowledge gap that experienced by different members of multidisciplinary teams regarding design methodologies and tools. By using the Activity Guides, the MappingTheIoT Deck become more structured and clear, balancing its high level of flexibility and freedom, which one of the weak points of card-based kits.

The approach of the Activity Guides is instructional, a step-by-step support to the "meta design" phases of problem framing and idea generation. Currently the Guides cover only few activities, but will be expanded in the future.

10 Future steps and conclusions

This paper, besides showing the process for developing a methodological Toolkit for designing IoT products, also attempts to get in touch with the scientific community. Its goal is to open up the discussion about the best practices to design meaningful networked products, and to foster academic collaborations within different departments and universities to test and expand the Toolkit. To underline this the MappingTheIoT Toolkit has been published under a Creative Commons license and is available for free download.

The IoT debate is in continuous evolution. To embrace this attitude the kit offers a methodology based on constant research, that encourage being aware and up-to-date to any technological updates. Its structure is also able to evolve and expand. Its aim is to help spreading a cultural design approach for dealing with products with a technological matrix. This idea of openness is also related to the possibility of personalizing the elements of the Toolkit (e.g. the cards in the Deck) and of receiving suggestions to propose new integrations. In this way the kit will be able to evolve, following future technological scenarios, covering updated issues and topics: for example machine learning and AI in consumer products, the use of chat-bots, the idea of UX bubble.

The Toolkit approach is cultural. It goes beyond the simple generation of IoT solutions, in which the action of mixing an object, a context, an input and an output makes it possible to generate and prototype experimental artefacts. The MappingTheIoT Toolkit has the ambition of making its users, whether designers or not, more aware of the product design possibilities of the IoT. It wants to provide a method that will encourage a culture of research and self-enrichment.

A first possible road envisioned in the future development of the Toolkit is the creation of a digital version, alongside the current one. While tangibility is valuable for some activities, like workshop usage and team discussion, a digital version or a digital Toolkit element may augment some specific functionalities. For example, an online tool could be able to suggest automatically design feedbacks and insights, highlighting recurrent design patterns.

The Toolkit is currently in its testing phase, from design students of Politecnico di Milano, and the current elements will be the starting point for a PHD.

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The Ideas Café: engaging the public in design research

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doi: 10.21606/dma.2018.564

The Ideas Café brings together members of the public with domain experts to stimulate conversation in a high energy, highly collaborative participatory event. We aimed to explore how multi-disciplinary automotive design research could be accomplished using this tool. The automotive industry is now on the cusp of a design and technology revolution with the advent of driverless vehicles, and it is important to understand the social aspects of this technological change. Trust has been shown to play a major role in our ability to correctly and safely use autonomous systems, so understanding the facets of its development is critical. As experts in this field (in design, engineering and policy), we wanted to explore the potential of the 'Ideas Café' format as a channel for exploring the public's needs for the design of future driverless cars and systems. 36 participants attended our Ideas Café event held at the Coventry Transport Museum in June 2017. We found that participants were highly engaged and the event provided practical user data which was valuable for design, engineering and policy. The results also provided recommendations for how designers could run similar participatory events for their own research.

participatory design, Ideas café, Driverless cars, public engagement

1 Introduction

An 'Ideas Café' is an event where members of the public and experts in the field are brought together around a particular topic, to stimulate conversation between the two. As the name suggests, the format bears similarities to a café, with participants sat around tables with coffee and cake to engage in discussion. Through facilitation, the Ideas Café affords design researchers the opportunity to explore various experimental methods, as we demonstrate in this paper.

Rowe and Frewer (2005) identified the three terms 'Communication, Consultation and Participation' for the success of Ideas Cafés, and stressed the differences in the definitions (Rowe & Frewer, 2005). Communication describes the information moving from the expert to the public, consultation is the public informing the expert, and participation is the flow of information between both the public and the expert- mutually benefitting both parties. We identified these definitions as the first step in defining the appropriate methodology for the Ideas Café (Abelson et al., 2007).

Brown and Isaacs (2002) went further to identify the key concepts of an Ideas Café, summarised below in the second column of Table 1 (Brown & Isaacs, 2002). The authors recognised that these aforementioned principles draw many parallels to the KCP (Knowledge, Conceptualise, Proposal) model, often used in participatory design methods (Berthet, Barnaud, Girard, Labatut, & Martin, 2016). Comparing the three models, it is evident that the majority of the principles of an ideas Café is centred around facilitating conceptualisation and consultation, making it an ideal tool in design research looking to involve members of the public. The authors will aim to achieve the principles set out in Table 1.

Table 1 – Comparison of the KCP model and the principles of the Ideas Café (Brown & Isaacs, 2002) (Berthet et al., 2016)

Three success factors for Ideas Cafes (Rowe & Frewer, 2005)	Key principles of an Ideas Café (Brown & Isaacs, 2002)	KCP Model (Berthet et al., 2016)
Communication	Set the context	Knowledge
Consultation	Create a hospitable space	Conceptualise
	Explore questions that matter	
	Encourage everyone's contribution	
	Cross-pollinate and connect diverse perspectives	
	Listen together for patterns, insights and deeper questions	
Participation	Harvest and share collective discoveries	Proposal

The principles of Ideas Cafes, have been used by governments to garner consensus and build trust in a new idea or topic (Petts, 2008; Yang & Pandey, 2011). At a high level, engaging with the public is key to building a society that can successfully adapt to change (Held, 1995), through enabling people to understand and verify different viewpoints and claims (Cooper, Bryer, & Meek, 2006). Many authors are developing models that attempt to formalise the engagement process to guarantee effective participation (Ebdon & Franklin, 2006; M. Kweit & Kweit, 1981). For this reason, it is evident that engaging with the public (through Ideas Cafes, for instance) is increasing in popularity as a tool in decision and policy setting (Irwin, 2001). However, many of the aforementioned studies have approached the study of public engagement from the perspective of organisational change and business management.

The authors were experts in the field from engineering, design and policy, and the Ideas Café format provided a method to explore the topic of driverless vehicles and trust on a broader, societal level. We are in an age of increasing automation, for example, GPS route planning, flight management, smartphones and now increasingly in the automotive context. Driverless cars are very much a reality. Given that we share so much of our road space with vehicles, it is essential that people can safely use this new technology (Hoff & Bashir, 2015). These automated vehicles will become increasingly responsible for the safety of the occupants of the car, and if the driver's relationship is suboptimal, there is evidence to suggest that automated systems can be dangerous (Cranor, 2008; Strand, Nilsson, Karlsson, & Nilsson, 2014). The user's trust in an autonomous system plays a vital role in ensuring correct human use. Furthermore, it is widely agreed that negative consequences occur as a result of the inappropriate level of trust placed in the system (for both too much, and too little trust) (Khastgir, Birrell, Dhadyalla, & Jennings, 2017; Muir, 1987; Parasuraman & Manzey, 2010). There is a pressing need for a better understanding of how we design these automated systems, like driverless vehicles (Dzindolet, Peterson, Pomranky, Pierce, & Beck, 2003). In this paper, we are particularly interested in the design of autonomous, or driverless cars.

However, trust is complicated, with many facets that contribute to its development between the user and the autonomous system (Jian, Bisantz, & Drury, 2000; Khastgir et al., 2017; Spain, Bustamante, & Bliss, 2008). There are many attempts to try to approach this from a quantitative, experimental perspective (Fallon, Bustamante, Ely, & Bliss, 2005; Jian et al., 2000; McCarley, Wiegmann, Wickens, & Kramer, 2003), where key metrics are driver distraction and usability. There are also qualitative methods used frequently in literature with the aim of measuring and determining trust. For example, the use of interviews to determine the dimensions of trust and factors affecting insecurity in many different fields is well established (Hedges, Sykes, & Groom, 2009; Mechanic & Meyer, 2000; Muñoz-Leiva, Luque-Martínez, & Sánchez-Fernández, 2010). However, the field of driverless vehicles and transport is very much future focussed; for the majority of people they have little exposure to the fully driverless vehicles of tomorrow. Hence, the speculative nature of this research must be reflected in the study methodology. Incidentally, few have sought to understand the more experiential aspects of trust and there is an opportunity to use more creative methods to lead to a deeper understanding of these facets of trust. Further, we found that most studies restricted the trust data collection until after the user had interacted with the interface (Cramer et al., 2008; Pu & Chen, 2006; Söllner, Hoffmann, Hoffmann, & Leimeister, 2012) and neglected to capture user perceptions in a futures thinking context.

There are many participatory design methods available, each with their own advantages and suitability to different contexts (Wölfel & Merritt, 2013). In this case, we want to engage a large group of participants in a conversation around futures thinking about driverless vehicles; and we believe the Ideas Cafe provides a platform in which people can explore ideas through futures thinking, which has been shown to help people to envision the world they wish to live in, despite the uncertainty of the future (Inayatullah, 2008; Varum & Melo, 2010). What makes the Ideas Café unique is the informal setting, and the need for the two way flow of information between the expert and the user. The Ideas Café not only enables people to discuss future scenarios, but also collaborate and have a joint conversation on a topic.

1.1 Aim

This paper describes the exploration of the public's perceptions of trust in driverless vehicles using an Ideas Café public engagement event. Methods from design research were used to try and frame the problem in a participatory way. The aim of the event from an academic research perspective were:

- To produce recommendations for designers on how to use creative methods like the Ideas Café to explore technical issues like driverless cars with the public.
- To consider how the findings from the Ideas Cafe can be translated into practical guidance for designers, engineers and policy makers

2 Method

We aimed to achieve the Ideas Café guidelines set out in Table 1. The key was to enable participants to conceptualise the driverless future, and to facilitate the two-way flow of information between the public and the experts in an encouraging and collaborative environment. The advantage of the Ideas Café is that it facilitates the use of multiple creative methods. In this section we describe the two main methods we chose to achieve this, and how each relate to the key principles of an Ideas Café (Table 1).

2.1 Participants and Recruitment

The Ideas Cafe was advertised through a variety of methods with the help of the communications department at WMG, University of Warwick. The event used a webpage, Twitter and newspaper press releases to give participants some preliminary pre-education before the event. The recruitment process is described below in Figure 2.

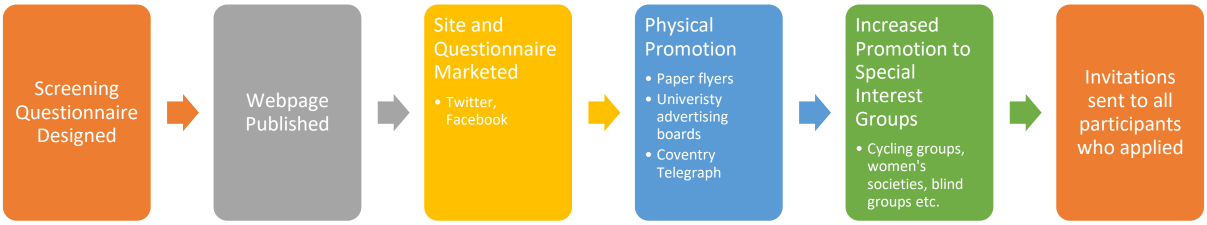

Figure 1 – Ideas Café Recruitment Strategy

2.2 Location

The location of the Ideas Café was very important in ensuring participants were able to attend the event (Baker, Addams, & Davis, 2005). The Coventry Transport Museum provided a central location for the target demographic of citizens of Coventry and the surrounding areas. We booked the venue for the 30th June 2017. Participants were provided with a bus pass to allow free travel to the location on the day of the event. Circular tables were setup to accommodate ten participants on each and were placed in a cabaret formation. Environmental cues can be influential in the participants' ability to engage with the task (Berger & Fitzsimons, 2008), and so the selection of the venue was very important to the design of the Ideas Café to ensure an informal environment that encouraged participation.

Figure 2 – Exterior of the Coventry Transport Museum

2.3 Participant Pack

Each participant was provided with a participant pack which provided them with information about the day, an agenda, a feedback questionnaire and a brochure detailing the work at the research institution. The pack also included two paper people that the participants would use in the first exercise of the day, described next.

The materials were deliberately designed to be friendly and easy to understand, avoiding the use of jargon and technical language. We wanted to create a hospitable environment and encourage everyone's contribution, so did not want to alienate any individuals.

Figure 3 – Participant pack containing key materials for the day

2.4 Scale on wall

We wanted to achieve a real time indication of the attitudes and perceptions of the participants in the room in order to cross pollinate ideas and to provide a task which could help participants settle into the event. Hence, a semantic scale was placed on a wall near the entrance of the venue. This consisted of a roll of paper approximately 5 metres long with a blue line down the length of the paper with a question placed above it. As participants entered, they were asked to stick their paper person on the scale in response to the question "Do you think driverless cars are a good idea?". This was also repeated at the end of the event to capture any differences in opinion from the start and end of the event. The scale had no markings, similar to Visual Analogue Scales (VAS) which has been shown to be less prone to bias (Carlsson, 1983).

2.4.1 Physical Scale

We aimed to capture attitudes and perceptions before and after the event, and also during the event using the table sessions. However, we recognised that after more than an hour of sitting, participants may become restless. To counter this, we proposed a standing physical semantic scale. Participants were then asked to this time physically stand on a line on the floor to represent their opinion. The compere then would ask participants to explain their viewpoint to the group and encouraged those with opposing views to engage in the conversation. Further, this helped cross-pollinate ideas and bring together people with opposing viewpoints in conversation, as recommended by the guidelines in Table 1. However, results were not collected for this as its purpose was as more of an energiser.

Figure 4 – Physical Semantic Scale Activity during the event day

2.5 Table Session

The table sessions enabled participants to freely express their opinions around a table of 4-7 participants. Three areas of trust were chosen for the table topics, these were Trust in Technology, Trust in Data & Privacy and Trust in Vehicle Brand; chosen from literature as the most pertinent issues to the topic of trust in driverless vehicles. We created a set of bespoke stimuli (Figure 5) for the event to explore these topics. These were artificial newspaper articles with headlines and small passage excerpts designed to help stimulate conversation around the table.

Participants were asked to capture their ideas on post-it notes and were asked to stick everything they produced onto a larger sheet of A2 paper. We did not provide any specific instructions on how participants should build or structure their posters, or if they had to be unanimous in their message. We wanted all points of view, particularly those that were opposed. This was displayed on a wall to the other groups. Each table facilitator then gave a one-minute summary of their discussion to the everyone. Bryson (2000) suggested that enabling participants to share and display their opinions in a public way is an effective facilitation method that can help build consensus in situations where opinions may be varied (Bryson & Anderson, 2000). Hence, for the goals of the Ideas Café, this methodology was a good choice.

Figure 5 – Artificial Newspaper Articles (for the Trust in Technology tables) designed to stimulate conversation around specific topics during the table session

2.6 *Summary of Ideas Café Day*

Figure 7 below shows the summary of the Ideas Café day plan. It should be noted that "Session 2: Social Impact" was an additional table session hosted by another collaborator and will not be discussed in this paper

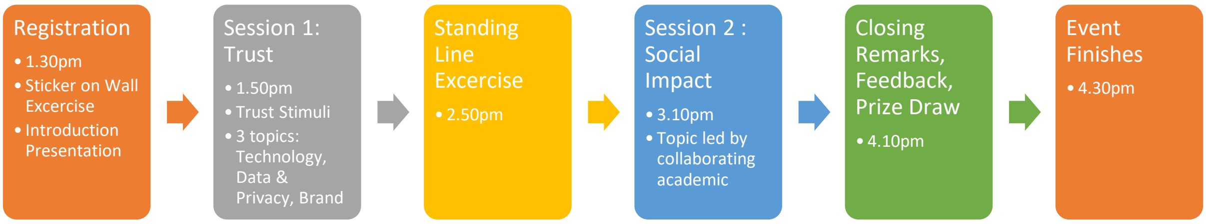

Figure 6 – Summary of the Ideas Café day

2.7 *Facilitators and Compere*

We were assisted on the day by ten table facilitators who were briefed on the event day and given detailed instructions on how to interact with participants and encourage participation. Facilitators were given guidance on how to structure the hour given for the table discussions. The goal of the Ideas Café was to facilitate two way communication, so we encouraged facilitators to engage in the conversation as a participant. Further, we encouraged facilitators to be wary of participants who felt uninvolved and to provide a platform for disagreement. The event day was also hosted by a compere who was experienced working in similar Ideas Café events. The compere's role was independent of the research, which allowed the researchers to focus on the content of what was being said. The event was photographed by the University of Warwick photographer

2.8 *Participants*

36 participants arrived on the day for the event (22 male, 11 female, 2 preferred not to say). The age demographic can be seen below in Table 2.

Table 2 – Age Demographics

Age Range	Number of Participants
35-44	9
45-54	9
25-34	5
55-64	5
75 or older	4
18-24	2
65-74	1

Participants were split across 9 tables, with 4-7 participants and a one facilitator per table. From participant feedback, 44% of participants said they were 'extremely satisfied' with the event location, and 38% said they were 'satisfied'. General comments from participants suggested that the location gave the event a sense of importance, and that the comments made were making a strong contribution to the research. 100% of participants said they were happy to be contacted again to take part in future research in the area, further suggesting that the Ideas Café was very successful.

However, we found that the majority of participants were recruited more effectively through email writing and networking with local special interest groups, such as parental groups and cycling clubs. This suggests that more work needs to be done to increase the awareness of the impact of driverless vehicles. The representation of society in the event can be seen below in Table 3.
The importance of pre-education was highlighted by the opportune showing of a television documentary on driverless vehicles the day before the event. Many participants came prepared with

discussion points and opinions, which were often attributed to having watched the programme the night before.

Table 3 – Representation of Civil Society in the Event

Occupation	Number of Participants
Retired	9
Academia	6
Student	5
Engineering	5
Government	4
Unknown	4
Charitable	1
Publishing	1
Marketing	1

2.9 Ethical Considerations
Ethical approval was granted by Coventry University for the study P52764 Trust in Connected and Autonomous Vehicles: Ideas Café. The Ideas Café is primarily based on perceptions and attitudes with no bio-metric or physiological data collected. All data was stored securely at WMG, University of Warwick in accordance with the University of Warwick's strict data protection guidelines.

3 Findings
This section will present and discuss the results from the creative methods deployed in the Ideas Café.

3.1 General Findings
We aimed to achieve the guidelines derived from literature in Table 1. Achievement of these guidelines would suggest that the Ideas Café was successfully able to facilitate the generation of knowledge, aid in conceptualisation and the creation of proposals. We found that this was the case, the Ideas Café provided an environment in which participants were able to discuss the issues of trust in driverless vehicles. The short presentations at the beginning helped set the context. The provision of cake, coffee and a comfortable environment created a hospitable space for participants. The table sessions with the help of table facilitators delivered on encouraging everyone's contribution, cross pollinating ideas and bringing together participants to develop patterns and insights. Finally, asking participants to develop A3 summary sheets of all their notes and have them displayed on a wall helped harvest and share the collective discoveries of the session.

3.2 Semantic Scale on a Wall
The scales were collected and the data converted into spreadsheet data by measuring the distance from each point to the left side of the scale in Photoshop. The results for the first and second line can be seen below in Figure 8 and Figure 9 respectively.

The subsequent statistical analysis using the Wilcoxon Signed Rank Test can be found in Table 4 and Table 5. This test was chosen because it allows us to see if there was a statistically significant difference between the two sets of results where the same participants were involved in both trials. Importantly, the 3 assumptions of the test were met: 1. The dependent variable should be ordinal or continuous (in this case, it was continuous). 2. The independent variable should consist of two categories which contain related groups i.e. the same participants are present in both sets of data (hence, those participants who left the event before completing the second line had to be excluded from the analysis) 3. The data from both groups have distributions that are symmetrical with each other (this was verified using a boxplot in SPSS)

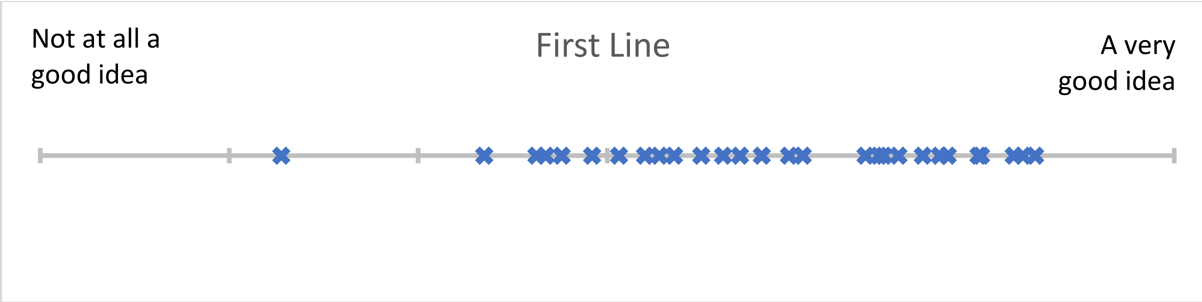

Figure 7 – Representation of the Line Exercise from the start of the event

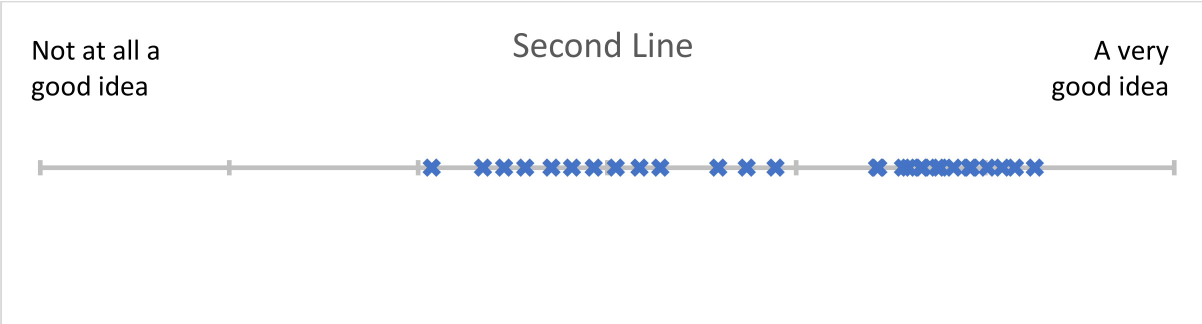

Figure 8 – Representation of the line exercise from the end of the event

Table 4 – Descriptive Statistics for the semantic scale on the wall analysis

	N	Mean	25th	50th	75th
First	28	7694	6193	7780	9473
Second		7902	5913	8861	9629

Table 5 – Wilcoxon Signed Ranks Test for the semantic scale on the wall activity

Second-First	N	Mean Rank	Sum of Ranks
Negative Ranks	13	13.65	177.50
Positive Ranks	15	15.23	228.50
Z	-0.581		
Asymp. Sig. (2 tailed)	0.561		

The descriptive statistics in Table 4 suggest that participants were in favour of the idea of driverless cars (on both scales), with the mean and 50th percentile being placed towards the more positive response on the semantic scale. The Wilcoxon results in Table 5, (indicated by the positive and negative ranks) show that 13 people became more negative versus 15 who became more positive about the idea of driverless cars. However, the Z value (-0.581) told us that this difference was statistically insignificant. It may have been the case that the demographic present were more steadfast in their opinions and were not easily influenced by opposing views.

In addition to capturing attitudes and perceptions, the activity helped participants feel settled and comfortable. Second, it provided the event with a strong user centric focus by enabling participants to easily share and publicly display their views, setting the precedent for participants to be more willing to share their opinions.

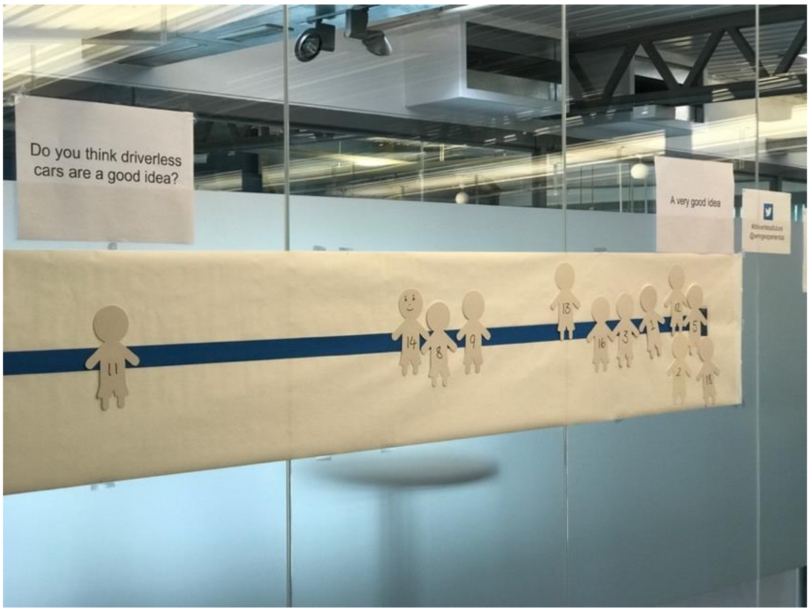

Figure 9 – Partially completed semantic scale on the wall with participant paper people

3.3 Table Discussions

3.3.1 General Comments

We had originally thought that the vehicle's brand would be a key factor for trust. However, the method revealed that this was not the case and societal acceptance was the key emergent theme. Emergent themes were a result of the open ended, conversational nature of the event. The newspaper articles were only provided as a general guide, and facilitators were instructed to allow the group to take the conversation in the direction they wished. Evidently, this methodology was effective at revealing different design issues to be addressed more specifically in the future. However, generating specific solutions would have required a more explicit topic choice and structure.

Figure 10 – Example of one table's finished poster, comprising of post it notes from the table session and the artificial newspaper articles

Figure 11 – Participants engaging in conversation at the Ideas Café in the Coventry Transport Museum

In the following results tables (Table 6, Table 7, Table 8), sources represent the number individual of participants who made a comment applicable to the corresponding code. References represent the total number of comments for that code, allowing us to account for one participant who may have made multiple relevant comments to that code.

3.3.2 Analysis

By transcribing all participants comments into Nvivo, we ran a thematic analysis as part of grounded theory. This methodology was chosen to enable the us to draw the emergent themes and theories from the data. This open ended qualitative format enabled us to collect rich data and find underlying themes that would not have been possible with just a quantitative approach. This allowed us to discover what factors affect the development of trust in driverless vehicles.

3.3.3 Trust in Technology

Table 6 – Coding analysis results for the theme: Trust in Technology

Code	Sources	References
Capabilities of Vehicle	7	9
Reliability	7	10
Vehicle Brand Matters	6	9
Coexistence of traditional and self driving vehicles	5	5
Aesthetics	4	4
Service and Maintenance	4	5
Driving Style	4	4
Cost	3	3
Nothing can stop Driverless tech arriving	3	3
Testing of Technology	3	5
Brand does not matter	2	2
Resale	1	1

The capabilities and reliability of the vehicle were the key concerns. Participants appeared to draw on their previous experience with computers in general, "Computer systems are not all they should be" (P15) and "Technology can go wrong, it can do a lot of damage" (P7) when communicating their opinions on driverless vehicles; consistent with findings which suggest previous experience is a key aspect of trust (Lee & See, 2004; Teacy, Patel, Jennings, & Luck, 2006).

Both the capabilities and reliability featured with equal importance in participant responses (both with seven participants each). Some participants named specific issues, for example, "can it be trusted with speed limits?" or "Can it be trusted with last minute changes?" (P25). We would suggest that the Reliability and Capability codes can be categorised under the theme of safety. Hence, ensuring the public are content and convinced with the safety of the technology would appear to be a key success factor for the technology.

Participants were also concerned with the 'co-existence of traditional and self driving vehicles' (5 participants). For example, "What will be the impact on traditional vehicle manufacturing?" (P14) and "How do old vehicles perform?" (P11). All comments in this code were written as questions, suggesting participants seek more information on this topic. This would highlight an area where research can do a better job of communicating the potential solutions to these issues.

Consequently, what should be done to communicate the capabilities and reliability of the vehicle? Statistically proving the technology's safety is one possibility. However, it has been found that this would be impractical, requiring hundreds of millions of miles of testing to prove their safety (Kalra & Paddock, 2016). With capability and reliability being key findings for the adoption of driverless cars, it warrants further research as to how this can be communicated with the user.

3.3.4 Trust in Data and Privacy

Table 7 – Coding analysis results for the theme: Trust in Data and Privacy

Code	Sources	References
Safety Risk	11	16
Customisable Privacy	8	10
Acceptance that data is shared	6	6
Not concerned	6	8
Differential Privacy	5	5
Unaware of Sharing	5	5
Targeted Advertising	4	4
Data Storage	3	3
Reasons why	3	4

Participants were concerned with the safety risk associated with data collection. Hacking featured multiple times in the safety risk code, *"Could they be hacked?"* (P14), *"Potential for hacking"* (P2), and *"Self driving cars are open to cyber security threats, more susceptible to terrorism"* (P34). Given the prevalence of software based attacks and security leaks in the media recently, it is understandable that participants were vocal about this aspect of driverless cars.

A few participants were aware of the benefits of data sharing in creating more reliable and better supported systems, for example, *"Good thing, data will help the technology work more efficiently"* (P1), *"Information…communication are necessary to enhance the quality and reliability for self driving vehicle"* (P19). It is evident there needs to be further exploration on what types of data sharing is deemed critical to the function of the car and should not be turned off. However, some participants remarked, *"I accept that most of my data is already out there, especially my location at any given time"* (P1) and *"We already share our data,"* (P18). With the numerous online services that we use and the data collected from them (for example, Gmail, Facebook etc.), it may be the case that the data sharing by driverless vehicles would not be an issue.

The event would suggest that there was no general consensus on data. One solution that appeared to be able to satisfy all viewpoints was the idea of differential or customisable privacy. These are new techniques that allow analysis of data collected from personal devices whilst removing all personally identifying information from the data (Eigner & Maffei, 2013). Though no participant specifically named this technique, it was evident from their responses that this could be an amicable solution.

3.3.5 Societal Impact

Table 8 – Coding analysis for the theme: Societal Impact

Code	Sources	References
Accessibility Issues	7	10
Involve People in the Design	7	9
Legal, Regulatory	7	9
Concerns with No Driver	6	9
Infrastructure	4	4
Adoption of Technology	3	4
Age Issues	3	4
Pedestrians	3	6
Physical Privacy	3	4
Children	2	2
Job Loss	2	2

The social impact of driverless vehicles featured in almost all participant responses across the three discussion tables. Accessibility issues were voiced by participants, concerned with how the technology interacts with people, for example, "Would the technology be too complicated for the average person?" (P25) and "Control for all people, not just the technologist" (P8). Participants were able to describe methods that would solve this, akin to the methods used in participatory design, "Technology can be trustworthy, but it needs to start from a certain group of people (and not engineers) to assure that it's working" (P5) and "Involve public i.e buses and taxis should be involved" (P23).

Communication was raised as an important factor in the adoption of the new technology, "Unbiased communication towards building trust" (P23), "Use of language- explain why needed" (P16). Studies have found that in any change process, good communication and the language used to deliver the message is critical to the success of the change initiative (Bordia, Hunt, Paulsen, Tourish, & DiFonzo, 2004). It also highlights the importance of events like Ideas Cafes as a tool for communicating with the public, and how participants perceive good communication as a key part of building trust. These findings suggest that the issue of building trust is not a technical problem, but one that is based primarily on good communication with the public.

The next major theme was the legal and regulatory impact. For example, "Who is liable? [in a crash]" (P25), "Needs to be regulated, legal and ethical" (P10). These appeared to stem from the lack of human driver, led to accessibility concerns. For example, a few elderly participants remarked, "who will take luggage and help visually impaired to reception desk (eg. In a taxi)" (P6), "remember the human element of taxi drivers" (P8), "Trust late at night, no bus or taxi driver, not good for reassurance" (P6). These issues are present regardless of the maturity of driverless technology and raises questions as to what kind of solution can provide the same level of tertiary services (such as help with luggage) as a human driver. The results make it evident that though increased accessibility is touted as a beneficial feature to older users who will be able to maintain their independent travel, there are other aspects which may be more detrimental to the vehicle user experience to older drivers.

3.3.6 Design Recommendations

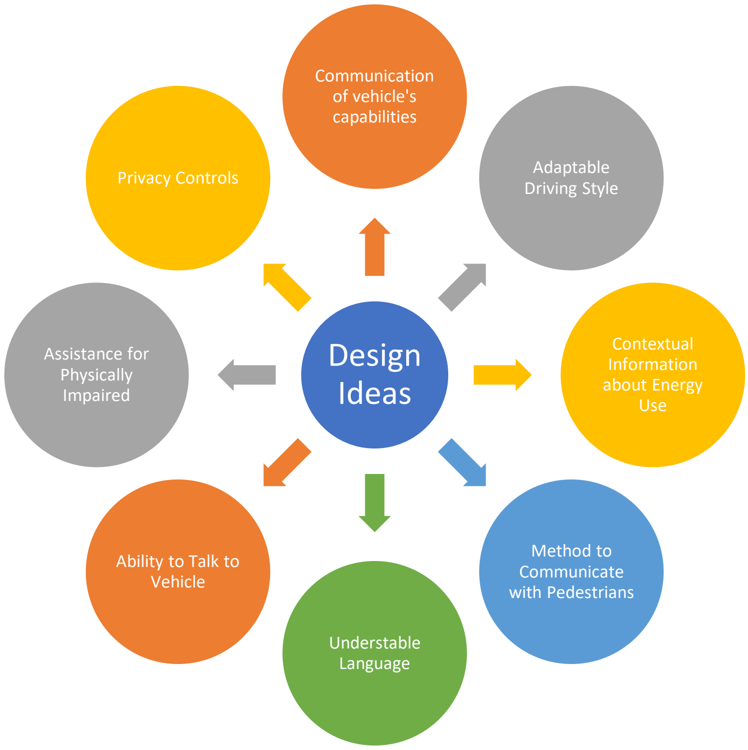

Figure 11 – Summary of design ideas from the table discussions

After our analysis of the table sessions, we were able to identify themes from participant responses that can be used to motivate our future research. The variety of methods used were aimed at achieving the principles defined in Table 1, which helped realise the value of the Ideas Café in bringing together a large group of people to discuss a futures thinking topic. Our current research up to this point found that the vehicle's situational awareness was critical to trust formation. The results from this Ideas Café expands on this, suggesting that more contextual awareness of both the impact of the environment on the vehicle (by displaying other vehicles it sees) and the impact of the vehicle on the environment (by displaying information about its energy use, adapt the driving style and methods of communicating with pedestrians) are also important to trust. Also highlighted was the importance of avoiding jargon in the interface design through 'understandable' language. Interestingly, common rhetoric has been that self driving vehicles are a boon to accessibility, by providing those who are unable to drive a platform to maintain their independence. However, the lack of a driver raised concerns about how luggage can be handled, or how they can be provided with assistance when checking into a hotel. Participatory design aims to involve as varied group of demographics as possible, and can help explore these issues further. This is a good example of how the open ended nature of the ideas café format enabled participants the platform to freely explore design issues.

4 Limitations

This section will provide a description of the limitations of the methods used at the Ideas Café.

4.1 Scale on the wall

A key limitation of the scale on the wall is the possibility that the question “Do you think driverless cars are a good idea?” is leading, and perhaps if participants were asked instead if they were a bad idea, the result may have been different. A more appropriately designed question would have been “What do you think about driverless cars?”.

The physical standing semantic scale, while very useful during the event, had limited value to the results of the day because of the difficulty in capturing the result. With the limited time available during the day, it would have been impractical to measure the positions of every participant, and so the data was not captured. We recommend that future events could plan for longer time to be given to the exercise, and perhaps capturing the positions with a panoramic photograph. However, it was still beneficial to the event, as an energiser.

4.2 Table Session

The table sessions provided the most significant proportion of the data collected from the event. The Ideas Café format allowed participants freedom to discuss and approach the topic as they saw fit. This is both an advantage and disadvantage; while this allowed the results to cover a broad spectrum of topics, it also meant that no specific topic could be explored in particular depth.

This alludes to one of the limitations of the Ideas Café in that it did not audio record the sessions, this placed greater stress on the expert facilitators on taking detailed notes and encouraging participants to write all their thoughts and comments. Audio recording the tables would have been beneficial, but difficult to analyse given the number of participants on each table.

5 Conclusion

This paper set out to explore how the Ideas Café event can be used in design research. Specifically, it set out to produce recommendations for how designers should run these types of events in their design research and to consider how these events can be used to generate guidance for designers, engineers and policy makers.

5.1 Unique Aspects of the Ideas Cafe

The Ideas Café is unique in that it provides an informal setting to explore a variety of different engagement tools with the express purpose of creating a two way flow of information from the expert to the user. Educating the public, whilst also understanding their perceptions. Other methods like Charrettes (Gibson & Whittington, 2010) and Focus Groups (Asbury, 1995) appear to be similar, but place far greater emphasis on defining a specific topic to solve, and having a greater structure to the event. Ideas Cafes take a much more informal, open approach, providing participants with a relaxed café style environment with cake and tea, and more focus on two way communication.

Consequently, location was far more pivotal in the success of the event in comparison to other methods. Providing participants with a strong context of vehicles and the open informal space afforded by the Coventry Transport Museum was evident from the high engagement and feedback, and also the breadth of results gathered from analysis. For future design researchers, the location of the event is of critical importance to the success of an Ideas Café.

5.2 Future Work

We have demonstrated how it is possible to gather perceptions whilst also educating the public on the topic of driverless vehicles using an Ideas Café. The methodology we have presented show how designers can run similar futures thinking events, the results of which we are able to take forward into more focussed research questions. We gained a better understanding of the key issues that must be addressed for users to trust the autonomous vehicle.

Specifically, we will be taking the communication of the vehicle's capabilities into future research using more technical methods such as the use of a driving simulator and quantitative data collection. The value for our research is that we've been given a select number of areas that we can focus on, in comparison to the myriad of research topics that driverless vehicles involve.

The highly positive feedback from participants on the day, as well as the fact that all participants were happy to be invited back to take part in future research, were endorsements of the method. For the authors this means we are now able to access a large pool of participants for future research in the area, this was an unexpected but very useful outcome. For design researchers, this could mean the Ideas Café can provide the platform to create user groups for future workshops where one could explore design problems in more detail.

We have shown how the Ideas Café can provide an environment to help participants conceptualise the future and shown how the results from open ended discussions can be translated into a set of practical guidelines. We hope to see more designers adopt the Ideas Café format to engage with the public to design the technologies of the future that will have a significant impact on society.

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DRS 2018 Design Research Society 2018 Catalyst

University of Limerick
25th – 28th June 2018

Horse, Butler or Elevator? Metaphors and enactment as a catalyst for exploring interaction with autonomous technology

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doi: 10.21606/dma.2018.329

As technology becomes increasingly intelligent and progressively gains agency, the relationship between system and human is redefined. Conventional interaction design methodologies cannot fully encompass the emerging new types of relationships, and new methods are necessary to address interaction at early stages in the design process. Both design metaphors and enactment techniques have been suggested as a way forward, and this paper explores whether a combination of the two can support the design of interaction with future autonomous systems. In three workshops, 27 participants in total utilised this combination of methods to design the interaction with an autonomous vehicle. The analysis of the workshops shows that the combination of the methods manages to support the imagining and design, where the metaphors aided the creation of a joint conceptual vision of the relationship, and the enactment created tangible experiences and contextualisation of the design concepts. Nine guidelines for the use of the methods when designing intelligent systems are defined, based on the insights from the workshops.

design methods; metaphors; enactment; autonomous vehicles

1 Introduction

Machine learning and artificial intelligence are enabling systems that act with a greater degree of autonomy than ever before, drastically changing the relationships between systems and the humans who interact with them. This intelligent technology creates a challenge for designers, who must proactively suggest ways for people to understand and engage with these new systems. The interaction with highly intelligent future systems may be difficult to imagine at an early stage in the development process and places novel demands on the processes and methods used (Höök, 2000;

Taylor, 2009). For example, how can design handle potential conflicts between system and user, and how can disciplinarily diverse design teams agree on the character of the human-system relationship?

These questions are currently a pressing issue in the automotive industry, where the introduction of increasingly advanced automation in vehicles requires a rethink of the relationship and interaction between driver and vehicle (Kun, Boll, & Schmidt, 2016). In the development stages toward full automation, the vehicle becomes an independent actor that the user still must interact and share control with. Issues of mode confusion (Endsley, 2017), mistrust (Parasuraman et al., 2004; Verberne, Midden, & Ham, 2012), loss of situation awareness (Kaber & Endsely, 2004) and even misuse (Parasuraman & Riley, 1997) are possible consequences. To ensure safe use, the system must communicate appropriate use (Beller, Heesen, & Vollrath, 2013; Inagaki, 2008) as well as sense the user's state and capabilities (Sibi et al., 2016), creating a much more mutual and dynamic relationship than before. Conventional interaction design methodologies and guidelines may not encompass this increased agency of the system and need for mutual understanding (Pettersson & Ju, 2017; Schmidt & Herrman, 2017). New methods, as well as application of old methods in new ways, may be needed to address interaction with autonomous technology at early design stages. Considering the complex technology, and the potential effects on users' everyday life, it is also important to find methodologies that serve as communication tools in early design efforts for finding common ground between developers from different disciplines, as well as when involving users.

In the automotive case, suggestions have been made to use metaphors as a way into imagining the interaction (Davidsson & Alm, 2009; Flemisch et al., 2003; Ju, 2015), and to evaluate designs at a very early ideation stage through enactment methods (Pettersson & Ju, 2017). We see that these methods perform complementary roles in the design process and can be combined to address the design of the relationship between human and vehicle. The aim of this paper is thus to explore if, and how, design metaphors and early enactment together can support the design of interaction with future autonomous systems. More specifically, the focus is on investigating how these techniques help the designing team to imagine and conceptualise designs of autonomous systems.

2 Combining metaphors and enactments

In a design process, both conceptual association to frame the problem and concretisation of the solutions are necessary (Burns, Dishman, Verplank, & Lassiter, 1994). We propose employing metaphors and enactment as a hybrid design tool for autonomous systems, as they together should theoretically provide those two necessary parts when applied to a use scenario. Design metaphors should be able to provide the conceptual groundwork and create the vision necessary to guide the design process, while enactment should create the tangible experiences necessary to move forward. This section provides overview of the separate methods and their relation to autonomous vehicles.

2.1 Design metaphors

Metaphors have been used in design to frame design problems, to create meaningful product experiences and, perhaps most famously, to guide user's interaction through e.g. the desktop metaphor of personal computers (Cila, 2003; Hey, Linsey, Agogino, & Wood, 2008). The suggestion to use metaphors in the design of automated vehicles was made by Flemisch and colleagues (2003), as a way to handle the interaction consequences of the vehicle's increased agency. They argued that a design metaphor has two strengths; it can serve a way to create a uniting vision for the design team, and it can help the user create an initial mental model of the system if properly communicated in the design. In the context of autonomous vehicles, the metaphors have to be applied to a new level of the relationship between vehicle and human, compared to previous use of metaphors in design. That is, instead of relating how to use the vehicle, it should help clarify the division of control and responsibility, communicate intentions and goals, and set the tone of relationship (Bruemmer, Gertman, & Nielsen, 2007).

The power of the metaphor is that it can, via conceptual association, link disruptive ideas to well understood objects and processes (Bruemmer et al., 2007). It creates the link between source and target by mapping properties from the source to a blended target (Cila, 2013). By doing so, abstract ideas (like the character of a relationship) can be given concrete properties and made more accessible (Bruemmer et al., 2007). Specific suggestions for metaphors have been made, notably comparing the new human – vehicle relationship to that between rider and horse (Flemisch et al., 2003), husband and wife (Ju, 2015), or players on the same team (Davidsson & Alm, 2009). However, neither of them has gained traction, and the translation of metaphors into the design of a vehicle – human relationship is not well explored. Research on design metaphors suggests significant challenges including how to choose an appropriate metaphor and how, and through which features, to transfer the conceptual association to concrete design (Cila, 2003).

2.2 Enactment

A metaphor alone is not enough for design decisions, the characteristics of the relationship need to be represented in concrete interactions, filling in the gap between metaphor and interface in the design process. There are a number of ways of which design ideas can become tangible, e.g. by sketches, lo-fi prototypes and storyboards. However, capturing the dynamics and the tacit aspects of the interaction design may be difficult in static or inflexible representations (Arvola & Artman, 2006). Enactment/body storming (Burns et al, 1994; Buchenau & Suri, 2000) serves as a very flexible and swift way of exploring future designs. By gesturing and expressing the interactions taking place between user and system, enactment can give "…the possibility to be flexible and contingent to user and system actions and reactions" (Pettersson & Ju, 2017). Furthermore, it provides a space for a group of designers/researchers to improvise and together "create a common focus" (Buchenau & Suri, 2000) of a future design.

Enactment has for example previously been used for example in improvising autonomous vehicle value (Jorlöv, Bohman, & Larsson, 2017), postures and activities in autonomous vehicles (Ive, Sirkin, Miller, Li, & Ju, 2015), expectations on interactions with autonomous vehicles (Pettersson, 2017) and evaluation for non-autonomous in-car interfaces (Davidoff, 2007). However, as enactment is in its nature explorative, using the technique as stand-alone base for generating interaction designs may lack the goal and stringency needed.

3 Methodology

The hybrid design tool of metaphors and enactments was explored in three workshops, where participants worked in groups to develop an interaction design concept for an autonomous vehicle[1]. There were small differences between the workshops as the setup had to be adapted to the preconditions but the structure comprised the same three steps for all workshops, as described in Figure 1. To support the process the following material was provided (more details in Figure 1):

- **Metaphor cards:** a set of ideation cards, each describing a metaphor for a potential vehicle-human relationship (see Figure 2), plus blank cards to encourage new metaphor creation.
- **Enactment techniques:** in all three workshops, a simple mock-up of a car was placed in the room as the scene for enactment; the "setting the stage" method (Pettersson & Karlsson, 2015). The mock-up consisted of four chairs and the outline of the car drawn on paper covering the floor. In the third workshop, two further enactments were available: a small-scale road scene constructed using a play-mat with a map and toys representing cars and pedestrians (Figure 4), and a lo-fi driving simulator, constructed of a projected film of driving scenarios, and a simple foam board mock-up of a cockpit (Figure 6).
- **Prototyping material:** paper, cardboard, pens to make simple mock-ups for interface elements.

[1] Vehicle was SAE level 4: The driving mode-specific performance by an Automated Driving System of all aspects of the dynamic driving task, even if a human driver does not respond appropriately to a request to intervene (SAE, 2016)

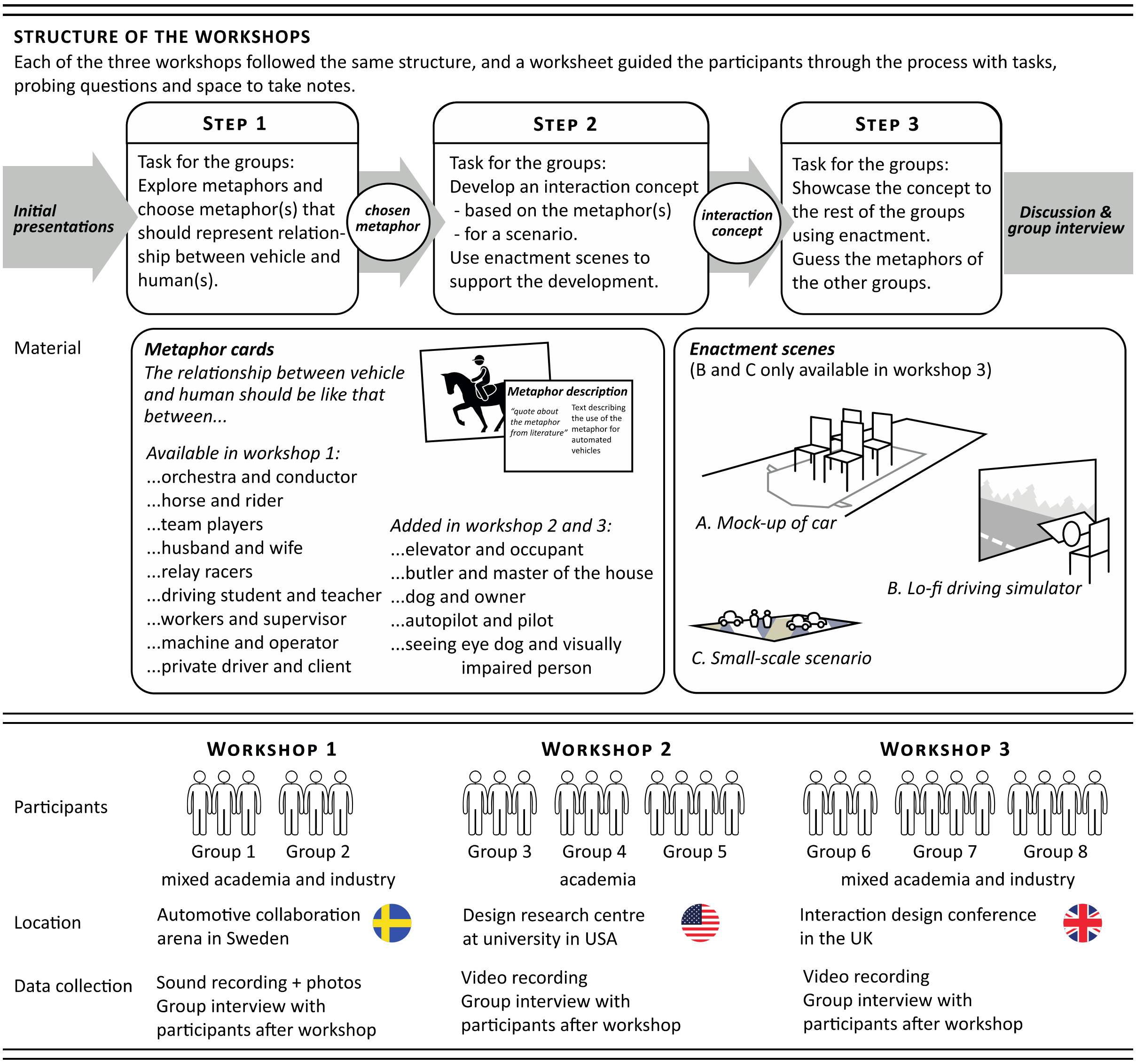

Figure 1 All three workshops had a common structure and similar material, but the number of participants and location varied for each workshop occasion.

Since the study focused on understanding whether the methods help the design team to imagine and conceptualise designs of autonomous systems, participants with some experience of working on the interaction between humans and automated vehicles were sought. Some participants came from industry and others from academia (from master students to assistant professor). The workshops were organized between late 2016 and mid-2017.

For the analysis, notes from the workshops and video recordings where gathered in a spreadsheet, where information from the individual groups and general discussions where structured according to metaphor choices, evoked discussions, created interaction designs etc. A thematic analysis was performed, utilising affinity diagrams (Martin & Hanington, 2012), to map out and group the general outcomes and insights from the use of metaphors and enactment. Next, these findings based on the analysis of videos, notes and worksheets are presented.

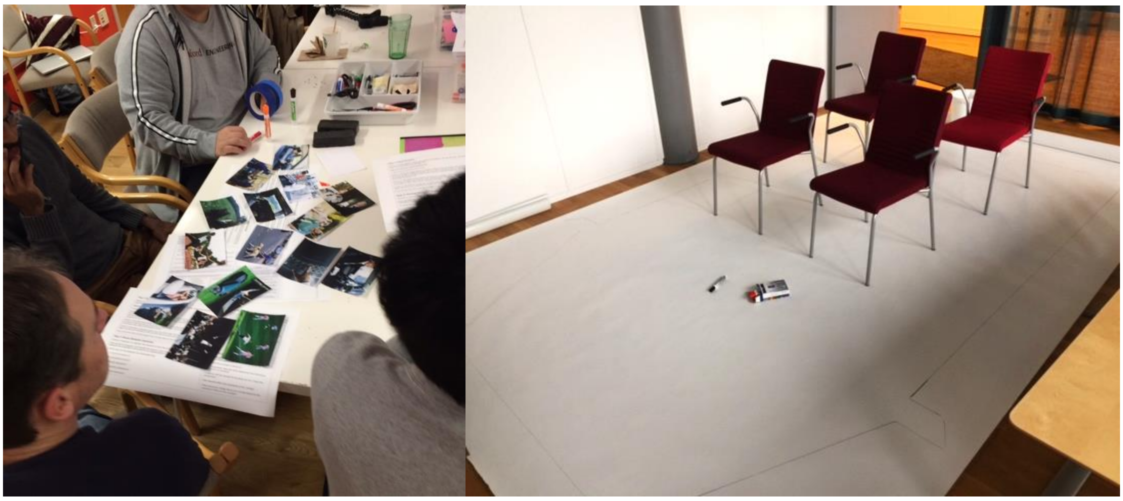

Figure 2 Metaphor cards during discussions in Workshop 2 and enactment "stage" in Workshop 1.

4 Findings

During the workshops, participants produced a diverse set of interaction concepts, making different prioritisations regarding which aspects to include and which events to design for. Figure 3 gives an overview of the concepts created.

4.1 Imagining a relationship together

The first hurdle for the groups was agreeing on which metaphor to choose and which relationship they would like to see between vehicle and human. The discussion leading up to a choice was approached differently in the groups and took different amount of time.

4.1.1 Design experience and diversity

Some groups quickly identified a few of the metaphors to analyse further and get to designing. For example, within a few minutes, group 6 had picked Husband, Guide Dog and Kit (vehicle in the TV series Knightrider) based on interest, and begun analysing the characteristics of these metaphoric relationships, saying e.g. about the Guide Dog that *"there is a lot of trust in that, [...] you put your faith in the dog".* Group 1 instead strategically chose metaphors representing different levels of involvement in driving; Butler (low), Horse (high), and Relay racers (switching between none or full). Both groups had a high degree of design experience, a good preconception of what they were applying the metaphor to, and quickly settled on a final choice.

Other groups seemed to struggle more with the choice, and spent more time discussing what they were going to apply a metaphor to. This was especially noticeable in group 7, where the different disciplinary backgrounds of the participants affected which approach they took to the metaphors. The system designer wanted to apply it to the intelligence of the system, the interaction designer to the relationship and the anthropologist wanted to string metaphors together into a narrative. While either approach could lead to interesting results, the group needed to agree to move forward in their joint design process. The discussion appears to have been useful for both highlighting how many dimensions there were to the human-vehicle relationship as well as merging the group's different perspectives. Group 7 and other groups with similar patterns indicate that groups with more disciplinary diversity will have to discuss more to come to an agreement, but that this discussion gives better insight to the dimensions of the problem.

The metaphors themselves were perceived as useful in this discussion as they opened up the design space and pushed participants to new discoveries; *"to be forced to think about this was actually nice because the metaphors open up for these extremes […] for us it was helpful as you realize the different dimensions* [of the system/user relationship and communication]*"*. The metaphors and the discussion together helped participants question their assumptions. For half of the groups, this

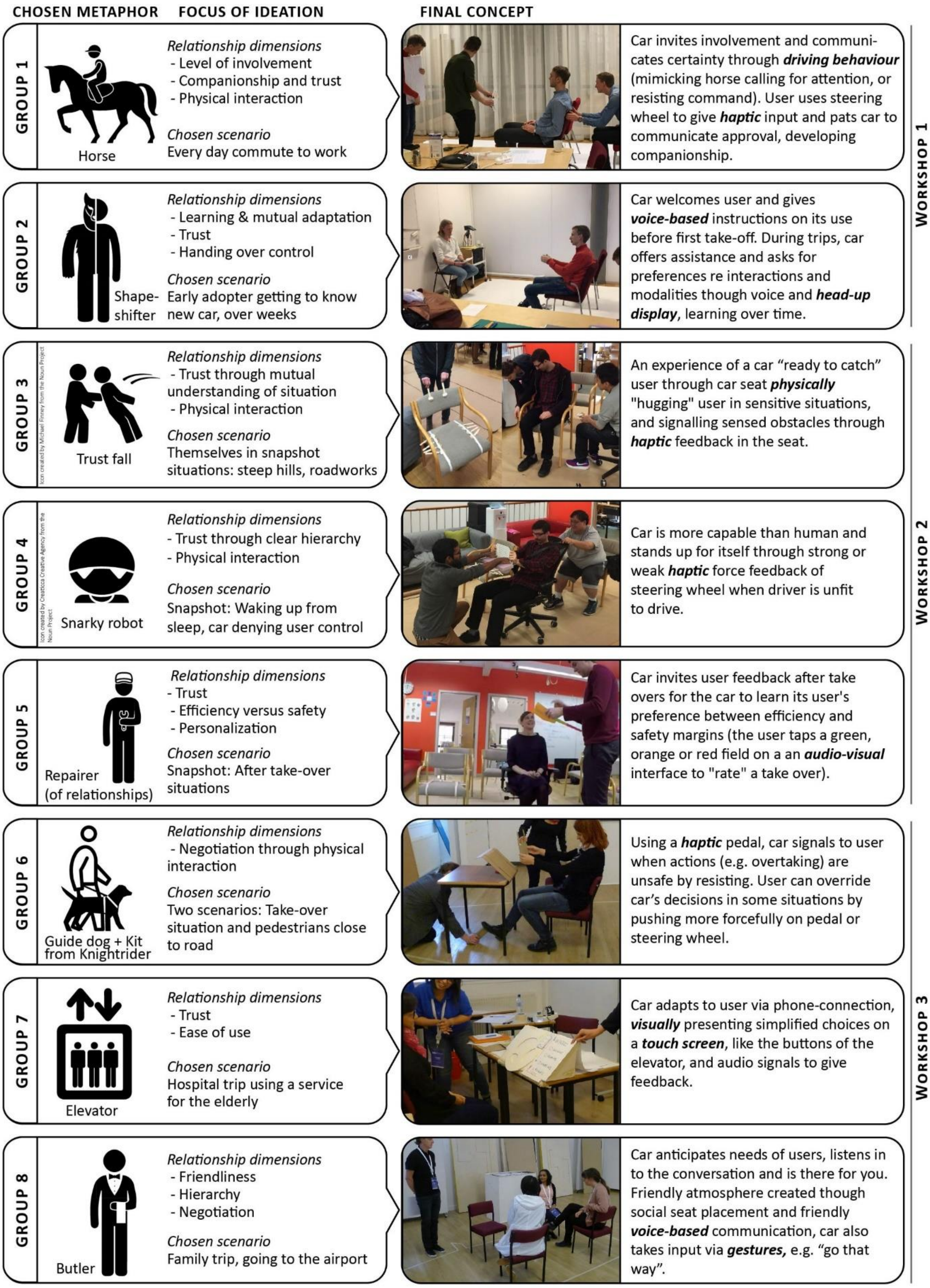

Figure 3 Overview of outcomes from all 8 groups, including which metaphor they chose, the focus of their discussion (relationship dimensions and scenario), and the final concept.

combination of design space and relationship dimensions resulted in the decision to go with a self-defined metaphor that described their specific idea, while the rest of the groups chose from the cards provided (groups 1,6,7,8).

4.1.2 Relationship dimensions and system expressions

The metaphor choice discussions revealed insights into the identification and prioritizing of relationship dimensions, including trust, adaptation, and level of involvement, as well as expressions of the system, for example assertive as in group 4's Snarky Car or submissive and subtle as in group 1's Horse. It is worth noting that all groups chose a different metaphor (see Figure 3) and the prioritisation of relationship dimensions played a major role in that choice.

Trust was mentioned by almost every group and was generally conceived as a fundamental issue to address, both in order to support the formation of trust (e.g. groups 3, 4, 5,7) and also avoiding over-trust (e.g. groups 1 and 2). Another frequent dimension was the *level of engagement* in the relationship; when, how and how much the system should engage with the user. This dimension is easily conflated with automation level but relates to the expression of the system rather than which tasks are automated. Thus, it includes both the level of involvement with the user and the communication style of the vehicle. Group 1 explored a relationship based on the Horse where the need for involvement was gently hinted at by the vehicle but using unobtrusiveness as a guideline: "*it's always there and you can control it super easily by just doing a small thing, otherwise it goes back to a baseline where it does its own thing".* Other groups (2, 6, 8) explored a much more active role for the vehicle; asking the user continuously for input and feedback. Group 8 expressed their concept as "*the butler [metaphor] has a very clear hierarchy, but the car is also your friend. So, we made a talkative machine, this whole idea of a friendly machine, a friend in the car* ". In contrast to the vehicle inviting involvement and "small talk", group 4 proposed a different approach, where the "Snarky Car" instead denied involvement through very decisive interactions, like the steering wheel spinning away from the user "*it would kind of be like snatching your hand, like - don't touch me!".* The concept demonstrates another dimension discussed by the groups: *hierarchy* and who has control over the interaction.

The *negotiation* of the system's and user's understandings of the situations was also explored, e.g. group 1's Horse signalling that there might be a better route to take by changing its driving behaviour, and group 5's Guide Dog providing haptic feedback to correct the user wanting to perform potentially unsafe operations. Other concepts created a shared understanding of the situation instead, including group 3’s Trust Fall concept that physically communicates to the user that the car has sensed road obstruction. Also, the relationship’s *evolvement* over time was explored (e.g. groups 2 and 5), where the car (and the user) adapts to each other.

4.1.3 Own or others' relationships?

The prioritisation of dimensions was partly based on interest, but also on who the groups imagined as user. Some groups prioritised dimensions based on their own experiences or desires, e.g. the recent experience of driving a very steep hill that led to the Trust Fall metaphor in group 3 or experiencing a passive-aggressive self-service check out that lead to the Snarky Car of Group 4. Others imagined what would be important to future users, e.g. the owners of the first, ground-breaking autonomous vehicles in group 2's Shapeshifter and the elderly person using a ride service in group 7's Elevator concept. Figure 4 shows group 7’s concept under development in the small-scale scenario, and group 3's Trust Fall concept is tried out in enactment. Groups that based their choices on an imagined other user tended to cover a wider range of events in their designs, including both mundane events like telling the car where you want to go, and situations where there was a conflict of interest between the car and the user. Self-experienced designs instead focused more on the specific situation.

Figure 4 Different starting points of the concepts: group 7 is working on an elderly person's trip to the hospital in the small-scale scenario, and group 3's Trust Fall metaphor is being translated into a tactile design inspired by one of the participants' own recent driving experiences.

4.2 Moving from the conceptual to the concrete

Two major types of outcomes can be distinguished from the groups' work; the overarching conceptual ideas about the relationships, and the concrete design of the interactions. As mentioned above, the range of metaphors forced participants to question their assumptions and explore the full design space and relationship dimensions, leading to the former type of outcome.

The latter type of outcome was instead more a result of the combination of metaphors and enactment, which directed participants *"to make it concrete and make it into something*" according to a participant in workshop 3. Applying the metaphor to the interaction meant taking the conceptual leap from the broad to the details and practical solutions. In doing this, three different levels of abstraction where employed. Some applied only the inherent meaning of the metaphor to the design (e.g. creating trust by physically "being there" as in the Trust Fall concept), some chose a combination (e.g. the tacit information from a guide dog combined with the assertiveness and smartness of Kit), whereas other let the metaphor guide interactions throughout the whole concept on a more overarching level (e.g. the elevator concepts selection of simplified choices and characteristic audio notifications).

Based on the groups discussions, certain types of metaphors seemed easier to interpret directly into a design solution than others. The clarity of the metaphor seems important here, as fuzzier concepts, such as the Shapeshifter, tended to result in less actionable design ideas. Group 2 reflected on the fuzziness of their metaphor in the design, saying *"but now we have a really hard time to say anything* [about the design]*, since we say that it is super fluent and can do whatever more or less".* Metaphors that instead were concrete, well-known to the participants and "complete" in themselves, resulted in more actionable interaction concepts. Furthermore, metaphors that involved movement, as in going for a ride in an elevator, taking a horseback ride or a blind person walking with a guide dog appeared easier to transfer into interactions, than for example butlers and shapeshifters, where interactions are fuzzier. Another aspect that appeared to help the concretization was the provocativeness of the metaphor – a strong metaphor with potential "drama" offered a more accessible "problem" for the interaction design to address. An example was the "Snarky Car's" authoritative behaviour hindering the user from driving when unfit to do so (Figure 5).

Figure 5 Becoming concrete: Enacting Group 4's "snarky" car's defensive haptics of the steering wheel and developing Group 2's "Shapeshifter " interactions during the enactment session.

Despite the guidance that the metaphors provided, after a while many groups started to feel restricted by the metaphor and took a more pragmatic stance in their design. One participant in group 8 commented *"the metaphors are a good start to get you thinking, but you get to a point where thinking about the metaphor is holding you back*, *maybe it's not the elevator but more of a plane*". At this point, the combination with enactment led the designs to evolved, as new design ideas emerged and new discussions took place:

> *"It was good to have the metaphor and also all these [enactment scenes] because it helps you to discuss the different levels, you go from the details to the more abstract...and the metaphors helps you to take on the scenario in different levels. It expands the design space. [...] it was great to be able to show stuff here* [in the car mock-up]. *It was like the diamond model, you go back and forth..."* (participant, group 8).

However, in workshop 3, the different enactments gave rise to different experiences. The majority of the participants preferred the freer enactment scene of a simple car mock-up, e.g. "*I liked that it had no restrictions what so ever, it's more imaginative and less restricted by technology"* (participant, group 6). No one preferred the small-scale scene and a minority the lo-fi driving simulator (Figure 6), e.g. "*it's good that it puts* [the design activity] *into an everyday context, that's how we came up with the idea of the car stopping...*". Our observations confirmed the insights of the participants; the open car mock-up contributed by being an open space for innovation, but still offering the basic notion of a car contextualizing the interactions.

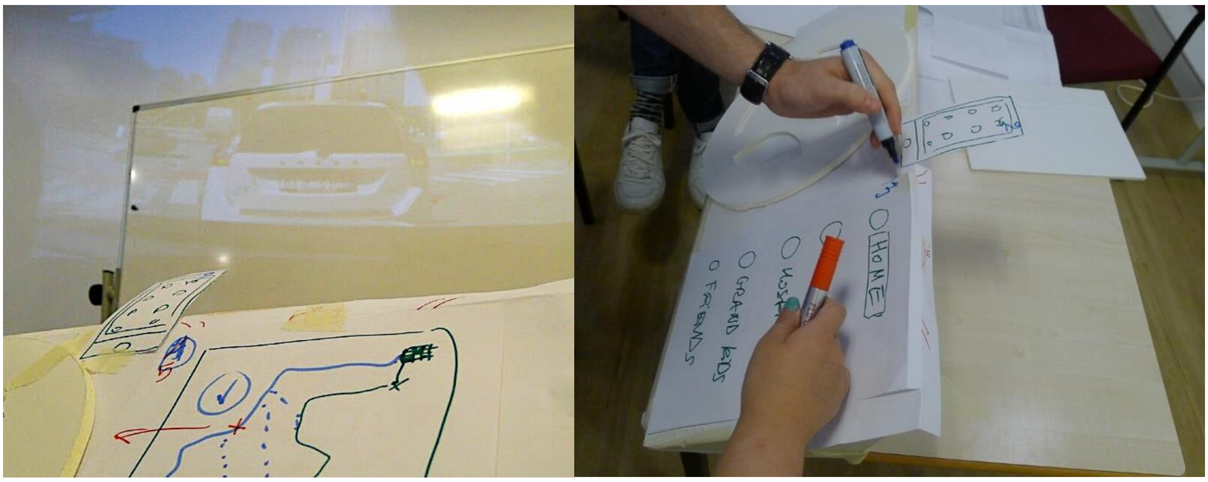

Figure 6 Developing the visual interface: the "Elevator" interface under development in the lo-fi driving simulator.

4.3 Methods trigger modalities

The vehicle context is unique in the range of interaction modalities available to communicate between vehicle and user. The vehicle envelopes the user, creating a range of channels for communication; senses pick up on speed and lateral control, sounds, visual and tactile information. New technology also enables advanced visuals, gestures, haptic and speech communication. In the workshops, the groups' propensity to take advantage of this range of available modalities was noticeably affected by the enactment techniques used and the metaphors chosen. The groups that chose a human-human relationship metaphor, like the Butler, and the Shapeshifter (which started out as "the new kid in town") tended to rely on solely voice-based communication. The human-human metaphors pushed the imagination towards a separate “agent” controlling the car, that should be embodied as a character, and use voice as primary means of interaction. In contrast, metaphors of human-animal/object relationships triggered more haptics. Group 6 reasoned:

> *"Dogs don't talk...it's that notion of you know, you're walking your dog and the dog pulls you away and you react to something you don't know what it is yet. But you trust the dog and you say, OK, that's fine I'll go with you..."*

The enactment techniques also helped develop the modalities used, in some cases challenging the chosen modalities and exploring other means of interacting. Group 7 for example, evolved their elevator-based design to incorporate more audio features in the move from small-scale scenario to very simple simulator. "Setting the stage" appeared to trigger the "body-based"/physical interactions, especially when combined with props (such as cardboard steering wheels, a block of wood acting as gas pedal, conveying haptic feedback, see Figure 7). Enactment allowed participants to express ideas that were difficult to verbalize - by acting them out. Imagining and trying out the physical use and actions in a concrete space thus provided a means to generate and evaluate the practical and embodied aspects of use. The timing of the utilization of the technique may have influenced, comparing group 6 who employed enactment early, and group 8 who used enactment later in the process (and through it added gesture interaction).

The physical interactions were positively evaluated by participants, as they were perceived as both natural and non-annoying compared to voice-based interaction. One participant said of the Guide Dog: *"this felt like the friendliest...because our interaction* (the Elevator) *felt so machine like, and unlike nature. This was much more natural and friendly*". The haptic modality could not only be used to convey information but was also seen to evoke feelings of safety and trust, two of the important relationship dimensions. Group 3 explored this emotional communication based on the Trust Fall metaphor (Figure 7) and by enacting the haptic interactions of car seats, belts and steering wheel, the experience was effectively communicated.

Figure 7 Physical interaction: Props conveying the haptic "hug" of the Trust Fall metaphor and the enactment of the "Guide Dog" where force feedback is given through the pedal.

4.4 A note on the impact of the scenario

The impact of the scenario on the design process was made evident across the workshops. The scenarios used by the participants to design and enact the interactions were of different character which impacted the character of their designs. Two different temporal dimensions of the scenario had an impact; *how far in the future* they were placed and the *timespan of the scenario* itself. Scenarios placed too far into the future offered challenges as they contained too many unknowns, in similarity to the fuzzy metaphors, and made it difficult to evaluate ideas. However, staying too close to the present limited the innovativeness of the designs and kept the discussion on the interface design rather than the relationship.

The timespan ranged from individual snapshots, to one leg of a trip containing multiple events, to over a longer time period (see Figure 3). Group 2 for example struggled with the evolving relationship over a considerable timespan, indicating that for first design steps this is not a fruitful scenario. However, choosing too simple scenarios risks leading to shallow design ideas too focused on one isolated interface aspect, rather than the essence of a relationship. It was also noticeable, that to really get involved with the relationship dimensions, the scenario also needed to contain situations where there was a difference in understanding or interest between vehicle and human. All in all, the granularity of investigation is important to consider, and the more concrete scenarios, the better the techniques appear to be applicable.

5 Discussion

The focus of the workshops was to explore how metaphors and enactments may work together to help design teams imagine future relationships and interaction designs with autonomous technology. Based on the findings, we believe that the combination of the two techniques did manage to push participants into imagining new types of relationships <u>and</u> concretizing them into designs that could be communicated to others. In comparison to creativity methods in interaction designs which may lack the necessary connection to the use context (cf. Biskjaer et al, 2010), the enactment helped to bring context to the design activity. This means that the method combination supported the challenging "conceptual leap" from discussions to concept (cf. Odom et al., 2012). In this process, the metaphors served as a way to formulate and challenge undirected approaches to the relationship, capturing the essence, and enactment served to bridge the metaphor into concrete interactions and offer a structured space for comparing the concepts.

5.1 The value and limitations of the methods

The design of an autonomous system encompasses both fail-safe, intuitive functionality and crafting the expression of the interaction. In an automotive context, different brands may follow similar guidelines to create a system that is easy to use and employ similar hardware and software, but the style of communication and tone of voice may be very different across brands. The metaphor and enactment combination offered a tool to address this differentiating quality in terms of both aesthetics and the nature of the communication, which was an additional value of the methods highlighted during the workshops. The combination also resulted in that participants explored the full design space of interaction modalities that the car has to offer.

In relation to the issue of designing communication with future intelligent technology, the metaphors managed to become the joint visions suggested by Flemisch and colleagues (2003) to constructively guide the design. The way in which metaphors were utilised by the participants could be likened to Hey and colleagues' (2008) description of prescriptive metaphors leading to innovative solutions by removing mental constraints, but the participants' discussion shows that the metaphors manage to both narrow down and open up the design space simultaneously, which compares better to Flemisch and colleagues (2003). In that, the metaphors managed to make the abstract concept of a mutual and dynamic relationship between vehicle and human more accessible to the participants, as suggested by Bruemmer and colleagues (2007). The way enactment was employed demonstrated previously concluded strengths with such methods (cf. Davidoff et al., 2007; Odom et al., 2012;

Pettersson & Karlsson, 2015), such as the ability to accentuate the flow of interaction between user and system, and to introduce and reflect on contextual factors affecting the use of the system (cf. Davidoff, 2007). Based on these findings, we see the combination of metaphors and enactment as able to contribute with a holistic outlook on interactions rather than islands of information exchange.

In the workshops, some limitations of the methods could be observed. Metaphors were for example limited by the participants knowledge of them. The power of a metaphor is connected to linking the unknown to something well-understood (Bruemmer et al., 2007), so metaphors that the participants did not fully understand themselves were harder to work with. It is easier to predict how an elevator would react than a mythological creature as a shapeshifter. However, metaphors that involved provocation could make up for an incomplete understanding of the metaphor by bringing out the nature of the agency of the interface, addressing the core of the interaction with the autonomous system. All metaphors did at some point limit thinking as well, as the translation into design could only be partially guided by the metaphor itself, and was highly impacted by the scenario, the dimensions that participants focused on, and the enactments.

As made visible in the enactments, the concreteness of the scenario impacted. It was clear that some concepts worked less well with enactment than others, especially those concepts encompassing learnability and long-term aspects. This does not inherently mean that they were worse ideas, just more difficult to map out with the techniques used.

The enactments used also affected the nature of the interaction designs in different directions, which has also been seen previously (Arvola & Artman, 2006; Tholander et al., 2012). The free form of enactment in a simple car mock-up, in combination with simple props, helped the participants to surface and exemplify the aspects of interaction designs that are difficult to bring into words, while the two other enactments appeared to tune associations in other directions (e.g. to a helicopter perspective of an entire drive in the small-scale scene and to audio/visual interaction in the lo-fi simulator). These perspectives are valuable in their own right, but not as useful when focusing on the essence of the relationship and flow of communication.

We recommend keeping scenarios focused and concrete when employing the techniques, given their nature and limitations. Being concrete in terms of context and scenario, by including contextual situations (e.g. road works and steep hills) and relationship events (e.g. different understanding of a situation) appear to make the techniques more applicable, in comparison to a free range of scenarios and problems.

5.2 Translation of workshops into real projects

It is difficult to get the full picture of how the method combination would work in the real-world context of a design project, based on three one-day workshops. However, there are some indications in the workshops. Designing interactions with autonomous technology is challenging and requires collaboration between multiple disciplines. With complex systems, multiple disciplines need to communicate and share ideas in the development, each bringing in own knowledge but also own assumptions. To work effectively, the joint vision of what the team is bringing into being mentioned above becomes even more important (cf. Buchenau & Suri, 2000; Heide & Henning, 2006). The metaphors offered an initial probe for developing this vision, but we also found that the more multidisciplinary teams generally took longer time to agree on the vision and start creating interactions. For the even more diverse teams which will be necessary in the development of autonomous systems, this stage will expectedly take even longer time, but will likely be very valuable to highlight disparities in assumptions and work towards a shared understanding. Enactment here served as a useful tool for these teams to push forward in the discussions, moving from the visionary and abstract to the more concrete. Experiencing tangible situations together in the team is an important part of creating a shared understanding (cf. Buchenau & Suri, 2000).

The enactments thus worked to create tangible experiences for the design team, but they also serve as a first step into prototyping of physical interactions. This is an important step for beginning to involve users in the design process, and truly evaluate the concepts. In a real development project, metaphors and enactment will need to be blended with other types of design activities, such as subsequent prototyping and user studies, where it is possible explore users' reactions including trust, mode confusion and misuse. In that process, it will also be possible to evaluate whether the metaphor-based designs manage to translate into users' mental models as argued (Bruemmer et al. 2007; Flemisch et al. 2003).

5.3 Future work

The design concepts that emerged from the workshops were in many cases very interesting, especially given the limited time for ideation. Most concepts contained seeds worthwhile further explorations, addressing identified issues of automation, such as misuse (such as the Snarky Car's and the Guide Dog's haptic feedback hindering the user to interact when unsuitable) and trust (e.g. the Trust Fall concept's intuitive communication for creating a shared understanding of the road scene). The discussions leading up to the concepts also captured important dimensions that are important for both for development of, and further research into, autonomous vehicles.

Our plan is to continue the explorations of metaphors as a vehicle for interaction design, analysing the application and translation of metaphors in these workshops further, as well as how they translated to the users. Exploring how the metaphors translate (or not) to users will also be further investigated through user tests with more finished interaction concepts.

6 Conclusion and recommendations

In conclusion, we found that overlapping the two techniques, creating a metaphor-enactment hybrid, can help multi-disciplinary teams design the interaction with autonomous systems: from the creation of a joint conceptual vision of the relationship they want to bring into being, to seeds of innovative concrete interaction design concepts utilising the full range of modalities the vehicle as a design space has to offer. However, the method also has limitations in the range of scenarios and dimensions that can be covered and requires a certain range of contextual knowledge from the participants. Based on our experiences from the workshops, we formulated 9 guidelines for the use of metaphors and enactment together in the design for intelligent systems:

1. Set a reasonable scope for the scenario in terms of time scope of the interactions explored, futurism, and evolving relationships.
2. Explore a number of metaphors before selecting one to help find your assumptions and draw the design space.
3. Chose a metaphor that you can relate to.
4. Include potential for drama in the metaphor and/or scenario, as this is when the new agency-related relationship dimensions truly surface.
5. Use enactments early to become concrete when designing the interactions.
6. Consider the dialogue/flow between the user and system. Designing for autonomous technology requires focus on the communication, i.e. not singular patches of information transfer.
7. Use "props" in the enactment to elicit physical interactions; i.e., introduce objects that may be part of the interaction itself and/or in the environment.
8. Keep it tangible and consider the full palette of modalities.
9. Invite others try out your ideas in the evaluation enactment – not only enacting for yourselves means even more pressure to become clear and challenge ideas.

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DRS 2018 Design Research Society 2018 Catalyst

University of Limerick
25th – 28th June 2018

A Study on the Roles of Designers Co-Evolving with Tools

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doi: 10.21606/dma.2018.533

Humans have always been making tools, creating artefacts with the tools and also using those artefacts as tools. The concept of tools is changing from the expansion of the human body to the expansion of human intelligence. The development of computer technology and the emergence of artificial intelligence raise serious questions about the faculties and roles of humans. The same is true for the faculties and roles of designers who use computers as their main tool in their work. In this paper, the inherent faculties of the human mind, revealed through the Kantian approach, are applied to designers. According to this, it is explained how designers use their own faculties in the world of human artefacts. The co-evolutionary relationship between computers, as evolving tools, and designers is analysed by establishing roles in mutual relations at each phase. The evolution of tools requires designers to take on new roles, which helps designers to better use their faculties.

tools of design; artificial intelligence; role of designer; generative design

1 Introduction

Henri Bergson (1998) defined intelligence as “the faculty of manufacturing artificial objects, especially tools to make tools, and of indefinitely varying the manufacture” (p. 139). The term *Homo Faber,* Latin for ‘the man who make things’, symbolically represents a human view that intelligence is expressed by the tendency of humans to make and use tools to control their own fate and their environment. Since the beginning of human history, humans have always been making tools, creating artefacts with the tools and also using those artefacts as tools. Martin Heidegger (1996) said, “Production itself is always a using *of* something for something” (p. 66). It is usually said that everything but nature is made by humans. According to this saying, human beings live every moment in relation to tools. Every time humans make artefacts, they use tools, so the way humans relate to artefacts is heavily influenced by tools. As time goes by and as technology develops, tools evolve, which also interactively impacts human roles. Even if the same artefacts are made, the role of humans continues to change as the tools evolve. If we just look at the periods before and after the appearance of computers, the role of humans in making artefacts is very different. In other words, humans and tools co-evolve.

In general, on the other hand, the role of an individual is determined by his or her abilities, regardless of the gender, race or other innate aspects of the person. When discussing human ability, the function of the human brain is often mentioned. According to this, human ability can be roughly divided into two sections in terms of the parts of the human brain, which are called the ‘creative part’ and the ‘repetitive part’. It is said that the right hemisphere of the human brain is related to creative, intuitive, synthesising and subjective thought, while the left hemisphere is associated with logical, rational, analytical and objective thought. According to this theory, human beings have always been using these two capabilities at the same time or alternately. The thinkers in the early history of computer science who were optimistic about the future of humans with computers anticipated that computers would make the repetitive part of the human brain obsolete. Thus, the ability to think creatively is inherent in humans, and with the advent of computers, humans could become even more creative. Tools not only can help human beings, but they also make it possible for humans to make better use of their abilities.

Designers have traditionally used drafting tools, such as drafting boards, compasses, triangles, T-squares, scales, templates, French curves, erasers, and so on. There are many other tools, but pencil and paper are the main tools used by designers. Since the advent of computers, however, most of the functions of drafting tools have been incorporated into computers. Computers are one of the most important tools for designers, and they are still evolving. The emergence of computers led to a new paradigm of the relationship between designers and tools. There are a large number of studies on the abilities and roles of designers using computers as tools, and there are some that worry about the negative impact of computers. These topics are still valid, and they will become more important in the future because of the development of artificial intelligence technology. Jeff Kowalski, a CTO of Autodesk, has redefined CAD as the abbreviation for ‘Computer as Designer’. The typical example is Generative Design, the new way of finding solutions in design by applying artificial intelligence technology. The Google Brain Team is also taking on new and challenging creative areas, letting machines with artificial intelligence compose music or draw pictures. The other part of the human brain, the creative part, seems to be being replaced by machines. The concept of tools has changed from the expansion of the human body to the expansion of human intelligence due to the development of computers. In the era of artificial intelligence, the tool is regarded as a personality.

As artificial intelligence is expected to emerge as a new paradigm of tools for designers, it is believed that designers’ capabilities and roles need to be discussed at a more fundamental level than they were before. In this paper, firstly, by applying the Kantian approach to the faculties of humans, humans’ inherent faculties from a philosophical viewpoint and designers’ faculties as human beings will be examined. Secondly, on the basis of this, the roles of designers will be considered in the relationship between designers as humans and computers as tools. Finally, the way in which the roles of designers have continued to fluctuate in each phase of the evolution of computing tools will be analysed.

2 The analysis of the faculties of designers

> *Strictly speaking, there ‘is’ no such thing as a useful thing. There always belongs to the being of a useful thing a totality of useful things in which this useful thing can be what it is. A useful thing is essentially ‘something in order to…’. The different kinds of ‘in order to’ such as serviceability, helpfulness, usability, handiness, constitute a totality of useful things. (Heidegger, 1996, p. 64)*

From the use of classical drafting tools to the days of artificial intelligence, the boundary between designers and tools has become increasingly blurred. This is not only due to the changes in the interface between designers and tools as computer technology advances. This is also because artificial intelligence technology has emerged and computers as tools have been trying to replace human intelligence. The history of artificial intelligence research has two main paradigms: computationalism (or symbolism) and connectionism. While computationalists view the human mind as a computable symbol processing system, connectionists believe the human mind can be explained by artificial neural networks. According to both paradigms, ultimately, human intelligence will be totally replaced by machines. It has been considered impossible until now, but it cannot be taken lightly. Regardless of one's stance on the issue, it must be admitted that artificial intelligence is changing real life now.

In particular, the use of artificial intelligence in the field of design has been accelerated in recent years. Adobe's Project Scribbler uses the deep learning-based image generation system to automatically colorize black-and-white photos or sketches. Google's AutoDraw uses machine learning algorithms to analyse user's doodles, find out what the user is trying to draw, and suggest a matching picture from the database. Design platforms that use artificial intelligence, such as Logojoy, analyse the mathematical patterns of visual elements in logos or business cards to produce results tailored to the user's preferences. On the other hand, in industrial design, artificial intelligence software, such as Autodesk Dreamcatcher, allows computers to generate their own chair designs. Even if user do not have a professional design education, the software will suggest various design alternatives to the user by entering the basic geometric elements of the chair, the loads applied to it, and the materials to be used in the manufacturing. When we look at the examples listed above, it is no longer awkward to say that 'the machine designs'.

“Asking ‘Can a machine design?’ is similar to asking ‘Can a machine think?’” (Cross, 2001b, p. 44). In the history of Western philosophy, almost every philosopher has sought to distinguish humans from animals, in that humans have intellect, albeit for different reasons. Thus, humans have a different status from animals on an ontological basis. The dominant reason that humans are considered ontologically superior to animals is that humans can think. On the other hand, in terms of tools that are intelligent, like evolving computers, it can be said that the present tools have changed their ontological position from the traditional tools. When we do some intelligent work, we say that we ‘use’ computers, even though we get practical help from the computers in the middle of the operations. If the machines with intelligence ultimately seek to replace human intelligence, this means that the tools try to move their ontological status from the normal tool level to the near-human level.

As can be seen in Figure 1, in the relationship between designers and artefacts over time, the ontological status of tools becomes increasingly clear, and it can be explained as being closer to the designers as humans. The word ‘use’ is still valid, but in the future, can humans say they ‘use’ artificial intelligence? In order for artificial intelligence to be considered as a tool, it is necessary to review the faculties of humans at a fundamental level.

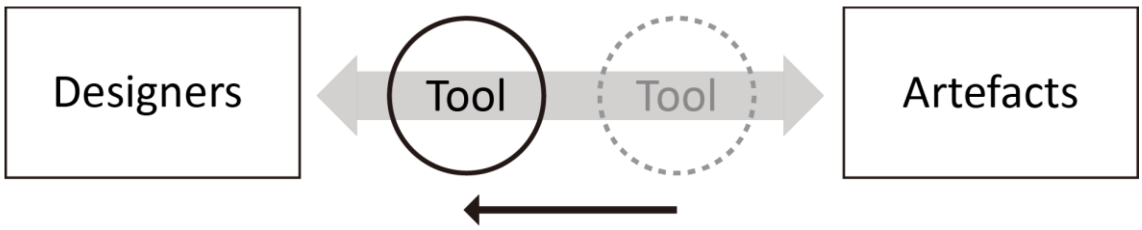

Figure 1 The changes in the ontological status of tools over time

2.1 The Kantian approach to the faculties of humans

Humans make artefacts when they want to seek or achieve something. Designers also make artefacts when they want to solve problems. At this point, designers may ask, ‘What do I design?’ and this question itself shows that they are designers. Philosophers, on a deeper level, ask, ‘What do I pursue?’ A question reflects the nature of the being asking the question, and in order to explore the faculties of the being, the following question may be asked: ‘How can it be possible?’ Since the time of the ancient Greeks, philosophers have explored the transcendental values pursued by humans and tried to explain human existence through the faculties of the human mind to make it possible. Those explanations, however, were generally focused on nature, the universe and God. In other words, it has been explained that by the providence of nature or the universe, or by the power of God, human beings can have such faculties to pursue the transcendental values and to ask questions.

On the other hand, representative philosopher of the Enlightenment, also regarded as a pioneer of modern philosophy, Immanuel Kant tried to explain the existence of human beings by focusing on humans themselves. He emphasised the active and voluntary faculties of human beings as a recognition subject.

> *Ancient philosophers were quite mistaken in the role they assigned man in the world, since they considered him a machine within it, entirely dependent on the world or on external things and circumstances, and so made him an all but passive part of the world. Now the critique of reason has appeared and assigned man a thoroughly active existence in the world. Man himself is the original maker of all his representations and concepts, and ought to be the sole author of all his actions. (Kant, 1979, p. 127–129)*

Kant's philosophy is often called critical philosophy, where the word 'critique' is asking for possible grounds (i.e., 'how can it be possible?'). Kant has formulated three values that humans should desire and pursue: truth, goodness and beauty. These are the transcendental values that have been valid until now. According to Kant, the questions asked by humans using their faculties of the mind are summarised in the following three.

- What can I know?
- What should I do?
- What may I hope?

Kant himself tried to answer each of these questions through the following books: *Critique of Pure Reason*, *Critique of Practical Reason* and *Critique of Judgment*. The unique faculties of the human mind revealed in the process of asking these questions are as follows: 'cognitive faculties', 'faculty of desire', and 'feeling of pleasure and displeasure'. Using these faculties, humans can ask the three questions above and thus pursue transcendental values. Ultimately, these three questions are related to the question 'What is the human being?'. Table 1 shows Kant himself summarising the faculties of the human mind in the introduction of *Critique of judgment.*

Table 1 All the Faculties of the Mind (Kant, 2007, p. 32)

All the Faculties of the Mind	Cognitive Faculties	A priori Principles	Application
Cognitive faculties	Understanding	Conformity to law	Nature
Feeling of pleasure and displeasure	Judgement	Purposiveness	Art
Faculty of desire	Reason	Final end	Freedom

On the other hand, just as the world of philosophical inquiry is the world of the human mind, the world of designerly inquiry is the world of human artefacts.

> *What designers know about especially is the 'artificial world' - the human-made world of artefacts. What they know how to do especially is the proposing of additions to and changes to the artificial world. Their knowledge, skills and values lie especially in the techniques of the artificial. (Cross, 2001a, p. 54)*

Since Plato divided the world into the world of ideal forms and the perceptible world, the philosophers throughout history have mainly grasped the world as a dualistic world, a conceptual world and a practical world. In this context, thus, the world can be divided into two. These are the world of the human mind as a kind of conceptual world and the world of human artefacts as a kind of practical world. The world of human artefacts cannot be said to be a sub-world completely contained in the world of the human mind as a philosopher's inquiry object, because designers deal with artefacts outside of the human mind. It is, however, also not a world that is completely different from the world of the human mind, because artefacts are the things that are made by humans, and they are still connected with the human mind. Figure 2 is a schematic of the two worlds.

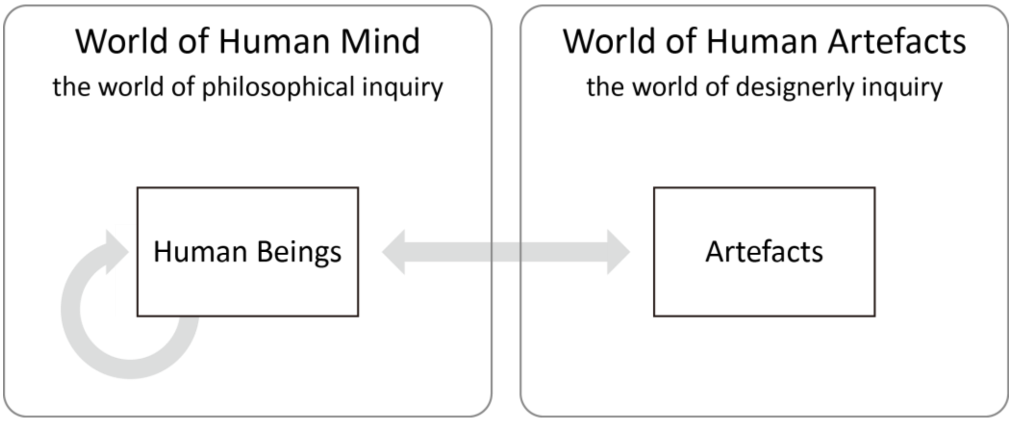

Figure 2 The world of the human mind and the world of human artefacts

2.2 The faculties of designers as human beings

> *In an experimental research study, Lawson (1984) compared the ways in which designers (in this case architects) and scientists solved the same problem. The scientists tended to use a strategy of systematically trying to understand the problem, in order to look for underlying rules which would enable them to generate an optimum solution. In contrast, the designers tended to make initial explorations and then suggest a variety of possible solutions until they found one that was good, or at least satisfactory. The evidence from the experiments suggested that scientists problem-solve by analysis, whereas designers problem-solve by synthesis; scientists use 'problem-focused strategies' and designers use 'solution-focused strategies'. (Cross, 2008, p. 21)*

Designers are the people who solve problems. Designers use 'solution-focused strategies' in order to present a variety of possible solutions. The main task of designers is to make these solutions into artefacts in the real world. When designers think about an ideal solution, they, as human beings, can ask the following questions to the world of human artefacts using the faculties of the human mind.

- What could it be?
- What should it be?
- What might it be?

As for the first question, just as human beings can ask 'What can I know?' by using their cognitive faculties and pursue the truth, designers can also ask 'What could it be?' At this time, designers think about what artefacts can be realised with respect to the design problem. As for the second question, just as human beings can ask 'What should I do?' by using the faculty of desire and pursue goodness, designers can also ask 'What should it be?' At this time, designers take some actions in order to achieve the objective in the process of designing the artefacts. As for the third question, just as human beings can ask 'What may I hope?' by using the feeling of pleasure and displeasure and pursue beauty, designers can also ask 'What might it be?' At this time, designers consider what kind of artefacts they design will universally deliver satisfaction to humans. As a result, designers can ultimately ask 'What is the artefact?' Figure 3 is a diagram of the possible questions for each of the two worlds through the faculties of the human mind.

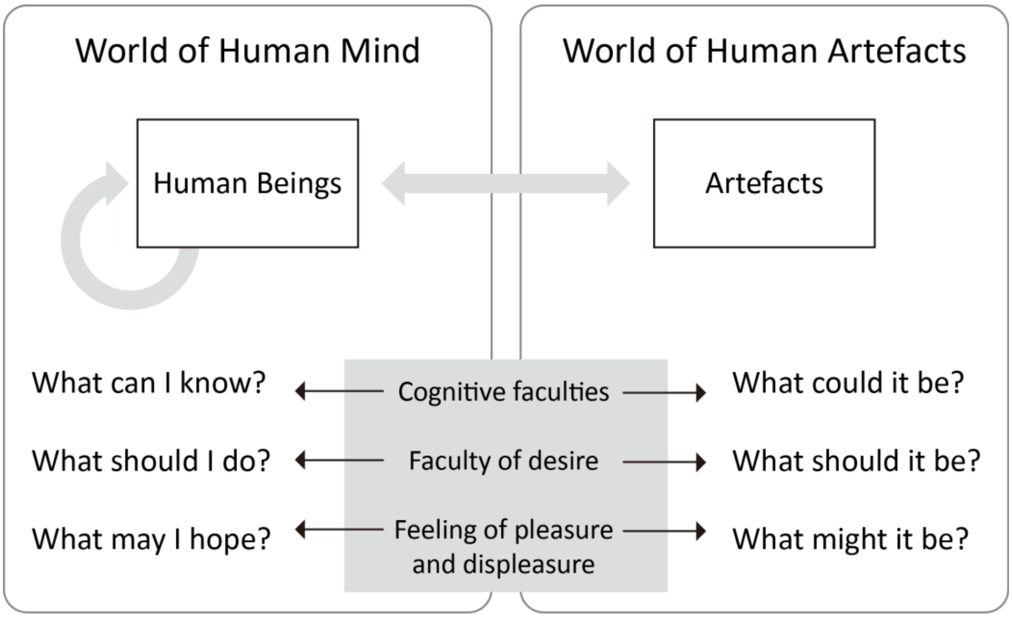

Figure 3 The possible questions for each of the two worlds through the faculties of the human mind

These three questions of designers are made possible by the unique faculties of the human mind. Through each of the faculties, we will look at how designers ask these questions.

2.2.1 On the cognitive faculties

Kant (2006) said, "Before the artist can present a physical form, he must have produced it in his power of imagination" (p. 67). Imagination, in this sentence, is the productive faculty of intuition that works without the presence of the thing. According to the common explanation of *Critique of Pure Reason*, human perception does not involve passively sensing the objects of the external world but reconstructing the objects actively from the inside of the mind through empirical data. When designers ask, 'What could it be?', they remind themselves of the final solution from within, through a variety of materials on design problems. At this point, it can be said that designers use their cognitive faculties.

2.2.2 On the faculty of desire

Kant (2006) defined desire as "the self-determination of a subject's power through the representation of something in the future as an effect of this representation" (p. 149). In another part, Kant (1998) also said, "The will is thought as a capacity to determine itself to acting in conformity with the representation of certain laws" (p. 36). The faculty of desire, or will, as a result, appears in the form of oughtness. In the world of the human mind, humans, as rational beings, can ask the question 'What should I do?' through self-legislation. In the world of human artefacts, designers also can ask the question 'What should it be?' through the faculty of desire.

2.2.3 On the feeling of pleasure and displeasure (especially on sensuous pleasure)

According to Kant (2006), "*Enjoyment* is a pleasure through sense, and what amuses sense is called *agreeable*'" (p. 125). Furthermore, humans have a taste, as a formal sense, that "concerns the communication of our feeling of pleasure or displeasure to others" (p. 141). In addition, the satisfaction is produced by taste. "Now satisfaction that can be considered valid not merely for the subject who feels it but also for everybody else, that is, universally valid, must contain necessity" (p. 141). When designers are asking 'What might it be?', designers are making artefacts not only for their own satisfaction but also aiming to universal for everyone. Taste "is the faculty of the aesthetic power of judgment to choose with universal validity" (p. 137). In here, taste is considered as a faculty of making social judgments.

When designers ask these questions by using the faculties of the human mind, there can be no strict distinction between them. Designers are always asking these questions at every stage of the design process. For example, a designer who wants to design a chair might ask himself 'What is the chair itself?' or 'What could the chair be?' He may recall many forms in him, and sometimes, he might try creating some sketches with pencil and paper. He also might ask himself 'What is the purpose of the chair?' or 'What should the chair be?' He might think of its structure, material, combination and so on based on the purpose of the chair, and sometimes, he might create prototypes using the things around him. He also might ask himself 'What is the universally valid chair?' or 'What might the chair be?' He may think about the various people who will sit on the chair, the space where the chair will be placed, the mood of the chair and so on. These questions can sometimes be asked at the same time. All of these questions are constantly interacting with each other. As a result, designers, like humans themselves, use the inherent faculties of the human mind simultaneously and in combination. The questions that designers who explore the world of human artefacts can ask, and the faculties of designers to ask such questions, are summarised in Figure 4 below.

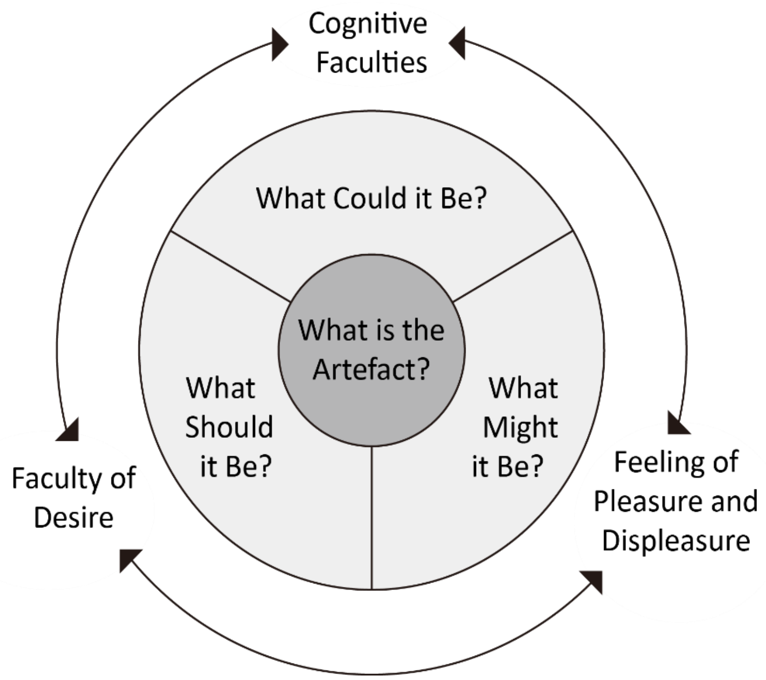

Figure 4 The relationship between faculties of designers and the questions available through the faculties.

3 The analysis of the roles of designers

> *In its familiarity with significance, Dasein is the ontic condition of the possibility of the disclosure of beings encountered in the mode of being of relevance (handiness) in a world that can thus make themselves known in their in-itself. As such, Dasein always means that a context of things at hand is already essentially discovered with its being. In that it is, Dasein has always already referred itself to an encounter with a 'world'. This dependency of being referred belongs essentially to its being. (Heidegger, 1996, p. 81)*

Dasein (Heidegger's term, which means 'human being presences') exists in the world through making relationships with other beings. Heidegger calls these other beings 'beings in the world', and the things used by human beings, the tools, are called 'useful things'. Like shoes when they are worn, and like clocks when they tell the time, the tools have their own meaning of existence the moment when they are used. Heidegger (1996) said, "The kind of being of these beings is 'handiness'" (p. 67), and the word 'handiness' can be replaced by the phrase 'ready to hand'. Designers, on the other hand, use their faculties by questioning the world of human artefacts through the inherent faculties of the human mind. The roles of designers are affected by the tools they use in the world of human artefacts. While designers are using tools, their roles are determined in relation to the tools. Thus, in the world of the human mind, designers, as human beings, give the meaning of existence to the tools, whereas in the world of human artefacts, the tools influence the role of designers.

In the context of the relationship between designers as humans and computers as tools, there were generally optimistic prospects for the future of humankind with computers. Bush (1945) divided human thought into two types and said, “Creative thought and essentially repetitive thought are very different things”. In the latter case, he predicted humans could get the help of the machines, the computers. This requires creative thought to select the appropriate data in the process and put it in the right place. However, the rest of the repetitive part is left to the computers. Licklider (1960) defined the roles of humans in the future symbiotic relationship between humans and computers as follows: Humans will “set the goals, formulate the hypotheses, determine the criteria and perform the evaluations” (p. 4). and the computers will perform the repetitive tasks that assist humans. He said, “Computing machines can do readily, well, and rapidly many things that are difficult or impossible for man” (p. 6), while “Men can do readily and well, though not rapidly, many things that are difficult or impossible for computers” (p. 6). In this context, Engelbart (1962) defined the future symbiotic relationship as the relationship between a ‘human problem-solver’ and a ‘computer-clerk’.

On the other side, it can be said that the development of computer technology in the field of design has made the roles of computers evolve, and the new roles of designers in each phase have been required accordingly. Moreover, we cannot be certain that the opinions of the thinkers in the early history of computer science are still valid for computers in the era of artificial intelligence. Since the advent of computers, the history of CAD can largely be divided into three phases by the roles of computers as tools: computer-aided geometric design, algorithm-aided parametric design and artificial intelligence-aided generative design. Computer advances have come from geometrically aiding the visualisation of designers’ ideas, computing optimised designs through algorithms and even suggesting many designs to designers through artificial intelligence technology. In this part, the roles of designers in the evolution phases of the roles of computers as tools will be examined.

3.1.1 Before the appearance of computers

Before computers appeared, or before the 1950s when computers began to be used in the field of design, designers performed all their design works with their hands and drafting tools alone. These tasks required very sophisticated skills and knowledge of a variety of geometrical concepts. The tools were made in shapes that fit their functions, and the designers used them for their own purposes. In this period during which tools were still seen as an extension of the human body, tools provided a kind of convenience to designers, but they were barely related to the designers’ faculties of the mind. Therefore, these tools could only show the role of designers symbolically, but they were considered to have little effect on the role of designers. In this relationship between designers and tools, tools are tools, and designers are tool users.

3.1.2 The first phase: computer-aided geometric design

“CAD systems were originally intended to serve as a platform on which to develop designs graphically” (Vidal & Mulet, 2006, p. 101). From Ivan Sutherland’s Sketchpad, which can be called the beginning of CAD, to Adobe Illustrator, to Autodesk AutoCAD, CAD has generally been regarded as an important tool used to support designers. The most important role of CAD, in this phase, is to successfully visualise the image inside the designers. In pre-computer design works, it took a lot of time and effort for designers to fully visualise their ideas through pencil and paper and other drafting tools. CAD reduces the gap between the designers’ internal image and the visualised image through the same task, with less time and effort. At this point, designers use their cognitive faculties as one of their faculties of the mind. Designers create forms, and computers support them in visualising them. This means that computers have begun to replace the repetitive part of the human ability in earnest as a calculator (i.e. its essential role). When Konstantin Grcic designed *Chair_ONE*, it was one of the first times that he used three-dimensional computer modelling to design. Grcic

(2015) said, “Computers are an extremely important tool for assembling three-dimensional shapes and coming up with the parts for the model”. Computers help designers make better use of their cognitive faculties to create forms. Therefore, as can be seen in Figure 5, the role of designers as creators and the role of computers as supporters can be defined in relation to each other.

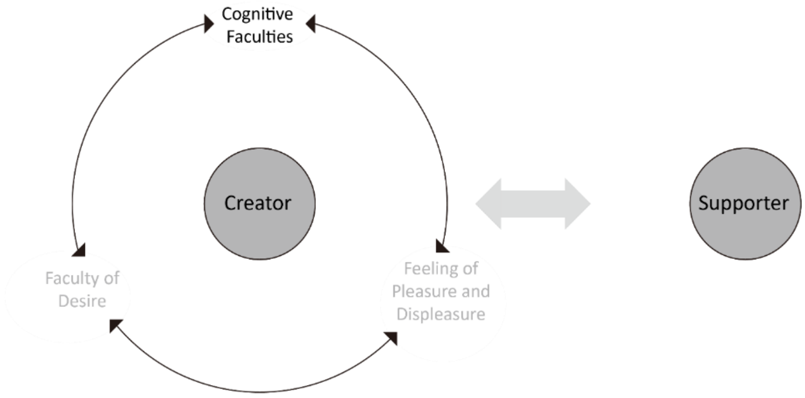

Figure 5 The role of designers as creators and the role of computers as supporters

3.1.3 The second phase: algorithm-aided parametric design

Parametric design is “a process of choosing appropriate parameters for a design problem and setting up the model definition that then can be used to explore the solution space” (Gane, 2004, p. 37). In modern society, which is becoming increasingly complex, designers need a lot of information to solve problems. The main function of parametric design is to process optimised designs in a short period of time through a large and complex calculation process that makes use of algorithms. This allows designers to design more diverse forms under the same conditions by utilising the calculated information. On the algorithm, designers can create and modify the shape by combining various components and adjusting the parameters. Here, the designers take the various conditions into account to find a more appropriate form. Oxman (2017) said, “In the context of algorithmic design, being reflective relates to the designer’s ability to understand and control the computational and scripting tools” (p. 10). As a result, parametric design provides logical information to designers and it helps them to clearly set and achieve their design goals. In other words, the designers adjust the parameters to design the shape that fits the purpose, and the computer calculates it in real time and shows it to the designers. Computers help designers make better use of the faculty of desire to solve the problem by designing artefacts. As can be seen in Figure 6, the role of designers as utilisers and the role of computers as providers can be defined in relation to each other.

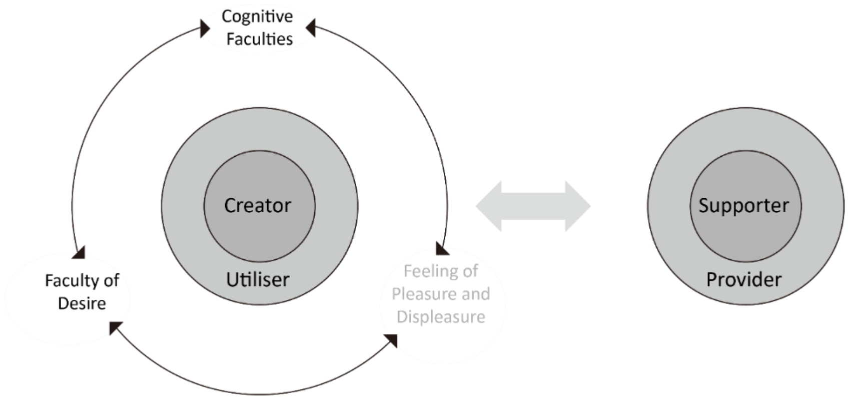

Figure 6 The role of designers as utilisers and the role of computers as providers

3.1.4 The third phase: artificial intelligence-aided generative design

Generative design is typically described as a rapidly repeating process through computers to explore as many design solutions as possible. In the case of the Autodesk Dreamcatcher, a generative design software, designers can enter conditions into the form of a given prototype to produce many variations of a design proposal. Designers can arrange proposals in order based on their preferences, or they can enter additional settings to allow the computers to generate other forms. As a result, the computers propose many forms to designers, and the designers can then choose among the proposals, making it more likely that they will provide satisfactory designs to customers. At this point, computers help designers make better use of the faculty, feeling of pleasure and displeasure, to make satisfactory design outcomes. Although artificial intelligence technologies are not yet widely available, we can imagine situations in which they will be used for design work. For example, in a scene from the movie *Iron Man* (2008), Jarvis, an artificial intelligence secretary, asks Tony Stark about the material and colour that will be applied to Iron Man suit, and he proposes a three-dimensional rendering. Tony Stark replies, 'I like it. Fabricate it. Paint it'. In the same vein, as an iterative process, designers can train artificial intelligence a kind of style by entering the selected result among the proposals back into the tool. In other words, "designers will train their artificial intelligence tools to solve design problems by creating models based on their preferences" (Girling, 2017). As can be seen in Figure 7, the role of designers as judges and the role of computers as proposers can be defined in relation to each other.

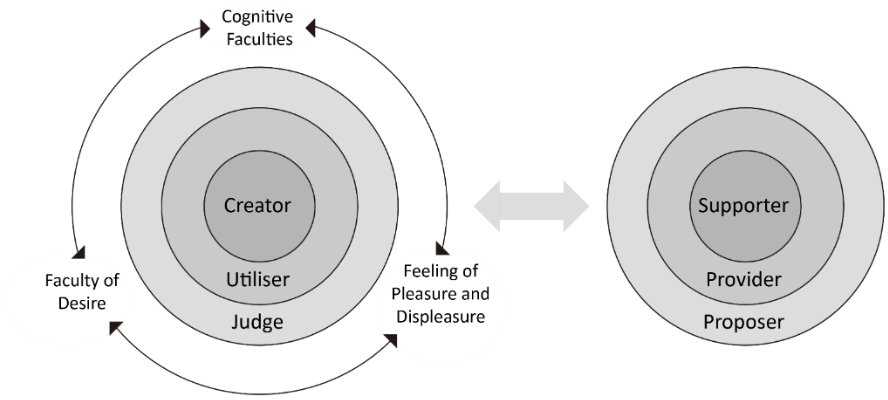

Figure 7 The role of designers as judges and the role of computers as proposers

4 Conclusion

The development of computer technology and the emergence of artificial intelligence raise serious questions about the faculties and roles of humans. The same is true for the faculties and roles of designers who use computers as their main tool. In this paper, the inherent faculties of the human mind, revealed through the Kantian approach, were applied to designers. According to this, it was explained how designers use their own faculties in the world of human artefacts. The co-evolutionary relationship between computers, as evolving tools, and designers was analysed by establishing roles in mutual relations at each phase. The roles of designers defined in this paper are not newly emerging roles, but rather, the roles, derived from the inherent faculties of the designers, are redefined in relation to computers as tools. Tools help designers to use their faculties, and the evolution of tools lead designers to newly regulated roles. Through such roles, designers become better able to use their own faculties.

This study is the starting point of a discussion about designers' roles that co-evolve with tools. For further research, we will analyse the collaborative relationship between designers and tools using actual artificial intelligence design software which is going to be commercialized soon, and based on this, we will develop a framework for changes in the future design process that reflects the roles of designers co-evolving with tools.

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Reinventing Graphic Design Software by Bridging the Gap Between Graphical User Interfaces and Programming

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doi: 10.21606/dma.2018.611

Graphic Design Software Applications radically transformed the practice and the industry of graphic design. However, they barely evolved since their introduction, leading designers to question their ubiquity. In this paper, we explore this mismatch by analysing digital design tools through two lenses. We first investigate digital design tools from a "lineage" perspective: how they reproduced the pre-existing design tools and practices. We then use two familiar examples: the colour picker and the alignment and distribution commands to explore the vision of design that they promote. We reveal how these tools assume that designers already have in mind a desired outcome and thus introduce a mismatch with current designers' practices. To bridge this gap, we propose "graphical substrates", interactive and visual tools that combine the strengths of both programming and graphical user interfaces. We analyse how several recent research design tools embed this approach and we propose two principles: tweaking and creation from example to foster their adoption by designers.

design tools; graphic design; graphical user interfaces

1 Introduction

Graphic Design Software Applications revolutionised the graphic design process as soon as they were introduced in personal computers. Under the name of desktop publishing, they greatly facilitated and optimised the different steps of the graphic design and production process. Designers could finally access and interact with real time visualisation of their work. Before the digitalisation of the printing industry, graphic design was an entire industry with many different and complementary professions (typesetters, paste-up artists, photomechanical technicians...) coexisting with complex machinery to operate (Briar, 2017). The profound transformation led by the adoption of graphic design software applications first drew a lot of criticism from established designers (Armstrong, 2016) but they were rapidly adopted by the industry. More than 25 years after, we saw the democratisation of internet and the wide adoption of mobile phones. Design practice accompanied this movement and many novel design disciplines appeared, including interaction design and user experience design. Yet, contrary to design practice, the digital design software landscape mostly did not change. Some of the same design applications that were introduced in the 1990's are still being used by graphic designers almost 30 years later.

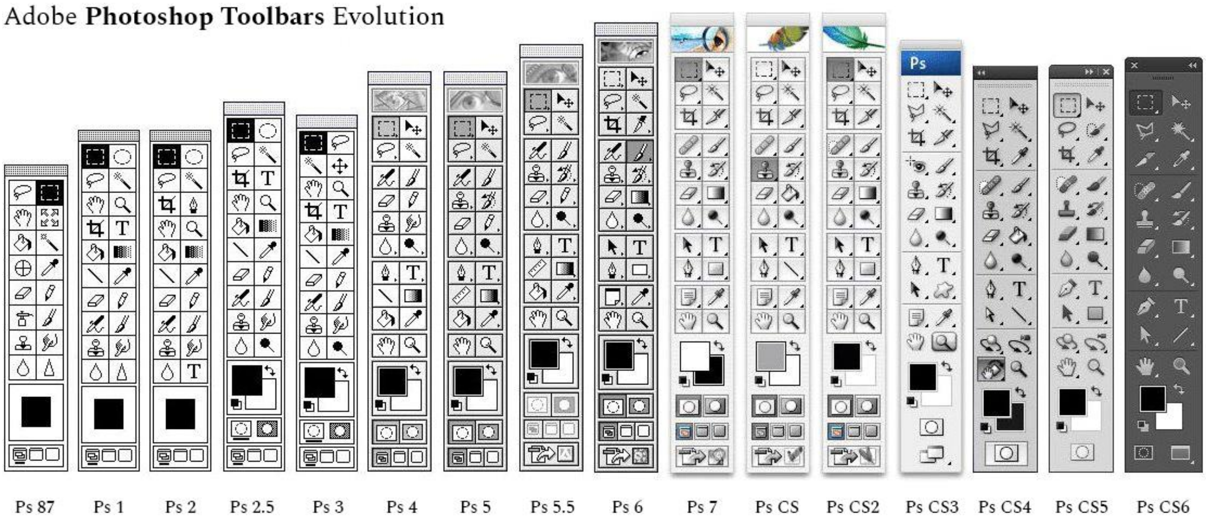

Figure 1 - Comparison of Adobe Photoshop Toolbars since 1987. Note how little they have changed.

For example, if we look at the toolbars from Adobe Photoshop, one of the most iconic design software application, over the years we can see that they provide the same tools since their origin and only added few new ones (Figure 1). Following McGrenere's analysis of mainstream software, we could describe their evolution as a form of "software bloat" (McGrenere, 2000). Does this mean that designer's tools are a solved problem? Two different elements demonstrate that design software remains an open question.

First, the importance of design tools is particularly striking when we consider the reasons behind design birth. Design birth is generally traced back to the industrialisation of Britain in the 19th century. For design pioneer William Morris and the British Arts and Crafts movement, the emerging industrialised mass production meant a uniformisation of the resulting products, as well as a degradation in product quality (Morris, 1884). In response to this trend, they advocated for a tighter connection between design, craft and production. Before the era of industrialisation and the separation of people and the means of production, craftsmen could create their own tools. As we can see in Figure 2, they were ingenious in adapting their tools to one's hand size and handedness, or to achieve particular effects. Morris sought to preserve this tradition. A few decades later, the pioneer Bauhaus design school encouraged its students to embrace machines and explore their potential. Designers were to appropriate industrial processes to create high quality products (Papanek, 1972). Thus, one of the first goals of designers was to reappropriate production means and to fusion design and production. Following this line of thought, separating the question of design and design tools is impossible. Design Software is an open issue because part of a designer's work ethos is to choose and question their tools.

The second, and probably more important reason is an emerging reappropriation movement coming from designers themselves. The iconic Processing programming language and environment, launched in 2001, was among the very first tool that sought "to introduce visual designers and artists to computational design" (Reas, 2007). For designers, programming offers a whole new range of dynamic capabilities that traditional software applications do not provide yet (Reas, 2010). These pioneer initiatives nurtured a new generation of designers who started creating design software, usually for their own needs. In a 2012 essay commissioned by the magazine *Graphisme en France*, Reas and McWilliams asked several designers who program their own tools: "How does writing your own software affect your design process and also the visual qualities of the final work?" (Reas &

McWilliams, 2012, p.26) They found that some ideas were prevalent across respondents. First, designers explained that writing custom software gives them more control over the resulting artefact. The second is that new tools bring novel creative opportunities: “Experienced designers know that off-the-shelf, general software applications obscure the potential of software as a medium for expression and communication. Writing custom, unique tools with software opens new potentials for creative authorship” (Reas & McWilliams, 2012, p.27).

Figure 2 - Some of the many trowels that can be seen at the "Maison de l’outil et de la pensée ouvrière” in Troyes, France. Note how very similar they look, yet how uniquely different each one of them is.

At the same time, several designers started to question the lack of interest and diversity in design software through their writings. According to designer and design critic David Reinfurt: “Function sets, software paradigms, and user scenarios are mapped out for each software project to ensure the widest possible usability, resulting in an averaged tool which skips the highs, lows, errors, and quirks.” (Reinfult, 2012, p.6). In his thesis “digital tools and graphic design”, graphic designer Kevin Donnot wonders “Why couldn’t we accept that tools influence us and that we could choose them depending on their impact? Shouldn’t we ask ourselves which tool is most appropriate before mechanically resorting to our usual software?” (Donnot, 2011). This recent interest started bringing design software in the spotlight (Leray & Vilayphiou, 2011) and shows the existing mismatch between designers’ practices and their current digital applications.

With this paper, we want to start qualifying the mismatch between graphic designers’ practices and current digital graphic design tools, as well as proposing principles for novel design tools that could mitigate this mismatch. In the first part of this paper, we analyse the “technical lineage” between the early examples of digital tools and the pre-existing processes and tools they were derived from. We then more specifically analyse two design tools, the colour picker and the alignment and distribution commands to understand the vision of design they embed and its limitations in designer’s practices. Through this analysis, we reveal some of the myths about the design process that underlie these tools. In the second part of this paper, we build on a recent wave of digital design tools and introduce the notion of “graphical substrates”, interactive visual objects that bridge the gap between traditional graphical user interfaces and programming. We briefly show how recent design tools started implementing such interactive objects and we propose two design guidelines to further enhance graphical substrates and facilitate their appropriation by designers.

1.1 A working definition of digital design tool

Defining design tools might be an endless endeavour, because the intricate architecture of software tends to blend different levels of granularity. In this paper, we focus on the main design tools produced by the industry and still in use today, even though the earliest tools created for designers were developed by researchers. Within this scope, we define design tool as individual tools within design applications such as Adobe Illustrator and InDesign. Concretely, we call "design tools" individual panels and commands such as colour pickers, alignment commands, levels panel, filters, etc. We otherwise use the term design software application to refer to design applications such as Adobe Illustrator, Photoshop and InDesign that include a wide variety of design tools. Even with such a definition, some design tools can be quite complex and include several interactive components such as the levels panel in Adobe Photoshop, while others, such as the rectangle selection, are much simpler. However, because they are all accessible at the same level in tool palettes and in menus, we can posit for now that they were granted the same level of importance by tool creators.

2 A technical lineage approach to understanding digital design tools

According to Simondon, philosopher of technology, a study of technology should not approach technology from an individual perspective. Instead, each technical object belongs to what he calls "a technical lineage" and cannot be fully understood outside of it (Simondon, 1958). As Masure showed, to establish their economic success and wide adoption, design software publishers needed to pursue an apparent continuity with existing environment and techniques (Masure, 2014). This lineage approach can be an interesting first step to understand digital graphic design tools. Taking a few examples of functionalities, we can show that at least some functionalities of the first commercial graphic design applications were derived from pre-existing practices and techniques. Contrary to the very first digital design software applications, such as Sketchpad (Sutherland, 1963), that were designed by computer scientists who had little access to how graphic designers worked, the first commercial design applications were created by people who were in close relationship with graphic design. To give two examples, Aldus' founder, Paul Brainerd, had himself been an editor for a small journal while the wife of John Warnock, co-founder of Adobe, was a graphic designer. They therefore had a close understanding of the concrete practices and tools used by graphic designers before the digital era.

Figure 3 - Prior to using design software applications, designers used to create layouts through "paste-up", cutting and pasting different content elements onto a blank page. Image from Graphic Means: A History of Graphic Design Production.

In 1985, Aldus released Page Maker, a Macintosh-dedicated software application for desktop publishing. This piece of software was specifically created to supplant traditional technologies and fit within the existing printing industry practices. As its creator explains, "*most of the page maker interface and dialogs and the way it works, the basic functions came from my experience of having*

done paste up myself with a razor blade" (Paul Brainerd, in Levit, 2017). Indeed, Page Maker, soon followed by its successors, Quark XPress and Adobe InDesign, introduced to graphic designers the possibility to freely drag and drop text and image onto the page, which is what they were used to do when creating layout through paste-up. Moreover, the way desktop publishing software applications handle text is also a reminiscence of the paste-up process that was prevalent in the industry at that time: First, designers would send the text to a phototypesetter to generate the whole text using the right font at the right size. They would receive single columns scrolls that they would then cut and paste onto the page. In design software applications too (and in contrast to text editors such as Microsoft Word), the text is received as one infinite scroll, it is disconnected from its containers. Designers can then compose, cut and adjust the containers onto the white page. The key difference being that the text continuously flows in the containers, and can freely be rearranged and recombined, offering greater exploration possibilities to designers.
A second example of the influence of the traditional process over desktop publishing can be found in its way of handling page format. In design software applications too, when creating a project, designers must first select pages' dimensions as well as margins. These parameters are then fixed and are not supposed to be modified. This echoes the traditional paste-up process in which the designer first chose a page format and established page margins. This page became the canvas onto which she could experiment with text and image layouts. Yet, in desktop publishing, the choice to first set page sizes and margins is not dictated by a technical constraint, rather, it simply reproduces a pre-existing process. Finally, when presenting their software, PageMakers' developers explained: "it was designed with the industry in mind, in other words it does half-tones, ligatures, kerning, all the words that the typesetting industry has been familiar with." (Paul Brainerd, in Computer Chronicles, 1986"). With these different examples, we can observe that desktop publishing first and foremost developed functionalities that matched previously existing ones in the industry. In fact, because their goal was to fit within existing workflow and to be easily adopted by designers, they tried to mimic the existing process.
The lineage approach can help us understand the design of some functionalities proposed in graphic design software applications. As we have seen, the environment behind the emergence of graphic design software applications led to the reproduction of some pre-existing constraints. However, this approach is limited when we look at individual design tools and try to understand their design. In fact, tools reproducing pre-existing processes coexisted with other functionalities that did not have direct equivalent in pre-existing processes, such as the undo command, the colour picker and the alignment and distribution commands.

3 Design myths behind design tools

To understand the current mismatch between designers' practices and digital graphic design tools, the work of Suchman can provide a helpful approach. According to the anthropologist, "Every human tool relies on, and materialises, some underlying conception of the activity that it is designed to support" (Suchman, 2007, p.31). By carefully observing individual digital design tools and how designers use them on a daily basis, we can analyse the perception of the design process that they embody. In this section, we focus on the two aforementioned design tools: the colour picker and the alignment and distribution command and we analyse the underlying conception of the design process that they embed in their design. We chose these two tools for several reasons. First, they don't directly mimic pre-existing mechanisms but they feature two different and pervasive mechanisms: selection and command. In his analysis of design applications such as Adobe Photoshop, Manovich, showed that selection mechanisms are pervasive in current design applications and he correlates this with the development of a remix aesthetic (Manovich, 2001). Moreover, they are among the oldest digital design tools and, above all, their design did not evolve since their first introduction in design software applications (Jalal, Maudet & Mackay, 2015) (Ciolfi, Maudet, Mackay & Beaudouin-Lafon, 2016).

3.1 *The Design process as a Hylomorphic process*

Since its origin, the colour picker presents three common features: "a visual representation of a specified colour model, the organisation of displayable colours into a three-dimensional colour space, and controls to change parameter values within that space" (Jalal et al., 2015, p.1). Its design significantly differs from the traditional colour mixing process used by painters or the colour charts used in industry. Designers now potentially have access to every possible colour. The colour picker focuses on selecting a specific individual colour from all the possible colours. The design brief behind the tool could be summarised as: "given that a designer wants to select a specific colour, help her achieve this goal in the fewest steps possible". This brief assumes that designers already have a clear idea of the colour they want to select and the colour picker simply displays them in a comprehensive manner to facilitate its retrieval. The second example, the alignment and distribution commands also don't have direct equivalent in pre-digital graphic design. There was no dedicated tool but using rulers and tracing lines on paper to verify alignment. In computers, alignment and distribution can be executed through a set of twelve commands, six for alignment and 6 for distribution. Designers can align graphical element using their centre or their bounding boxes' vertices as reference points. The designer first selects the elements and then presses the command to have them aligned following one of the six possibilities. This alignment is not permanent but is computed ad hoc by the system when the designer presses the command button. Here again, the command approach focuses on a single and specific action.

However, several recent studies showed that these two design tools have limitations. In our study of colour manipulation with designers and artists, we showed that designers have a wide variety of colour manipulation strategies that don't follow a simple selection process. Designers rarely used the colour picker directly (Jalal et al., 2015). In contrast, designers and artists created many different strategies, using diverse tools to manipulate colours beyond colour selection. For example, we showed how designers focus on the notion of palette while the colour picker only lets designers select individual colours in the context of their surrounding colours in the colour space. Similarly, in a study with 12 users of graphical authoring applications, we showed that designers find alignment and distribution commands confusing (Ciolfi et al., 2016). Moreover, commands do not support designers' practices: designers often resort to creating graphical elements and use them as "spacing objects". By focusing on the immediate action, commands omit the fact that alignment and distribution take place within a much larger process of layout composition.

From these two examples, we can see that both the colour picker and the alignment and distribution commands conform with the vision that design is what anthropologist Ingold calls a "hylomorphic" process: they posit that designers already have in mind the outcome they want to achieve (Ingold, 2013). In a commercial for the ground-breaking Adobe Illustrator 88, the narrator explains that this software application is "a revolution based on new tools, tools that free the imagination and eliminate drudgery" (Illustrator 88). Behind this assumption lies the idea that tools impose restriction on an otherwise boundless creativity. This idea also implies that the act of creativity and tool use are separated phenomena. According to this idea, design tools should allow designers to reach their preconceived outcome with the least effort, without getting in the way. Both command and selection mechanisms are extremely efficient when it comes to attaining specific goals with preconceived and definite outcomes: either choosing an element within a defined set of possibilities or applying a specific action to selected elements.

This conception of design as a hylomorphic process leads to the conclusion that design tools are necessary obstacles on the way of the designer's creativity. This vision is echoed in a 1987 Adobe Illustrator 88 commercial in which the narrator explains that traditional graphic design tools "take considerable skill to use, and even in the hands of a pro, take too much time, time that could be used to design and create" (Illustrator88). To overcome these limitations, Illustrator 88 is advertised as easy to learn and more efficient than traditional tools. As New Media professor Olia Lialina argued, the message from Adobe in their advertisement campaign is that the best kind of design requires designers to forget about their tools, so that they can focus on the core of their work: being creative (Lialina, 2012). The logic behind this assertion is that, ideally, the creative process should be decoupled from the tools. Because digital design tools were envisioned as obstacle on the way of the design process, they were designed by putting an emphasis on their user-friendliness and efficiency. Thus, the transparency, or the "invisibilisation" to put it in other words, of design tools should in fact become the ultimate goal for tool creators.

3.2 Limitation of the transparent design tool myth

The principle of transparency is not exclusive to design tools. Instead, it represents one of the core value behind the development of personal computing. As early as the Xerox Star, the first commercial Graphical User Interface system, user interfaces were designed to be as transparent to users and easy to learn as possible (Bolter & Gromala, 2003). While these values were very productive and can still be considered ideals of design in many contexts, they faced some criticism very early on. When it comes to learnability, Lucy Suchman, in her account of users' encounter with an "easy-to-use" photocopier in 1984, demonstrated that self-explanatory digital artefacts are a designers' fantasy and that despite their sophistication, interfaces will always require an "active sense-making" from the user and that it "[…] called into question the viability of marketing the machine as "self-explanatory or self-evidently easy to use" (Suchman, 2007).
Moreover, while these values might be worth pursuing in a strictly productive or in leisure-oriented software applications, they may not best support creative design work. Contrary to traditional work, designers face wicked problems (Rittel & Webber, 1973) that cannot be solved by following a prescribed series of steps that can then be optimised. About the notion of ease of use in graphic design software applications, Masure shows how new versions of Adobe Photoshop add functionalities that automate part of the design process, for example, automatically replacing objects on a photograph with a generated background in Adobe Photoshop CS5. He argues that this type of functionalities is meant to simplify the work of the designer by automating it. In doing so, Masure argues that "the semi-automatic functionalities orient the image towards a state that is socially and culturally accepted" (Masure, 2014). By focusing on the final outcome, current design tools neglect the intermediary steps in the design process and the relationship designers need to establish with their tools. This approach may for example limit exploration, one of the defining aspect of design work (Gaver, 2000).

3.3 The instrumental turn of design tools

Against this ideal of transparency and efficiency, we can observe what we can call "an instrumental turn" in the perception of designers and other creative professional's relationship with their tools. In a structured observation conducted with 12 graphic designers, Jalal showed that designers preferred to use general purpose Graphical User Interface (GUI) tools rather than the more novel and specific design tools, because they felt less in control with the latter (Jalal, 2016). Early on, from a set of observations with creative professionals, Schön demonstrated how designers approach problems as unique cases and focus on the peculiarities of the situation at hand. They don't propose or look for standard solutions. Instead, Schön argues that designers perform a conversation with the material of their design and that any action will have effects beyond what they had imagined. In Schön's terms, "[the designer]'s materials are continually talking back to him, causing him to apprehend unanticipated problems and potentials" (Schön, 1983). More recently, Dalsgaard further explores the pragmatist perspective to consider tools in design as "instruments of inquiry" (Dalsgaard, 2017). He argues that tools also affect our perception and understanding of the world and help us explore and make sense of it. Furthermore, he argues that "repeated use of a computer is likely to alter the way you think about and engage in the writing process through the changes it effects on seemingly functional levels". The perception of digital design tools as instrument is also developed by Bertelsen et al. Originally proposed in the context of musical creation, they introduce the notion of *instrumentness* as a "quality of human-computer interaction" (Bertelsen et al., 2007). They propose to consider creative software as instrument in the musical sense, to be able to move away from the ideals of transparency and usability. They explain that "the software is comparable to a musical instrument since the software becomes the object of [the composer] attention and something he explores, tweaks, observes, and challenges in a continuous shift of focus between the sounding output and the instrument". They argue that the notion of *instrumentness* can be adapted beyond music creation and be relevant to describe designers' relationship with their digital tools.

4 Graphical Substrates: towards a novel type of design tools

To acquire new possibilities and enhance their control over the design, graphic designers currently need to turn to programming. In our interviews with 12 graphic designers, we showed how five of them used programming to create projects that they could not have created using traditional graphic design software applications (Maudet et al., 2017). While these designers needed to spend time establishing their program, they then were able, for example, to easily produce hundreds of posters in one night, or to explore radical layout modifications in a second. The aforementioned principles, transparency, efficiency and user-friendliness, deeply integrated into current Graphical User Interface-based design applications, may partly be responsible for designers increasing interest for programming languages such as Processing or max/MSP. Programming does not focus on specific and production-oriented tasks, but rather, they offer new languages through which designers can think and work in new ways. More than producing one final artefact, programming lets designers setting up a process that can then be executed and modified.

While there is no doubt that learning to program can be extremely valuable for designers, programming cannot easily replace GUI-based design tools. A paper is not enough to thoroughly investigate the differences between programming and visual interfaces and how they impact creative work, but there are a few elements that can help us understand that we need to bridge the gap between the two approaches. First, it is still hard for designers to learn how to program (Ko, Myers & Aung, 2004) as programming may force designers to think in a different way. In the context of interaction design, we studied how designer and developer represent interaction in their own way (Maudet, Leiva, Beaudouin-Lafon & Mackay, 2017). We observed how they envision interaction from different perspectives. While visual software applications can predispose designers to focus on visual examples that describe specific moments of an interaction, programming forces developers to provide a complete and abstracted representation of the same interaction. Similarly, in a lab study, park showed that designers and developers describe differently interaction behaviours, stating that "designer's experience with tools like Photoshop and PowerPoint influences their natural expression of behaviors" (Park, Myers & Ko, 2008). Therefore, visual and textual representations provide different benefits. In his visual essay about "climbing the ladder of abstraction" (Victor, 2011), Victor shows how concrete, visual and symbolic representations might complement each other, providing different ways of seeing, interacting and understanding the same phenomenon.

Today, programming and Graphical User Interfaces are generally two mutually exclusive sets of tools. We can consider them as two opposite bounds of a large range of possible design tools. Some researchers and tool creators proposed a few models to bridge the gap. For example, departing from the strictly text-based representation of code, visual programming seeks to give a visual representation to code (Myers, 1986). Visual programming tries to simultaneously preserve the range of capabilities offered by programming while enhancing it through visual representations. On the other hand of the spectrum, graphic designers work with visual content. Current GUI-based design tools generally let designers manipulate content through direct manipulation and in the context of their final outcome. This characteristic makes them very flexible and easily appropriable by designers (Jalal et al., 2016). The power of direct manipulation (Shneiderman, 1981) originally led to the wide acceptance of digital design tools and greatly facilitated graphic designers' work. As graphic designer and critic Ellen Lupton recalls about the introduction of graphic design software applications: "being able to directly manipulate type, photography, colour, and being able to see it in real time, as you are working, that's what it's all about, that's the revolution" (Briar, 2017). In his paper about instrumental interaction, Beaudouin-Lafon proposes the notion of degree of indirectness to qualify different types of tools: a small temporal and spatial offset means that the action is performed closely to the object (Beaudouin-Lafon, 2000). Resize handles are a good example of such tools. While GUIs can have very little indirection, textual programming is generally further away from the object it is manipulating, both temporally and spatially.

4.1 Graphical Substrates

To fill in the gap between GUI-based design tools and programming, we need to invent novel types of tools. We argue that we need to preserve the qualities that GUIs can provide while enhancing them with more computational power. Grounding our proposal in the idea of *instrumentness*, we introduce the notion of graphical substrates to qualify a new wave of graphic design tools. Graphical substrates are interactive graphical objects that embed behaviours and interact with content elements. In the last part of this paper, we use the notion of graphical substrate to analyse how a new generation of prospective design tools supports designers' practices in novel ways. We provide examples of tools that embed design substrates but also identify two principles that can guide tool creators in making design substrates more effective in supporting designers' practices.

Graphical Substrates are interactive visual tools that represent relationships between graphical elements. By reifying these relationships, e.g., turning them into interactive objects (Beaudouin-Lafon & Mackay, 2000), they scaffold designers' exploration phase. The notion of substrate was first introduced by Garcia et al. who coined the term in the context of musical creation (Garcia, 2012). They proposed and designed substrates, a set of different types of musical scores that give structure and relationships to musical data. We then brought this notion in the graphic design context by observing how designers establish what they call principles, rules and constraints to guide their layout creation in digital applications (Maudet et al., 2017). They share a common characteristic: they define and guide the layout, but rarely appear in the final result.

For example, the concept of alignment can be reified into an object that embodies the alignment behaviour. Ciolfi et al. provide a recent example with StickyLines (Ciolfi et al., 2016), an interactive guideline that automatically aligns and distributes the objects that are attached to it. As a visual object, StickyLines not only provides interaction mechanisms that follow direct manipulation principles, but also embodies behaviours and rules, giving designers new possibilities for testing their ideas. In Object Oriented Drawing (Xia et al., 2015), the authors propose a graphical authoring application in which they reify attributes into cards. As they are turned into interactive objects, these properties can be moved, cloned, linked, and freely associated with several graphical elements. Another example is Histomages (Chevalier, Dragicevic & Hurter, 2012), a tool that allows users to edit images' colours by modifying a histogram of the coloured pixels within the image. A histogram is a *spatial rearrangement* of the image's pixels. The coloured pixels are grouped depending on the value of the color channel that is visualized. Therefore, it becomes very easy to select and manipulate related colors independently of where they appear on the original picture. Designers can select and change subsets of colours, such as turning the sky from shades of blue to shades of orange. Finally, Kitty, a sketch-based tool for creating animated illustrations, reifies parameters (for emission and oscillation textures for examples) into bubbles that can be linked to produce functional relationships among the graphical elements of an illustration (Kazi, 2014). These relationships can then be activated by the illustration viewers through drag gestures. For example, putting an egg into a pan provokes the emission of water drops.

Because they are interactive and persistent objects, graphical substrates can easily be modified. Design Substrates are particularly powerful when they embody rules and relationships that are automatically applied to content. This automation gives designers a much greater scale of exploration because if they decide to modify their substrates, they will be able to observe the results on all the content. For example, changing one colour card applies its result to all the graphical elements it was linked to. Analysing existing examples of graphical substrates led us to observe some of their current limitations. We propose two design principles to further develop Graphical Substrates and reinforce their adequacy with designers' practices.

4.2 Tweaking

Current graphical substrates are still very binary in their application. In practice, however, designers need to take into account exceptions. In our studies of designers' practices, we found numerous examples of this need. When manipulating colours, designers often sample existing ones, but they then manually adjust the resulting colour (Jalal, 2015); when aligning and distributing graphical elements, designers usually tweak individual objects to account for mismatches between objects' perceived visual weight and reference points (Ciolfi et al., 2016); when structuring layout, designers establish structures but very often need to break their own rules to take into account extreme cases (Maudet et al., 2017). Revealing and reifying relationships or constraints into interactive objects can be a powerful mechanism for designing design tools. However, in current software, existing structuring mechanisms tend to be rigid and binary: either graphical elements fully obey the structure they belong to, or there is no structure at all. When creating design tools, tool designers should take into account the flexibility of their substrates. Enforcing rigid rules greatly undermines substrates' usability and designers might end up resorting to a more manual process even when there is an existing mechanism. For example, StickyLines integrates two different mechanisms for designers to tweak individual objects' alignment: tweaks and bounding boxes. To create a tweak, designers can reposition objects, but the object remains logically attached to the guideline. This offset, called a tweak, is recorded and displayed as a purple line. They are first-class objects that can be edited, copied onto other objects, and deleted. Designers can also modify the bounding box of an object in order to finely control its placement on a guideline. Bounding boxes can be copied onto other objects, replacing their current one.

4.3 Creation from example

Allowing designers to manipulate and interact with Design Substrates can be an interesting perspective for future design tools, but to make substrates truly useful, we need to address the question of their creation. As we have seen already, with automation comes a greater risk of loosing creative freedom. In the context of weaving, Luther Hooper mentioned that "with each stage of mechanical improvement of the loom, as moreover is the case with all machine in varying degrees, the weaver's freedom and his or her control of the conception of their work is reduced" (Fetro, 2017). If all graphical substrates provide fixed and predetermined behaviours, their appropriability will be limited. When possible, structures should be reifiable from examples, i.e., design tools should let designers extract relationships and rules from existing examples. In doing so, they provide a way for designers to first explore different variations and then to apply principles to all the content. Creating the substrates thus becomes part of the design process itself. To continue on with the Styckylines example, the system lets designers create guidelines based on existing shapes by creating "a ghost", a guideline that takes the shape of an existing object. In Palette Explorer, a colour tool based on interviews with designers (Jalal et al., 2015), they can create a sample palette and can then modify this original palette as a whole on one of the colour axes (hue, saturation or contrast), retaining its original harmony by keeping the other axes fixed.

5 Conclusion

In this paper, we proposed an analysis of digital graphic design tools to better understand the current mismatch between designers and their tools. We first showed how design tools followed a lineage approach in their design, providing functionalities that mimic pre-existing. We also analysed in more detail two specific design tools: the colour picker and the alignment and distribution commands and we revealed how their design supports a vision of design as a hylomorphic process. This conception of design led to designing design tools with values such as transparency and efficiency. However, design research shows how the "instrumentness" of design tools more appropriately supports current designers' practices. To resolve this mismatch, designers currently turn to programming but we argue that we can combine both the strength of graphical user interface and programming. We call this novel type of design tools graphical substrates and illustrate it with several examples in recent design tool research. We argue that integrating mechanisms for creating graphical substrates from examples and tweaking them would further extend their appropriability by designers. Beyond design tools, this paper questions the underlying emphasis on invisibility, efficiency and user-friendliness in tool-design.

Acknowledgments: I would like to thank the reviewers who provided valuable feedback on the first version of this paper. Defining the broader notion of substrates is a collective effort in the ex)situ team. I would like to thank my colleagues, Ghita Jalal, Marianela Ciolfi Felice, Germán Leiva and Philip Tchernavskij, with whom I collaborated on the projects described in this paper. I would also like to thank my PhD advisors, Michel Beaudouin-Lafon and Wendy Mackay who profoundly influenced this work.

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DRS 2018 Design Research Society 2018 Catalyst

University of Limerick
25th – 28th June 2018

Post-Series Design: a tool for catalysing the diffusion of personalisable design

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doi: 10.21606/dma.2018.678

Today a range of increasingly mainstream Digital Fabrication tools help designers not only in prototyping, but also in the production of final parts for consumer products. These hardware tools, while still have significant limitations, they already offer new levels of morphological freedom and logistical flexibility, which allows the efficient production of personalisable products – supposing advanced software tools of Parametric Design. However, since DF, PD and personalisation are still marginal, one may suspect that the Design profession has a shortage of adequate capabilities. Therefore, this contribution proposes a conceptual tool focused on valorising the previous hardware and software tools to achieve meaningfully personalisable products. The proposed canvas tool is structured specifically to facilitate opportunity identification and conceptual design, based on a set of key advantages (variabilities) derived from numerous case studies of existing personalisable products realised with DF. The new approach and tool have been experimented with a class of product design students, but it also aims to facilitate product development at enterprises, coherently with the emerging Industry 4.0 paradigm.

canvas; opportunity identification; concept design; personalisation

1 Introduction

Digital Fabrication tools were first used for their capacity of making small batches of precise special equipment, manufacturing tools, then for relatively cheap and fast prototypes, and later also for unique and complex one-off pieces of art and design. Today, there is the promise of a profound transformation of the relation between design, production and consumption through the emergence of a more ‘on-demand’ model of design (Di Lucchio, 2014). This shift is expected to be multi-faceted: the academic community, large enterprises, or the maker movement aim for a variety of objectives. From a Product Design perspective, this contribution is particularly interested in personalisable products: highly variable designs that follow individual user preferences. This seems to be a logical evolution of the design profession, that have turned its attention gradually from generic products for the masses to niche products for smaller and smaller communities.

As Digital Fabrication enables the efficient enough production of 'variable' series of products, emerges the need to produce the digital data for this differentiated digital production. Parametric Design (also called computational or generative) comes useful for this purpose: a carefully structured mathematical model of the geometry can allow differentiating the design according to the input of user preferences, supposing an adequate interface for the user to interact with. This approach is close to the industrial practice of Mass Customization, well-explored also in the academic literature. To synthetize findings, Salvador, de Holan and Piller (2009) identify 3 fundamental elements of the successful practice: a robust manufacturing process, a well-defined Solution Space, and an intuitive Choice Navigation system to let the user choose the best solution, possibly keeping to minimum the burden of choice. These 3 elements seem to be useful considerations whenever a personalisable product is the goal, also outside the conventional mass manufacturing setting. Reflecting on the changing role of the designer when designing variable products, De Mul (2011) emphasizes the importance of the virtuous handling of numerous variables:

> *The designer [...] should become a metadesigner who designs a multidimensional design space that provides a user-friendly interface, enabling the user to become a co-designer, even when this user has no designer experience or no time to gain such experience through trial and error.*

This implies that creating an unforeseeable multitude of products needs a different design approach compared to designing a single solution: user diversity should not be circumvented, but considered as a resource to create authentically personal artefacts. The trust in the user's creative contribution underpins design philosophies (and practices) such as Participatory Design or Open Design. However, as Cruickshank (2016) notes, providing adequate guidance is fundamental:

> *with too much structure the outcomes are controlled by the hidden hand of the designer and people are simply selecting from a range of options laid down by them. Too little support and many potential creative contributions are lost because starting from a blank page is difficult, even for experienced designers.*

1.1 User motivations and the need for new design tools

Today few of the everyday products allow a deep intervention of the user, which raises the question: How can we go beyond simple ornamental customization and enhance significantly the value of products by involving every single user in a collaborative design process?

Aiming to promote personalisable design, it's worth noting that the diffusion of personalised products might be withheld by the lack of demand: the users' desire to have 'deeply' personalised products cannot be taken for granted, especially considering the already extremely divergent offer in mature industrial economies. Actually, excessive choice can introduce uncertainty in the decision process, thus diminishing sales and even making consumers less gratified regarding their purchases, raising the 'paradox of choice', as Schwartz (2004) calls this kind of anxiety. Other studies found that such decrease of motivation is not universally true, but the large amount of options has a strongly variable effect on consumer behaviour according to the specific conditions of the choice to be made (Scheibehenne, Greifeneder, & Todd, 2010).

Hence, it seems that offering personalisable design requires a special attention, not only on the technical level (that can be addressed well with DF and PD), but also on the conceptual level. We start from the observation that the current knowledge and skills (and therefore practice) of the Product Design profession is not reliable enough for finding the product categories where personalization would be desired, and then develop well-balanced products that can cover unmet needs. Designing a product that is open to the user's modification (prior to the production) is an unconventional problem for a product designer, more used to identifying a dominant need and to satisfy it with a single solution.

The Design discipline includes a progressively widening range of activities and purposes, therefore it is difficult to identify a dominant design approach, but in general we can observe a major attention to the methods that revolve around the users. This attention is manifested in a variety tools, developed by both the academic community, enterprises and design consultancies.

However, both Digital Fabrication and Parametric Design are process innovations (rather than product innovations), suggesting the need for a 'technology push' approach: they are solutions in search of a problem, in contrast with the 'market pull' approach, which targets a problem looking for solution, to use a distinction of the business/marketing literature (Osterwalder, Pigneur, Bernarda, Smith, & Papadakos 2014). In the debate regarding the ideal starting point Osterwalder et al. note that, "Contrary to popular belief, great new value propositions don't always have to start with the customer. They do, however, always have to end with addressing jobs, pains, or gains that customers care about."

Considering personalisability as a design principle that can valorise DF and PD and create otherwise impossible value for the user, but recognising the difficulty of implementation, emerges the question: how would it be possible to catalyse the diffusion of personalisable products? Is it possible to amplify strategically the range of products that benefit from DF and PD? While technical knowledge regarding DF and PD is widely available, it is still challenging to identify commercially viable opportunities and to develop valid concepts, which are in general difficult to come up with.

The initial 'problem finding' phase of the New Product Development (NPD) is considered a notoriously uncertain moment, also called the 'fuzzy front end of innovation'. Attempting to eliminate 'fuzziness', the often-cited Koen et al. (2001) have examined the development process in various enterprises, identifying a model composed of 5 interconnected activities: opportunity identification, opportunity analysis, idea genesis, idea selection, concept definition. The steps are rather generic, but nonetheless a useful division that is reflected in the elaborated tool. Regarding the practice of formal approaches, Keinonen and Takala (2006) note both their difficulty, and their potential usefulness, especially for hardly possible projects:

> *Within the industrial design community there is some mistrust of formal approaches that do not exactly match the designers' requirements. However, in the same team there may be individuals who can take comfort from well-defined approaches during the stressful concept creation process when the results are on the borderline of being achievable.*

Therefore, this contribution aims to provide a new tool/method/workflow for the conceptual development of meaningfully personalisable products, targeting designers, both students and professionals, considering the possibility of working for any kind of client (e.g. an artisan, a consumer brand, a DF service company or directly the end user). More specifically, in order to enhance the design practice and knowledge about personalisable products, the tool aims to facilitate discussion within a design team (and with the client, or instructor in academic settings), with a focus on the early conceptual development. A structured approach could lead more reliably to viable results, but it requires a clear, easy to replicate methodology with an (as much as possible) self-explanatory tool to guide the conceptual design process. A tool with these characteristics should minimize the instructor's workload regarding the discussion of recurring issues and facilitate the future implementation in a productive context, where professionals are not necessarily tutored to follow any specific method, unlike students.

To visualise the progress and allow rapid iteration, the proposed tool is a large format canvas optimised for print and group work with post-it notes; for individual use without post-its, an A4 printable format is provided. These are available from a dedicated website, along with a detailed user guide. The following sections will discuss briefly the principles behind the proposed tool, more in detail its structure and usage, then describe its first (experimental) didactic application within a BSc 3rd year atelier course titled 'Post Series Design'.

2 Tool background

2.1 Case studies on personalisable products: reasons for the variable design

A key element of the proposed Parametric Concept Canvas tool derives from the analysis of case studies, which lead to the understanding of the reasons why users would choose a personalisable product, usually more expensive and slower to acquire than similar mass-produced objects. We have examined a series of projects, mostly commercial products that use DF and PD, searching for the personalisable aspects that determine their competitive value from the users' viewpoint. It was possible to identify 6 types of variabilities, dividable in two groups between mechanical and cognitive variabilities (Figure 1):

Mechanical Variabilities: physiology/ergonomics; environment/objects; function/performance.
Cognitive Variabilities: aesthetic/emotional; social/cultural; narrative/experience.

Each case study could be categorized according to a dominant type of variability, but in many cases there were more than one potentially interesting aspects to be modified by the user, e.g. shoes are adapted both to the physiology and the aesthetic taste of the user. Therefore, the (often) multiple nature of personalize-ability has been recorded in a radar diagram for each case study, in order to make them easier to confront visually.

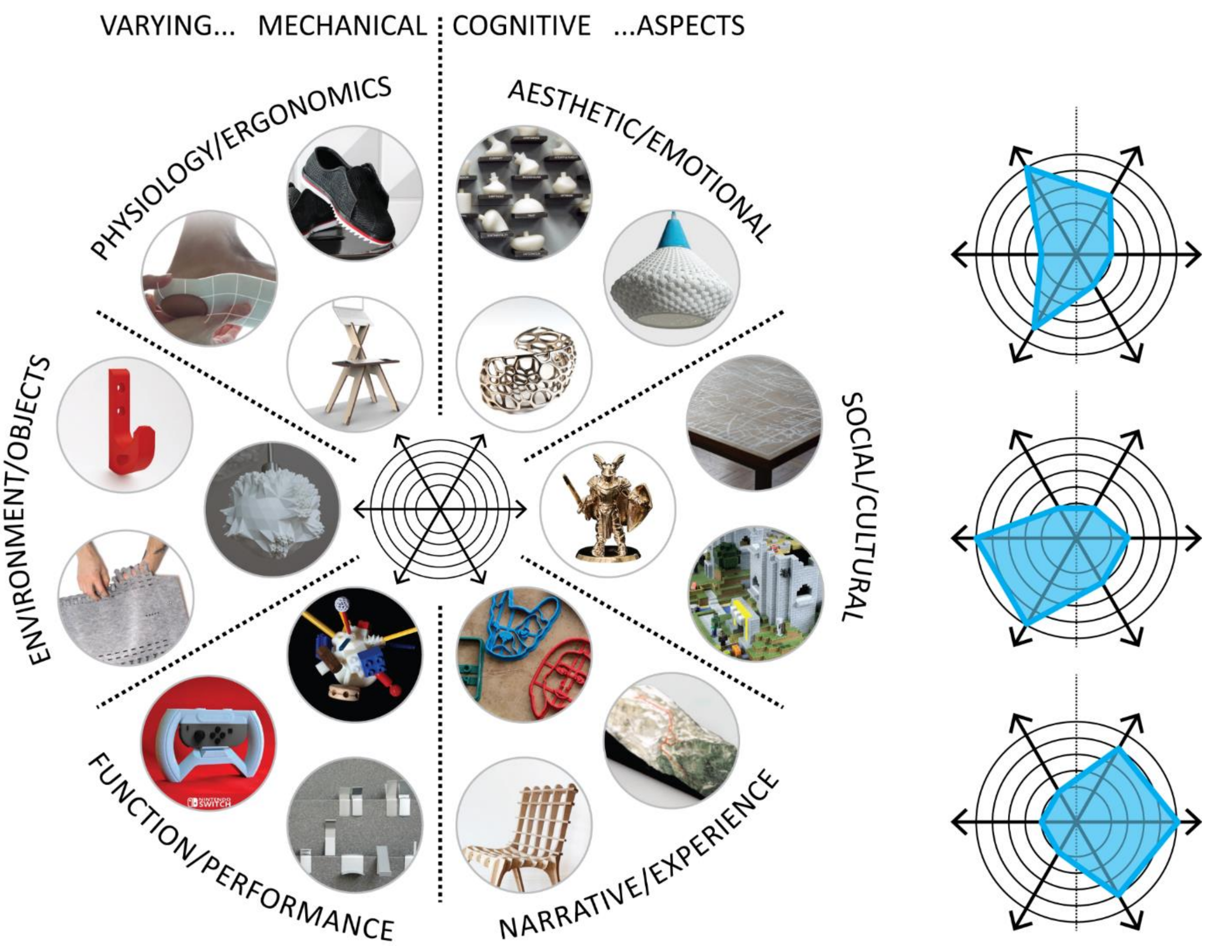

Figure 1 An overview of the analysed case studies and examples of the radar diagrams representing the mix of variabilities personalisable products can have. The 6 identified 'variabilities' are fundamental for the proposed tool.

The outlined system of 6 variabilities can be applied to a variety of product typologies, attempting to identify which aspects of these products are personalisable in a desirable way. Hence, the key principle for the development of the proposed method/tool was the systematic attempt of connecting the possible variabilities with the divergent needs of possible users.

2.2 Further principles of the ‘Parametric Concept Canvas’ tool

The main expectation from the proposed method/tool was to facilitate the process of transformation from a (today) static product category to a dynamic, mutable geometry, according to the possibilities of PD and DF and the principle of personalization. The literature review of various collections of design tools (e.g. Hanington & Martin, 2012; Visocky O 'Grady, 2006; Tassi, 2008; Kuma, 2012 and online collections such as designkit.org) have not found any tool focused on our objectives, but there were some potentially useful strategies that were considered as inspiration.

One tool in particular demonstrates well how helpful a conceptual tool can be: the Business Model Canvas of Osterwalder and Pigneur (2010), widely used in the entrepreneurial community, provides a well-defined structure for developing and evaluating entrepreneurial ideas, reminding the user to consider a series of factors that are fundamental for developing a profitable product or service (Figure 2). The canvas format offers a logical layout of communicating fields to be filled with post-it notes, an approach that is effective in a wide range of contexts from the conceptual development of new products for start-up companies, to the verification and improvement of the offer of large corporations. An interesting offshoot (or complement) of the Business Model Canvas is the Value Proposition Canvas (Osterwalder et al., 2014), an even simpler format that stimulates the articulated discussion of the perceived value of products, also beyond their trivial functionality (jobs), explicating the pains it alleviates and the gains it provides to the user, also on the ‘abstract’, social level. This threefold discussion of values has been integrated directly into the proposed canvas.

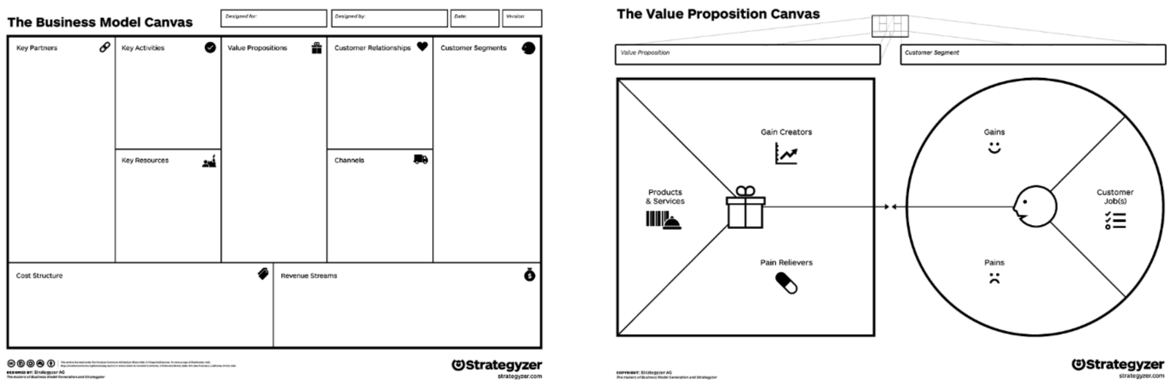

Figure 2 Business Model Canvas and Value Proposition Canvas, widespread examples of paper tools that facilitate the comprehensive conceptual development of business ideas. source: https://strategyzer.com/platform/resources

Similarly to the BMC, the proposed tool aims to provide a flexible but uniform structure to the analytical observations and to the design ideas, helping a comprehensive development by reminding the designer to consider a range of important factors that could underpin the success of a personalisable product, as well as the possibilities of PD and DF. In order to promote the ‘courageous’ compilation of the tool, it suggests the use of post-it notes (as opposed to direct writing on the canvas), maintaining the possibility of later corrections. It is worth noting that there are risks associated with the (mockingly) so-called “post-it design”, which, in its attempt to objectivise an otherwise subjective design process, fragments decisions and degrades the designer into an administrative role (Manzini, 2015). However, systemizing the flow of thought can lead to a more complete understanding of the design problem at hand, especially important in case of a relatively unusual process of designing.

3 Parametric Concept Canvas

3.1 Central elements

The logical structure of the ‘Parametric Concept Canvas’ (PCC) tool has been derived from its objective of guiding the design process from the choice of a product typology to the concept of a variable product. To do so, the canvas offers a series of fields for the analysis according to numerous aspects. The most relevant of these has been derived from the already discussed case studies, which were categorized according to the variabilities that determine the perceived value of the products. Based on these, the backbone of the work on the canvas is the examination of the chosen typology according to the 6 variabilities that could make the personalization desirable. In addition, the designer analyses 3 more factors that determine the feasibility of the personalization using the available PD and DF tools. To each of these 9 factors, there is a corresponding quantitative question, that asks to evaluate approximately how much the relative user requirements can vary; current diversity within the given product typology can strongly indicate whether there are divergent requirements, but designers should consider also the possibility of currently unmet needs. High evaluations indicate greater probability of developing concepts that are personalisable according to the given parameters.

While this system of criteria is the backbone of the analytical work on the PCC, it is completed with already existing frameworks and visual tools, such as the mentioned jobs-pains-gains analysis derived from the Value Proposition Canvas, the widespread *personas* technique, or storyboarding of the customers journey.

The workflow on the canvas follows the approximate reading order, from left to right, from top to down. It was not possible to establish a strictly linear order of execution, but interacting elements were kept in proximity.

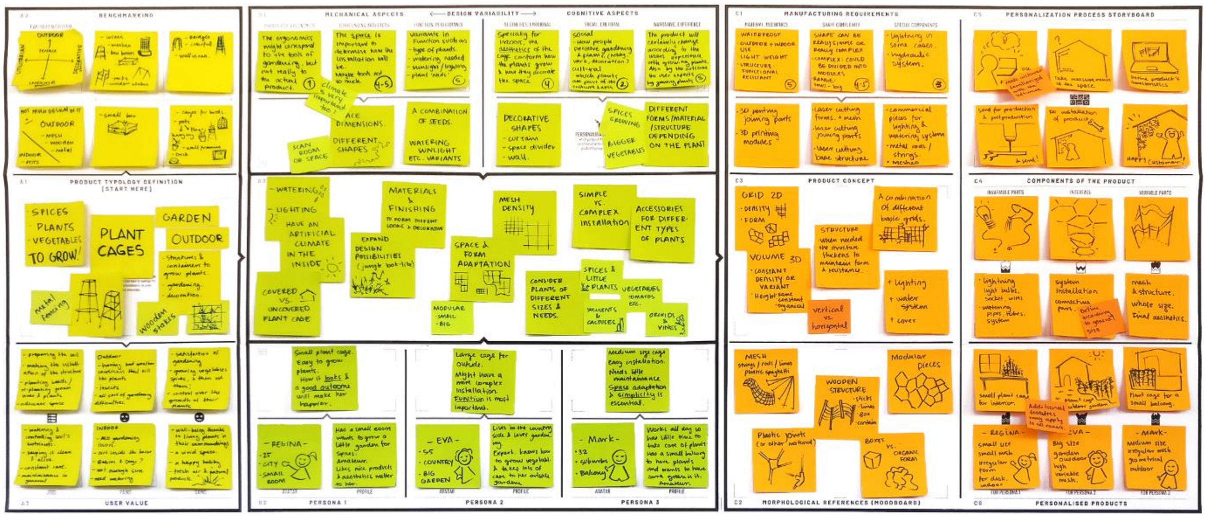

Figure 3 Parametric Concept Canvas, completed. Different colour post-its show the three main blocks of the canvas, better explained on the next page. Note that also various smaller versions have been elaborated, as explained later.

3.2 *Canvas structure*

The 15 fields of the canvas are grouped in three modules, which should be completed sequentially: even if fields within the module A and B are not compiled in strict order, the designers should fill in at least a hypothesis of them before moving on the next module.

Module A. Product typology definition:

- A1. deciding the adequate scope of the design activity;
- A2. analysing existing products within the chosen product typology (benchmarking);
- A3. clarifying the possible user values through jobs-pains-gains analysis.

Module B. Personalisation principle definition:

- B1 evaluating the relevance of the previously mentioned six personalisation principles and understanding the personalisable features of the product;
- B2 constructing personas that represent potential users and their personalisation need;
- B3. identifying design opportunities between the previous elements of the module.

Module C. Detailed concept definition:

- C1. analysing manufacturing requirements and identifying digital fabrication options;
- C2. collecting morphological references (moodboard);
- C3. crystallising the product concept based on previous opportunities;
- C4. distinguishing between variable and invariable elements of the design;
- C5. defining the personalisation process through storyboarding;
- C6. hypothesising possible outcomes of the personalisation based on the needs of the tree previously constructed personas.

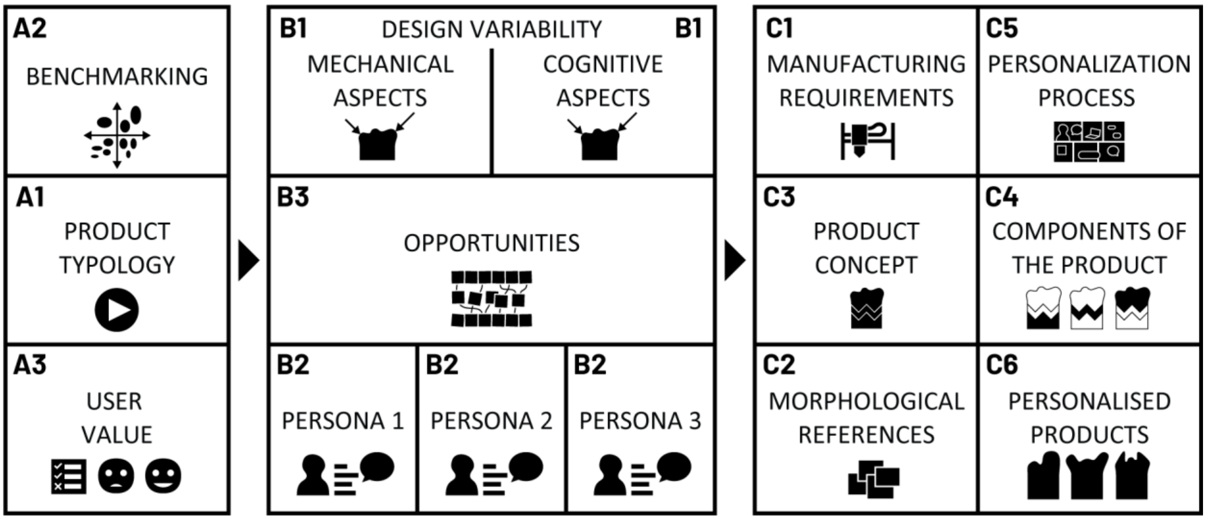

Figure 4 The structure of the canvas, as detailed above. Figure 5 shows the actual canvas graphics.

3.3 Workflow

Module A. Product typology definition

A1. Product typology definition. The starting area where the designers enter the product typology that they want to redesign for DF, aiming for a personalisation as a key competitive advantage.
A2. Benchmarking. Exploration of the current variety within the chosen product typology, through a set of examples organised according to observable tendencies. The benchmarking should highlight how much divergence is there among currently existing products in the category, hence indicating the already existing need for personalisation.
A3. User value. The third square in the bottom with the title 'Usage' helps to clarify the product typology's *raison d'être* (reason for being) by analysing the jobs users want to carry out with the product, the pains (difficulties) they might experience during the usage and the gains they hope to obtain as a result.

Module B. Personalisation principle definition

B1.1 Design Variability. Area of key importance, where the designer analyses how much the previously mentioned 6 variable aspects (derived from case studies) determine the shape, usage and perceived value of the product. Each of these aspects are evaluated on a 1 to 5 scale according to a specific question, and the motivations are registered on a post-it note. This field relies on the capacity of the designer to critically assess the design of existing products, building on the observations in the previously filled fields of the canvas (A2. Benchmarking and A3. User value).
B1.2 Personalisable features. In this field the designer should clarify how the most interesting variable aspects (evaluated in B1.1) might influence the design of the features of the product, respecting the given typology's functional requirements. This field should clarify which part(s) of the product can be personalised while satisfying the requirements of the given product typology. According to the previous evaluation (on the 1 to 5 star scale), the most interesting aspect(s) should be considered, while dropping those with low ratings.

B2.1 Personas Profile and avatar. In order to comprehend whether user needs are sufficiently divergent to justify a personalisable product, in this area the designer constructs 3 'imaginary' user profiles according to the widespread *personas* technique. To create empathy and allow quantitative work, fictional personal details and an evocative avatar (drawing or photo) are added, making the persona a realistic character for whom to design. The constructed personas should have markedly different expectations from the chosen product typology.
B2.2 Personalisation need. After constructing the personas, in these fields the designer should insert ideas regarding their most particular needs, which would motivate them to engage in a personalization process.

B3. Opportunities. In this area the designer should connect the possibly personalisable features (B1.2) with the identified personalisation needs (B2.2). The ample and unstructured space is open for idea generation, allowing to dedicate the necessary number of post-its for ideas, ideally connected to previous observations; connections should be marked e.g. with sticky paper tape. The designer should try to identify which personalisable features have the strongest connections to the identified personalisation needs, resulting in more defined ideas about the desirable configuration and morphology of the final product. However, in this phase it is not yet necessary to define precisely the product concept, it is more important to map out many opportunities and focus on connections.

Module C. Detailed concept definition

C1.1 Manufacturing requirements. Approaching the final concept, the designer analyses the requirements that determine the feasibility of the previously identified product/feature opportunities, trying to find the ideal Digital Fabrication strategy. For the ease of discussion, the manufacturing requirements are divided according to three aspects; similarly to the nearby B1.1 fields, beyond the verbal assessment the feasibility of these aspects should be rated on a 1 to 5 scale, where lower ratings indicate harder to satisfy requirements, which need extra attention.

C1.2 Technology candidates. In this field, the designer should identify which digital fabrication technologies could match the above requirements. Beyond the digitally manufactured components, the product might include parts which must be realized with conventional, serial manufacturing technologies; these requirements should be listed as well.

C2. Morphological references (moodboard). This field illustrates the expected visual qualities of the final object through a collection of images and/or text description. The morphological references (moodboard) should be coherent with the range of previously constructed personas (see the neighbouring B2 fields).

C3. Product concept. This field contains the morphological concept of the product, considering an 'average' personalisation. Based on the previous analytical work and ideation, the overall design should be illustrated, as detailed and precise as possible, providing a preview of the final product.

C4. Components of the product. Further illustrating the concept outlined in the C3 field, here the designer should distinguish between the variable and invariable parts of the design, highlighting also the interface where they meet. 'Variable' parts are those which can be personalised through parametric design, to be manufactured with digital fabrication. 'Invariable' parts are those which cannot be personalised, either because they need to have a given geometry in order to function properly, or because personalisation would not change the object's perceived value. Invariable parts can be produced by either digital fabrication or serial production. Finally, under 'interface' the designer should describe where/how variable and invariable parts meet.

C5. Personalisation Process Storyboard. This field contains an illustration and description of the main steps necessary to obtain the custom product. Based on one of the previously constructed personas, the storyboard should begin with the emergence of the personalisation need and proceed with the persona entering in interaction with the system of personalisation, e.g. webpage or physical shop.

C6. Personalised Products. This field should illustrate and describe briefly three hypotheses of the product, personalised for the three previously constructed personas (B2). Noteworthy differences in the creative input should be described.

3.4 Workflow conclusion

Considering the previous experience, it is advisable to dedicate 3-5 days for a full and accurate compilation of the full canvas with a working group. Naturally, growing experience can decrease the time necessary for arriving to a valuable conclusion. However, let's note that the process is not necessarily linear, because emerging ideas could stimulate revisiting previous steps. In fact, when the canvas is completed, it is advisable to review it in order to confirm whether the previous statements are still valid and whether they are coherent and supportive of the elaborated concept. The review might result in the rebuttal of the original hypothesis of working on the chosen product typology, especially in an entrepreneurial environment, where working on sub-optimal (non-profitable) ideas can have substantial cost, unlike in didactic settings.

As the output of the canvas, the designer can expect a concept that is mature enough for the rather onerous phase of parametric modelling, with a good comprehension and confidence about the potential utility of the personalization.

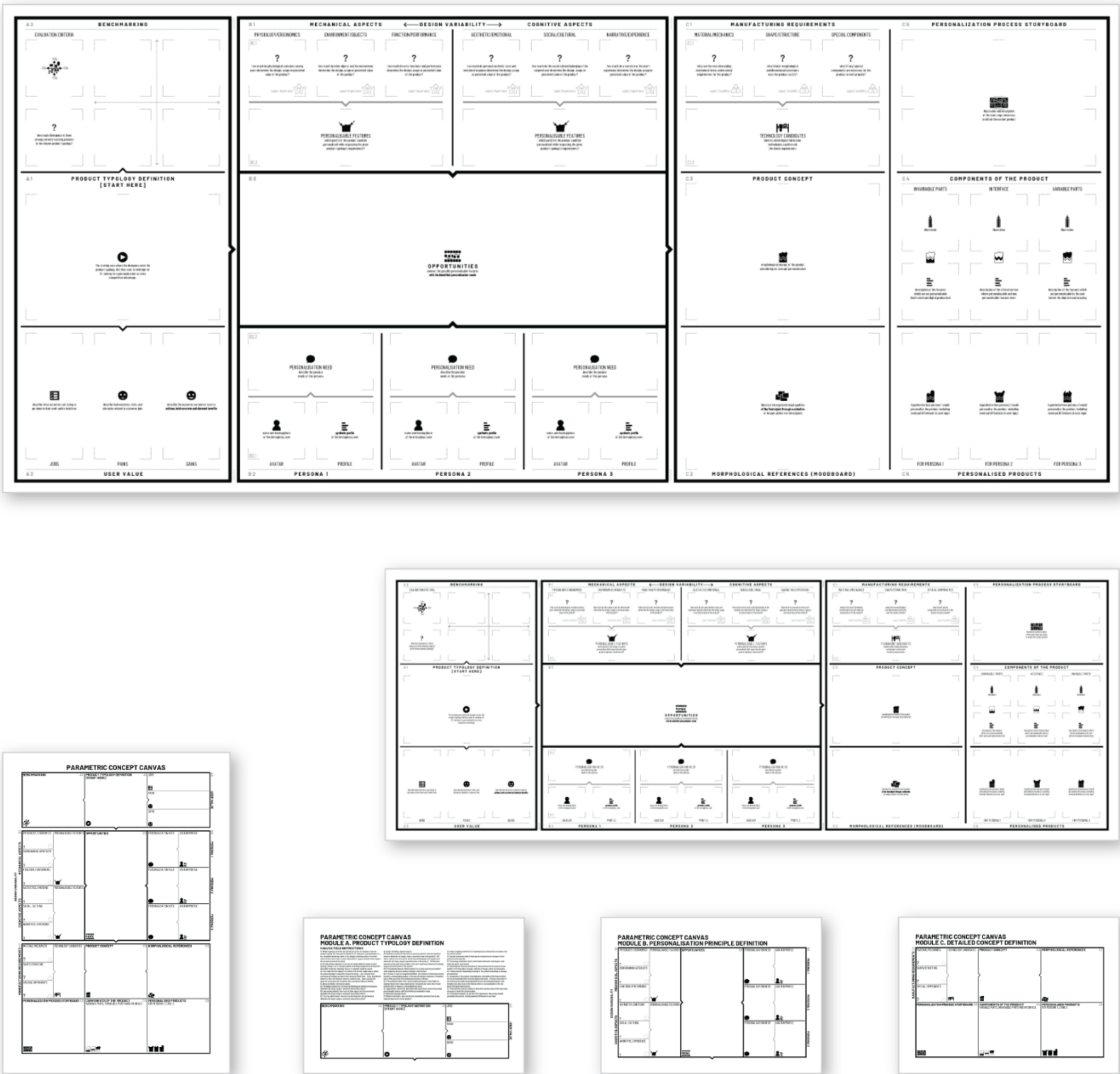

Figure 5 All formats of the canvas as described below, depicted proportionally (bottom row: standard A3 and A4 sheets). For readable (and printable) PDF versions of the canvas, please visit http://www.malakuczi.it/canvas.html

3.5 Canvas formats

In order to maximize the utility of the proposed tool in a variety of contexts, several versions have been elaborated in different dimensions, for individual or group use, with or without post-it notes, allowing both continuous development (post-its on big canvas) or rapid iteration (direct writing on small canvas). The following formats are offered:

- **Normal canvas**: canvas for working in groups, using standard post-its (3x3” or 76x76 mm). Canvas dimensions: 1500x630 mm, foldable to A4 format for portability.
- **Small canvas**: canvas for individual work or small groups, using small post-its (2x1.5” or 52x39 mm). Canvas dimensions: 1000x360 mm, foldable to 200x360mm.
- **Compact sheet**: mini-size canvas for individual work, for direct writing on the sheet. Dimensions: printable both A4 or A3, for cheap printing to stimulate iterations. For convenient writing in the restricted space, the small sheet contains a vertical (rotated) version of the canvas with simplified graphics.

- **Triple sheet**: mini-size canvas for individual work, cut in three pieces for convenient handling. Dimensions: printable on A4 or A3 sheets (3x), suitable also for A3 sheets. Offers slightly more space than the compact sheet and instructions for all fields are included on the first sheet.

Regardless the format, all versions of the canvas share the same fields, which are identified with the same icons and letter-number combination (e.g. C5).

4 Didactic experiment

So far, an early version of the proposed tool has been experimented in an academic context, with students of product design, anticipating also future uses with industrial partners, for whom we aim to create a useful knowledge. Experimenting with personal fabrication with university students is not new; the course “How to make almost anything” at MIT since 2001 show examples of how empowering Digital Fabrication can be for creating unique objects (Gershenfeld, 2005). A recent interesting didactic/research program example is Beyond Prototyping, carried out at Technische Universität Berlin and Berlin University of the Arts. This project was more focused on designing feasible products that are easily personalisable through online services, yet offering the aesthetic quality that one would expect in design-oriented shops (rather than technological demos); after the teaching experience, some projects were further developed in commercially available products (Ängeslevä et al.,2016). In the past, also the Authors have carried out similar teaching experiences, e.g. an international workshop for personalisable souvenirs to enhance the tourist experience in the city of Rome.

Even considering the many related examples, there seems to be no strong attempt to guide and visualise the conceptual design process of personalisable products, nonetheless the apparent difficulty; this was part of the motivation for developing the Parametric Concept Canvas. This development relied on a course with Product Design students in the third year of their bachelor studies in Product Design, who helped to test the first version of the canvas; the PCC described above is, actually, the revised final version.

4.1 Post-Series Design course

The ‘Post Series Design’ aimed to prepare the students to the contemporary cultural and productive environment, characterized by a strongly segmented market, saturated with a wide offer of alternative products. In order to promote competitivity in such environment, the course was focused on personalisable products, and in order enable designing them, the aim was to provide both conceptual and technical skills. Beyond the didactic objectives, the course had the research objectives of A.) verifying the proposed method/tool of conceptual development, and B.) demonstrating that DF and PD are applicable to a wide variety of products.

While it would have been desirable to work on product categories as divergent as possible, starting from a blank page or assigning a wide range of predefined product typologies would not have been adequate for the syllabus. Therefore, the 55 students organized in 21 groups were divided in 6 macro-groups, each receiving a keyword that left a wide possibility of interpretation. These keywords were derived from the exhibition “Neo Preistoria: 100 Verbi”, held at La Triennale of Milan (Branzi, 2016), showcasing how 100 actions (verbs) were manifested in mass produced objects of the twentieth century. While the 6 randomly assigned verb were interpreted freely by the students, their thinking was channelled towards established product typologies that are already mass manufactured, therefore ‘needed’ by many people. Moreover, experimenting with the (parametric) re-design of an existing product stimulates the conscious thinking about the relative advantages that DF and PD can offer, important for gaining a more solid understanding of the future role of these technologies. Therefore, based on the assigned action, each group have analysed a set of objects they collected in their homes, and then they choose a product type to work on for the rest of the semester.

4.2 Workshop of analysis and opportunity identification

The described choice of product typology has provided the input for the work on the 'Parametric Concept Canvas', the tool that this paper is focused on. Each of the 18 groups had a canvas to work on during the 3 intense days of a workshop, divided in the following way:

- day 1: analysis of the product category through examples, the jobs-pains-gains framework (left column) and the system of variabilities derived from the case studies (top-centre row).
- day 2: construction of personas and analysis of their needs, connecting them to the possibility of variation, i.e. feature ideation (bottom row, central field)
- day 3: establishment of the product concept and user journey through a storyboard, presentation of findings in front of the entire class (right column).

As usual in the design atelier courses, the abilities of the students have determined the pace of the process, and so did the product category they choose to work on. However, nonetheless the clearly visible differences of quality, the level of completeness at the end of the three-day workshop was quite uniform among the groups: less than 20% of the groups have shown significant disadvantages compared to the aimed level. This is considered a progress compared to a similar workshop organized a few months before, and the difference can be associated to the presence of the Parametric Concept Canvas tool. During the previous workshop, the absence of a strictly defined process (tool) resulted not particularly fruitful, wandering discussions in some of the groups. In the latter workshop, however, the defined format has helped many groups to identify autonomously their own mental blocks, as these caused a visible blocking in the compilation of the canvas, therefore these students could turn to the tutors for clarifications. For the same reason, from the instructor's points of view, it was relatively easy to identify the groups to help, simply by observing their advance of the canvas. The specific questions that guide the work on the canvas also create a platform of discussion, which helps professors to switch rapidly between completely different topics, particularly important when the attention must be divided between numerous students, as this is an increasingly typical issue also in the higher education of design.

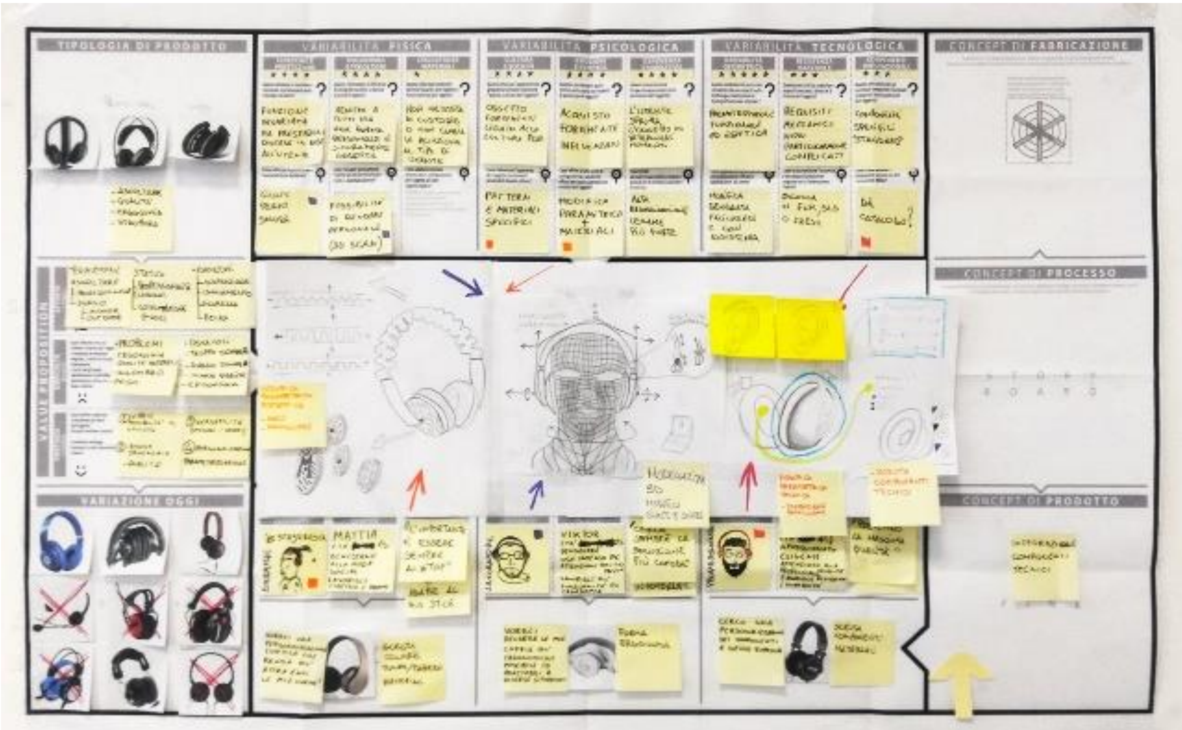

Figure 6 An example of the first version of the canvas, which was refined subsequently, arriving to the previously described final version of the Parametric Concept Canvas tool (Figure 5).

On the other hand, the workshop has helped to surface some (precious) negative observations, to consider for the future development of the tool.

- difficulty of applying some of the analytical questions to some of the product categories
- difficulty of reasoning in terms of 'variabilities' (rather than in terms of 'simple' improvement)
- sometimes misinterpreted suggestions, as limitations rather than stimuli
- sometimes mechanical compilation of the fields, rather than critical discussion

Therefore, on a general level we can assert that the canvas has fulfilled its main function of guiding the discussion in the desired direction, however we can also note the difficulty of the students to change their approach from developing single solutions (that respond specific problems) to wide solutions spaces (that respond variable requirements). Since the research (of which the course is a part of) was started with an awareness of this difficulty, it was not surprising to observe it on the field. However, this also indicates that tackling with the problem of variable design would need a higher level of professional preparation of what third year bachelor students have, who are still in the process of solidifying their skills for a simpler, 'univariable' kind of design. More specifically, more past experience would have been helpful with conceptual tools such as personas and user journey storyboarding, as well as with the technical tools such as parametric modelling software.

As far as the 'Parametric Concept Canvas' concerned, the previous critical feedback has stimulated its simplification and partial restructuring, which lead to the final version of the canvas, already discussed.

4.3 Next steps

The proposed 'Parametric Concept Canvas' tool provide a framework only for the first steps of a design project. After the ideation workshop, the 'Post Series Design' course continued with a more conventional process of weekly meetings, during which students have elaborated firstly a 'static' 3D model simulating the personalisable product, then a parametric (personalisable) model. In order to facilitate the discussion, students were asked to document each step of the development with a standard style of visualisation (figure 7), that distinguishes with colours the variable parts (cyan) from the invariable parts (grey), and the interface where these two meet (magenta).

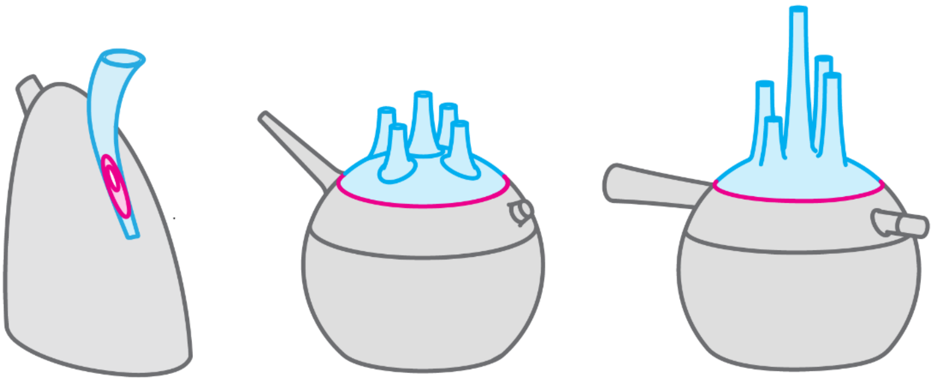

Figure 7 Development process of a student project, following the provided colour scheme to distinguish variable parts (cyan) from invariables (grey) and to show the interface between them (magenta).

While the technology to use for the parametric modelling can vary according to the business model suggested by the concept, in case of the 'Post Series Design' course, the parametric modelling was done with Grasshopper for Rhinoceros 3D.

This simple but powerful approach to parametric modelling allowed most students to create a variable geometry that is readily personalisable using the online platform ShapeDiver. This implies that with the currently available software tools one product designer plus one web designer can easily design and market a personalisable product for Digital Fabrication.

Figure 8 A selection of the 21 personalisable products developed by the students.

Since the use and teaching of parametric modelling tools (as well as DF machines) is already a well-established practice, discussing in detail these aspects of the 'Post Series Design' course is out of the scope of this paper. Yet, it is worth noting that today the parametric approach is largely facilitated by evolution of software tools also beyond those used during the course. In a previous work, the authors (Di Lucchio and Malakuczi, 2016) have examined them according to their level of abstraction, which determines the effort needed for the acquisition and practice of the necessary knowledge, ranging from simple parametric solid modelling (e.g. Solidworks, Fusion) to visual programming of generative geometries (e.g. Grasshopper) until demanding but versatile direct code writing (e.g. Processing, Javascript, Unity). According to the tools used, the designers' role and business model can range from digital tailormade through the offline use of parametric solid modellers, to an enterprise collaborator who helps to redefine an entire range of products according to the contemporary creative and productive possibilities.

5 Conclusion

While this paper was focused on the development and educational experimentation of the 'Parametric Concept Canvas' tool, it also aims to help professional designers to develop successful personalisable products, hopefully more fulfilling for the end users, thus providing competitive advantage to the designers' organisations. Moreover, the structured approach to concept development could help researchers to understand better the possible scope of Digital Fabrication, Parametric Design and personalisable design in general. While the proposed method is based on a set of variabilities extracted from case studies, future research could extend or refine this set of key characteristics. In fact, a limitation that must be acknowledged is that the tool is not promoting actively the discovery of entirely new meanings of personalisation, neither does is promote the exploration of entirely new morphological qualities.

However, it is worth remembering that:

> *methodology should not be a fixed track to a fixed destination, but a conversation about everything that could be made to happen. The language of the conversation must bridge the logical gap between past and future, but in doing so it should not limit the variety of*

possible futures that are discussed nor should it force the choice of a future that is unfree. (Jones, 1970)

It is also important, though, to acknowledge that there is a large undiscovered territory to be explored, if we intend to maximise the positive impact and move towards a strategic use of new technologies, that benefits economic and social progress, as well as the design profession. Future research and innovation actions should verify whether and how the proposed tool can be applied in entrepreneurial settings at different scales, from artisanal micro-enterprises to large international brands. This would be particularly timely because the concept of technology driven personalisation falls under the Industry 4.0 paradigm, which currently enjoys a strong governmental support across Europe. In order to facilitate the diffusion, the elaborated toolkit (containing both the canvas and a more detailed user guide) was made available at http://www.malakuczi.it/canvas.html with Creative Commons license.

Whether and how the design profession can accommodate the new approach of designing wide solution spaces for parametrically variable products is not yet clear. The necessary new technical and conceptual skills might require a further branching of the discipline, which would be a natural and welcome sign of maturation. In any case, we hope to contribute to raising the profession's capacity to adequately valorise emerging technological possibilities.

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DRS 2018 Design Research Society 2018 Catalyst

University of Limerick
25th – 28th June 2018

Surfing for Inspiration: digital inspirational material in design practice

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doi: 10.21606/dma.2018.352

Over the last decade, many new opportunities have emerged to support creativity and problem-solving in design by finding inspirational materials via the Internet. Online design communities such as those of Behance and Pinterest showcase portfolios and user-made artwork, and they offer support for designers' day-to-day work to find and collect inspirational material. However, very little is known about how these communities affect inspiration-related practices of professional designers and how designers view them. This paper presents new data on the practices designers employ when seeking digital inspiration sources online and reflecting on, tracking, and managing them in today's Web design. Current practice and views on sources of inspiration were described based on responses from 51 professional designers. The results suggest that the Internet has become a prevalent source for ideas in design, yet designers experience mounting issues of trust and relatedness with regard to online sources. Therefore, encouraging both should be considered a guiding principle for tools aimed at supporting designers within the realm of design practice.

inspiration; online design platform; design practice

1 Introduction

This paper investigates the effects of the proliferation of online design tools and the associated communities that have emerged over the last decade. Previous research has approached online sources for Web design as an opportunity to design beyond borders and to gain impact globally (Tan & Yuen, 2015). Here, we complement this perspective by asking how these sources are starting to affect design thinking, especially with regard to seeking inspirational material for creativity, reflection, and problem-solving.

The growing number of design solutions online, coupled with designers' increasing global connectedness, has led to the development of services and platforms *dedicated* to supporting inspiration, discourse, and information-seeking. For instance, Ember[1] allows designers to save Web links, images, and documents with annotations, all in one location.

With the advent of online social design platforms, such as Behance[2], Pinterest[3], and Dribbble[4], the spectrum of design sources available changed dramatically, affording the creation of online sample galleries, curated design data, and visual search technologies – enabling designers to find inspiration through examples as presented in figure 1-4. This development is of interest for the design research community. On one hand, these services may aid in team-based work to collect and organise sources of inspiration, work that can be time-consuming and difficult (Porcheron, Lucero, & Fischer, 2016), by providing sources of design inspiration and thereby improving efficiency and efficacy in problem-solving. On the other hand, some of these online platforms provide only limited exchange and feedback possibilities, even though collaborative creativity is a central aspect of design (Keller, Pasman, & Stappers, 2006; Tan & Yuen, 2015). Hence, the important question arises of how designers' practices change in the context of these online developments.

1.1 Inspiration in Design Practice

In this paper, we look at designers' evolving inspiration-seeking practices. We begin by discussing the key terms 'practice' and 'inspiration', as preparation for outlining our empirical research questions in the next section.

Green (2009) provided a comprehensive analysis of definitions of 'practice', categorising them into four groups by the sense of the term. While he grouped them into categories, he found all to cover three main aspects: experiences, activities, and contexts of practice. For the notion of 'practice' applied in our study, we extend the concept along these three dimensions beyond the individual. In line with Goodman et al.'s understanding (2011), we include as well 'technical systems, organizational structures, tools, and knowledge'.

We particular focus in this paper on *inspiration*. Designers have several ways to find inspiration (Lucero, 2015), including browsing magazines and the Web, reading books, visiting trade fairs, and meeting people. Other activities, such as taking short breaks to perform physical activities both within and outside the design studio (e.g., playing darts or football at the office, riding a bicycle through town, or walking a dog), serve the purpose of helping the designer forget about work for a while, hence creating room to approach design problems from a different perspective, with a fresh mind (Lucero, 2015).

Inspiration depends on the individual-specific experiences of each designer, which is partly represented by their previous work, but mainly influenced by external inspirational input. Looking at similar products and other design examples helps designers diversify their thinking (Gomes et al., 2006). Conversely, creative thinkers often rely more on non-related input to extend their vantage point on the problem (Ansburg & Hill, 2003).

Our focus is especially on external *design examples* as sources of inspiration. Accordingly, 'inspiration' in this paper refers to digital sources that can directly and indirectly influence the final design by serving as a starting point for the design, a precedent, an element for reuse, a pattern, and a primary generator for new ideas (Eckert & Stacey, 2000). It serves the understanding of the context as well as of the targeted mood or functionality beyond the immediate sphere of the designer's experience (Tan & Yuen, 2015).

Designers habitually seek inspiration from pre-existing related designs (Bonnardel, 1999). In this context, Siangliulue and colleagues (Siangliulue, Arnold, Gajos, & Dow, 2015) have highlighted that the creativity in each individual example is as important as the diversity of the overall set of examples for the quality of the whole inspirational set. Design examples may be either one's own

[1] See https://hackdesign.org/toolkit/ember(2017).
[2] See https://www.behance.net/(2017).
[3] See https://www.pinterest.com/(2017).
[4] See https://dribbble.com/(2017).

previous solutions or newly discovered from others. While they inspire new approaches, they also provide solution templates, structure ideas, and sources of concepts for changing perspectives (Eckert & Stacey, 2000). These solution templates relate to Lawson's gambits describing patterns, like UI patterns, containing certain properties and capabilities to solve recognizable design problems (Lawson, 2004). In contrast, understanding abstract concepts or schemata enable expert designers to identify and describe design situations where a certain solution template can be applied. However, Lawson concluded that designers 'need to have studied a substantial body of precedents to develop schemata that enable them to recognize underlying structures in design situations' (Lawson, 2004). This requires extensive learning from precedent design solutions, yet finding an appropriate example is not always straightforward. Consequently, designers tend to create *local repositories* of interesting examples for later access (Herring, Chang, Krantzler, & Bailey, 2009). On the downside, such repositories tend to grow and become unmanageable, can be perceived as ineffective (Herring et al., 2009), and quite rapidly grow outdated. This requires designers to constantly seek for new appropriate inspiration beyond known ideas. Current tools and systems can support designers' work to structure, retrieve, and broaden high-quality example sets and can offer inspiration sources recommended by others.

1.2 Online Design Platforms

In 2006, Keller et al. identified six considerations for designing collection tools in the light of designers' common practices of collecting visual material for inspiration and referencing (Keller et al., 2006). These include that a tool should 1) support collecting as an ongoing process, 2) afford merging of physical and digital material, 3) support serendipity, 4) support visual interaction and selection of material, 5) encourage changes in interaction and idea chains, and 6) encourage social values within the collection of inspirational material.

Recent years have witnessed the proliferation of online design platforms, including Behance, Dribbble, Niice[5], Pinterest, and others. While these platforms fulfil some of Keller's above-mentioned criteria, little research has been done on their impact on everyday design practice.

These platforms currently allow designers to collect new ideas, and some (e.g., Behance) support the visibility of one's work through additional information such as the design's purpose, designer contact details, and even target groups and approaches (Deka et al., 2015). The interconnection with previous work allows the observer to get a better picture of the general style and quality of the work. Overview pages include rankings, and indications of the most popular suggestions, which further favour the discovery of new unexpected material – i.e., serendipity (Keller et al., 2006). Finally, design-related discussion held via comment sections and streamlined with symbols (a shorthand that simplifies the interaction) encourages social community values.

Even though those online platforms offer a large repertoire of inspiration and information, little research has been done thus far on their use in professional design practice. The studies coming closest have addressed artists' use of DeviantArt (Salah et al., 2012) or public collecting and curating of inspiration in the Pinterest service (Gilbert, Bakhshi, Chang, & Terveen, 2013; Scolere & Humphreys, 2016). The research gap is especially important because finding a good inspirational example for professional design use can be challenging, and a critical gulf may exist between online tools and designers' current needs.

1.3 Storing and Managing Inspirational Material

Another dimension of design practice is storing, organising, and maintaining inspirational visual material to stimulate creativity (Keller, Visser, van der Lugt, & Stappers, 2009).

[5] See https://niice.co/(2017).

Figure 1: Ember allows screenshots, Website renderings that include source code and documents to be annotated and manipulated

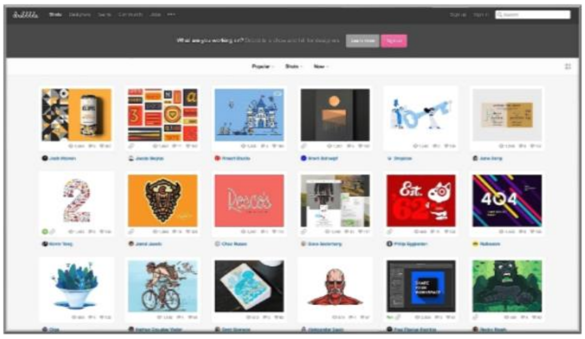

Figure 2: Dribbble presents designers' portfolios in a gallery, which can be filtered by items' recency, popularity, and features – such as use of animation

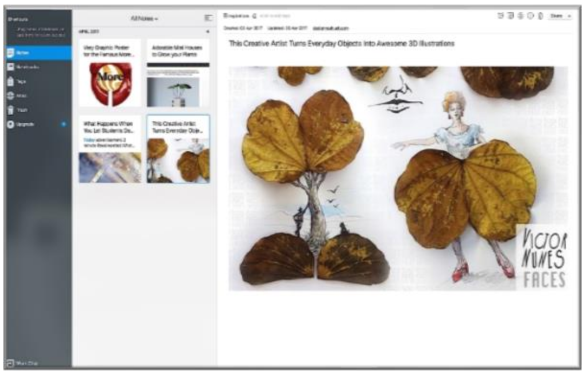

Figure 3: Evernote organises design ideas as a searchable collection of screenshots and articles that can be annotated

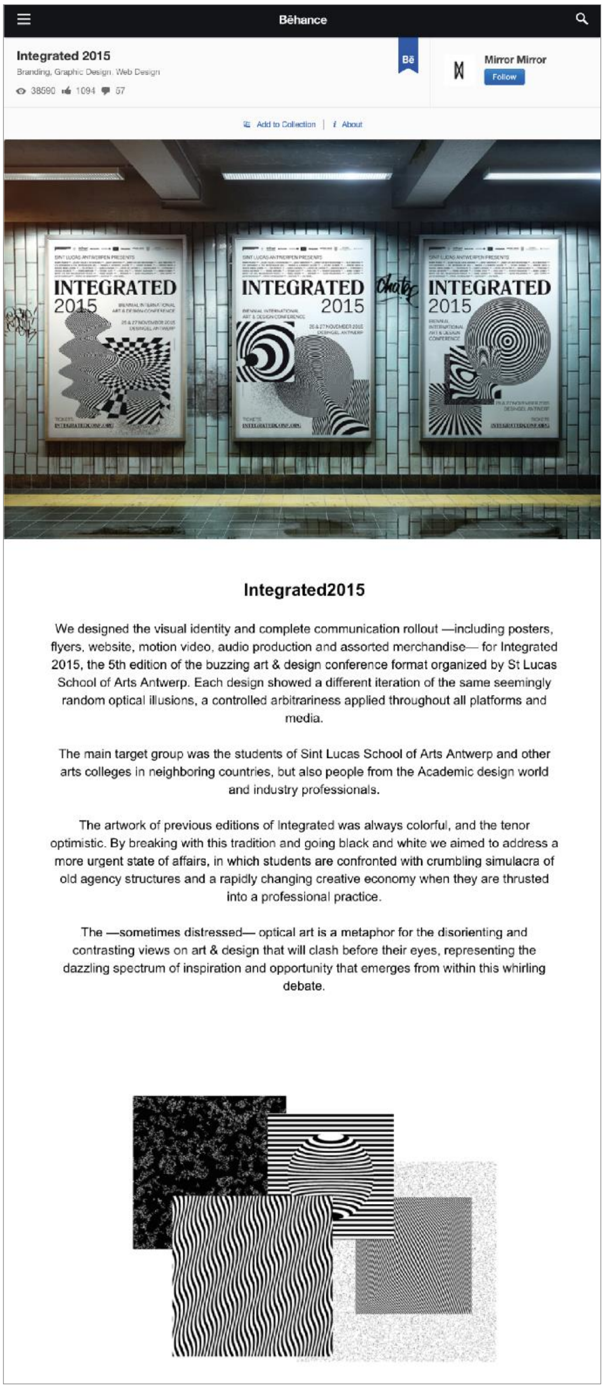

Figure 4: Behance displays projects, along with the authors, contact details, social recommendations, a description of features, design material, and examples

Earlier work (Keller et al., 2006) has characterised designers' inspirational material as either physically or digitally stored in folders. Digital material is often arranged by project, date, or purpose. Retrieving an image from the directory structure demands either manually finding it in the appropriate folder, which may not be obvious, or using a searchable keyword. Hence, digital material with inspiration potential has been used rather more for a specific purpose – such as a planned collage or mood board (Lucero, 2012) – than for explorative inspiration-seeking. Online inspiration sources have been mentioned as places to 'look up' material more than store or keep track of it. However, this behaviour most likely has changed in the wake of technological developments, as more recent work on Pinterest suggests (Gilbert et al., 2013).

2 Research Questions

Rogers (2004) highlighted a need for understanding current design practice if one is to develop new tools, theories, and methods of supporting everyday practice. Nonetheless, recent studies have not yet assessed the potential impact of digitalisation of processes and materials on the way designers work. Our main interest is related to current practice in finding, using, and storing *inspirational* material. We aim to increase the understanding of current practice and concerns related to seeking inspirational material, in order to define guidelines for tools and systems aimed at supporting designers.

Considering these objectives, we identified three main inspiration-seeking dimensions and expressed them as the following research questions:

1. Finding: What inspirational material do designers search for online? Where do they look for this material?
2. Reflection: What concerns arise in looking for inspirational material? What guides the selection or application of inspiration later in the process?
3. Keeping: How is online material organised for later retrieval? How have advances in technology affected the organisation of previously retrieved material?

3 Study Methodology

Our goal was to reach a broad range of professionals, with differing cultural, professional, and experiential background, for soliciting their views on practices. A key aim was to identify their concerns and criticisms with an eye on possible improvements and developments of tools that are better aligned with current practice. Our methodological choices build on previous research using survey-based methods to understand design practices and design thinking. Rogers, for example, presented a survey-based study wherein she identified a 'gap between the demands of doing design and the way theory is conceptualised' as one of the main issues with current system and tool design for design practice (Rogers, 2004). Others published findings from survey-based studies aimed at improving the understanding of user-centred design practice within companies and the problems that occur (Gunther, Janis, & Butler, 2001; Vredenburg, Mao, Smith, & Carey, 2002).

The Web-based survey presented here employed 53 questions on current design practice, with special focus on the participants' usage of inspiration in their day-to-day. At the beginning of the survey, we introduced the context as a 'research study regarding the decision process behind designing for the Web'. The survey included 19 multiple-choice and Likert-scale questions and 34 items in free-text form[6].

We first collected demographic data and design related background information as the years of experience in interaction/service /UI/UX/web design or similar or number of projects in parallel and per year to evaluate the design expertise of the participant. The survey was divided into two main sections: a general reflection on design habits and inspiration-seeking and, second, a part focusing on a current project of the respondent's choice, for more concrete answers. This division provides two perspectives on each participant's behaviour – the tools, processes, and sources currently used on a more general level and reflections on recent practice narrowed to a specific project.

The general design habits were situated in the practice of *'working on web interaction design projects'*. We focused on the subcategories *Reuse of own work* by asking *'Under which circumstances would you use your own work as inspiration?,'* and S*eeking inspiration* by using open questions like '*When you are confronted with a new type of project, what kind of inspiration do you look for?'* and the way these are managed, stored and retrieved. We further looked into the preferred *Choices of tools* e.g. by asking *'For what purpose do you use paper prototypes?'* within the design process.

[6] The full set of questions can be found at http://userinterfaces.aalto.fi/inspiration-in-design.

In the second part, we asked designers to choose *'an already finished Web interaction design project from the recent past'.* We further encouraged the respondents to *'review the project [since] it might help you to answer the following questions'.* The second part of the survey began with a description of that project for contextualising the following answers, including self-reflection on the satisfaction and quality of the project. We then looked at sources of inspirational influences by probing the respondent with questions like *'What kind of inspiration did you look for in this project?'*. Further, we investigated the practice of selecting among alternatives of concepts, wireframes, and layout including criteria, challenges, and stakeholders involved in the selection process.

For sampling, we used social media to reach design professionals. We distributed an advertisement via online communities such as IxDA[7] and LinkedIn[8]. The target group consisted of designers with at least two years' work experience. We informed respondents the survey was voluntary, and their data would be recorded anonymously. No compensation was provided.

Two researchers analysed the data set for respondents' suitability. Of the 61 people responding, we removed eight who did not meet these criteria and two because of incomplete answers, for a total of 51 respondents. Then both researchers independently analysed and categorized the remaining data without prior predefined coding. In a second step these emerged categories were discussed and generalized into themes as recommended in inductive thematic analysis (Braun & Clarke, 2006).

4 Results

4.1 *Respondent Backgrounds*

Most of the 51 respondents were between 31 and 40 years old, and resided in Europe. A slight majority of respondents were male (31/51), which is expectable in view of the higher number of men among practitioners in the Web design field (ALA, 2009). See Table 1 for more details on respondents' demographics.

Table 1: Demographic Data for Respondents (51 in All)

	Age-Range			Gender		Region				
Characteristics	20-30	31-40	41-50	Male	Female	Europe	Asia	South America	North America	Africa
Number of Respondents	16	28	7	31	20	34	7	6	3	1

In keeping with the target group for this survey, our sample consisted mainly of UX/UI design (27/51) and interaction design (13/51) professionals with an average of eight years of experience. An overview of their self-reported primary job and amount of experience in 'interaction, graphic, service, UI, UX, or Web design' is shown in Table 2.

Table 2: Professional Background of the Respondents

	Profession				Years of Experience		
Characteristics	UX/UI Designer	Interaction Designer	Graphic Designer	Other	2-6	7-12	13-18
Number of Respondents	27	13	6	5	21	20	10

The respondents reported working on one to six projects in parallel and between two and 55 projects per year. Nearly half of them chose a corporate Web site design as an example of a recently finished project (22/51), while a few picked a personal Web site (5/51). Other responses referred to

[7] See https://ixda.org/(2017).
[8] See https://www.linkedin.com/ (2017).

an ‘art project Web site’ (P50) or a ‘Web service redesign’ (P30). The industry the specific projects were conducted in ranged from finance (P19) to education (P16) and health care (P33).

4.2 *Finding Inspiration*

In our analysis, we compared inspirational use between previous work created by the respondents and work retrieved online. It is worth noting that, while we speak of inspiration in general, the meaning can be framed in multiple ways, which depends on the stage in the design process: (visual) reference points, design patterns, or guidelines.

Table 3: Strategies for Using Respondent-created and External Work for Inspiration (Multiple Answers Possible)

	Respondent-created	**External**
Usage	47/51	50/51
Solution Template	25/47	44/50
Learning	6/47	1/50
Look-and-Feel References	1/47	12/50
Lack of Resources	3/47	0/50

4.2.1 Using Personally Created Examples for Inspiration

The respondents’ answers reflect predominantly a reuse of functions and interaction concepts from one’s own work, as presented in Table 3.

Almost all designers reported inspiration-related use of work they had previously created (47/51). One respondent (P34, a UX consultant with 15 years of experience) mentioned that ‘similar solutions can always be applied and usually are. Problems are very rarely unique’. We found two common reasons to use respondent-created designs for inspiration: 1) reuse of the previous design as a solution template and 2) its use as a learning case.

1) Finding Solution Templates Among One’s Own Designs

Complex design problems require intensive research and evaluation, which encourages designers to turn to existing solutions, approaches, and methods. We found that previous design examples are likely to be used as inspiration if they were aimed at a similar industry, target group, or meeting similar interaction requirements. Those examples help designers to work more efficiently (13/51); for instance, *‘if the UI will have a structure similar to the old one, the old project inspires me to reuse the components and design methodology’ (P24, Student/Designer, 2 yrs)* and for ‘avoiding reinventing the wheel’ (P4, UX designer, 6 yrs). Among other reasons cited for using previous design solutions was brand-design consistency.

2) To Learn, Examining Examples One Has Created

Using one’s earlier designs as a learning case was the second most common theme (6/51). This includes ‘successful and unsuccessful cases, to learn what really works and what does not’ (P26, Graphic designer, 8 yrs). Design is undergoing rapid changes due to developments in technology and requires constant learning and adjusting from designers. Rejected designs for a design process could serve as study objects in later projects. A ‘good idea that stayed in the drawer’ (P50, Creative director, 16 yrs) can be a good starting point for brainstorming and new ideation processes.

4.2.2 Using External Examples for Inspiration

We can highlight two main aspects of using online design examples, identified by 50 of the 51 respondents: using online designs 1) as a solution template and 2) for look-and-feel inspiration.

1) Finding Solution Templates Online

Finding online inspiration for solutions to design problems was the main reported use (44/51). Identifying possible structures and improvements was mentioned as the main intention behind retrieving online inspiration material. One respondent explained: ‘First I look at similar Web sites and I take note of the things that work and look good. Then I look for [a] completely off-topic site’ (P27, Frontend developer, 8 yrs). Comparison of design solutions in the same industry help designers form general ideas about structures for new designs. In contrast, six respondents mentioned unrelated Web sites with potential to target the same audience and needs as being used to widen the design space via new structural inspiration.

Further, 35 of our 51 respondents reported having used online design examples to find trends, and 9/51 looked specifically for existing UI design patterns for addressing new design problems. This is important because design exists not in isolation, but rather amidst continuous changes in trends, technological possibilities, and user needs. We identified a strong role of online design example sources (e.g., design libraries) and online communities aiding with this need. Within the answers we observed a need for validation of one's own design, for instance respondents mentioned 'best design practices' (P36, UX designer, 4 yrs) (4/51). This involves referring to sources such as well-known company designs (e.g., Apple's) and highlights from design communities.

2) Finding Look-and-Feel Inspiration Online

About a quarter of the respondents (12/51) were seeking look-and-feel inspiration prompted by other Web designs. 'Usually I look for visual inspiration and less UX' (P20, UX/UI designer, 4 yrs) was a recurring answer. Respondents reported searching for images and visual inspiration that convey the look-and-feel targeted with the new design, from sources such as Pinterest, Dribbble, and Behance (7/51).

4.3 Concerns Related to Inspiration

4.3.1 Concerns About Using One's Own Examples for Inspiration

Using one's work as inspiration was linked to three main concerns: the inspiration has to be 1) well tested, 2) exceptional, and 3) unique.

1) The Need for Reliability

One key concern was the credibility of the work, including knowledge of the target group, as one designer described: 'it was tested properly and proved to be working well with the users' (P44, senior UX designer, 4 yrs). A third of the respondents (17/51) self-reported trust in their own design solutions as a reason for preferred reference.

2) Self-created Innovation Standards

Another driver was a desire for improved solution innovativeness. Reusing one's own design ideas is more commonplace when these represent an 'unconventional method and approach to design' (P10, UX designer, 2.5 yrs) or seem to be 'highly innovative' (P25, UX designer, 2 yrs).

3) The Inspiration's Uniqueness

A few respondents reported to avoid own work as inspirational source (4/51). The reasons presented were diverse, but most were related to the uniqueness of design problems and to the need for 'inspiration, as in ways to create something fresh and improving on [what came] earlier, com[ing] from others' (P36, UX designer, 4 yrs).

4.3.2 Concerns Surrounding Use of External Examples for Inspiration

We observed two main concerns and reflections linked to using online digital material: 1) the missing reasoning behind the observed example and 2) the need of credibility.

1) The Lack of Reasoning Behind Online Design Solution

Six of the 51 respondents highlighted attempts to reflect on the reasoning behind a certain design decision represented online. This may be related to competitors, as in *'[we] have to be better than that, understand why they've done it like that' (P4, UX designer, 6 yrs)* or *'I study them to understand what works, [to] use similar methods with my own adjustments to build a concept' (P35, designer, 7 yrs).*

2) The Need of Credibility

The second concern is reflected in statements such as *'usually I look for visual inspiration and less UX, because even if I check a competitor I can never be sure what kind of research they did […] or if they target a different group of users' (P20, UX designer, 4 yrs).* Other respondents reported that they first *'tested them and used them' (P18, interaction designer, 15 yrs)* for evaluating the quality of solutions presented online.

4.4 Storing Inspiration

4.4.1 Storing One's Own Examples for Inspiration

In the context of using examples they had created themselves, 34 of the 51 respondents reported storing previous work and earlier versions, as well as tracking the current use of designs they had created. Of these 34, 24 were using private file-organisation schemes, as in one respondent's account *'I keep a digital archive organised by client, then project, then by the phase of the project' (P29, Senior lead designer, 14 yrs).* These local files also include screenshots, reviews, and documentation of the design process conducted. Further, designers mentioned using public portfolios as a way to store the previous (best) work they had created (5/51), self-managed, and on public platforms such as Behance.

4.4.2 Storing External Examples for Inspiration

We continued by asking respondents whether and how they were keeping track of or saving external sources of digital inspiration. Of the 51 respondents, 33 answered that they save inspirational material for later retrieval. The most common way to store sources of information (12/51) was via online design platforms: Behance, Pinterest, Evernote, etc. These platforms allow users to mark an element as interesting, after which it will be added to the main area, from which it can be retrieved later on. However, some mentioned also non-design-related tools – Pocket[9], Feedly[10], and others – for saving interesting Web sites or other material on their personal devices. Bookmarks and links were the second most common way (11/51) to save references to inspirational material such as Web sites or images. These can accumulate rapidly and become hard to handle at overview level, as one respondent indicated by referring to them as 'Bookmarks. Lots of them' (P52, Creative director, 16 yrs). Nearly as commonplace were local files/folders with screenshots (4/51) or notes (6/51) about online inspiration.

5 Discussion

We intended to identify within this work how designers find, reflect on, and store digital inspirational material in the context of the increasing digitalisation of design practice. We focused on Web design practice in this study, because it represents a large proportion of current design practice. However, the research method chosen allowed us to gain more general insight into various individual-specific design practices, which extend over various branches of the design profession and amount of experiences. The somewhat limited number of participants notwithstanding, our results point to some coherent behaviour and concerns in the realm of online design practice.

5.1 From Physical to Digital Sources of Inspiration

With our study, we aimed to identify how inspiration-seeking practices have changed from those found in earlier research. We identified that the proliferation of online design platforms has caused the role of online sources to shift from 'look-up' sources alone to comprehensive tools for finding and storing inspirational material. Further, we saw a change in perceptions of online inspiration. While Keller et al.'s (2006) subjects reported that looking at other products 'was considered to be "not very creatively stimulating" (LS)' and that these are '"unethical to steal" (PR)', our results show that most designers nowadays find potentially inspiring visual material and solutions online. This was a common theme in our results independently of design field or number of years of experiences. Possible resources for this change are the increased online availability and accessibility of inspirational design material, the rapid change in (Web) design trends, and the availability of design tools and patterns shaping a new digital community of practice. More qualitative studies on

[9] Information is available (2017) at https://getpocket.com/.
[10] See https://feedly.com/i/welcome (2017).

individual design processes are needed to identify the underlying intentions and reflections on this behaviour.

5.2 Supporting Trust in Online Design Platforms

One of the main factors we observed as guiding the use of inspirational design sources is trust. Online sources are often poorly documented and referenced. Further, their credibility with regard to following of good design practices and the validity of the applied solution concepts in the use case presented is not clear. Therefore, designers frequently turn to their own design solutions for inspiration if faced with similar design problems. This is due to the certainty of these being well-tested solutions and the availability of background information, including the target group and initial requirements. Retrieving all this information for online design examples is seldom easy and forces the designers to interpret the quality of a certain design themselves.

Some of the more popular design platforms, including Behance and Dribbble, offer attempts to respond to this need by encouraging the author to add further information about the designer, design and the design process. This serves a reciprocal need: on one hand, it allows designers to showcase the quality of their work processes, and, on the other, it lets other designers follow the ideas and processes behind a certain design. In contrast, some tools to support inspirational design practice (for instance, Ember) do not provide such functionality. Here, the material collected can be extended only by personal interpretations, in the form of notes; the platform has no support for further describing elements of each design.

5.3 Reflecting Relatedness with Online Design Platforms

Another guiding factor was relatedness, the closeness of an example to the design at hand. In our study, the use cases for one's own design examples were often related to the new design – for similar solution and learning purposes. This is in line with Lawson (2004), which highlighted the need of knowing and understanding a large repertoire of design solutions to identify solution patterns, he refers to as gambits, within existing design situations. Using such related design solutions was criticised by a few designers, who stated that a new design can only come from new and fresh inspiration sources outside one's mental space. In line with that, more than half of the participants mentioned the intention to find examples addressing similar problems for solution inspiration online. As mentioned by Gomes et al. (2006) and Ford (1999), designers need a dynamic area between divergent and convergent solutions to design problems, which can be represented here by well-known solutions (one's own material) and solutions created by others. Again, online sources are often poorly documented, and their encoded requirements have to be evaluated and interpreted for appropriateness by the designers themselves. While some online design platforms support attaching further information such as purpose, target group, and intentions for the design presented (e.g., Behance, Pinterest and Dribbble), this is still only rarely observed, even though most of the respondents highlighted the use of online sources for this purpose and reported concerns about the background information available. In contrast, protecting one's own unique solutions as a competitive advantage (as referred to in the 'Results' section) as well as customer strategies would be obvious arguments against such publicly presented information. The growing digital community of practice in which designers learn, exchange ideas, and get inspired while also competing against each other for clients will have to strike a balance between these two needs if it is to increase the benefit to the whole community.

5.4 Storing Inspirations Online

One of our observations involved the popularity of using online digital portfolios and design platforms for storing inspirational material, alongside an increased use of digital tools in general. This is consistent with the hypothesis that the design process is adapting to the digitalisation of inspirational resources. The latter tendency was stronger than found in earlier studies of the topic. Whereas digital design materials used to be stored primarily for specific purposes, the technological advances in what systems allow designers to add any type of inspirational material quickly (by saving designs to collections as in Behance), group the items (for example, via boards in the Pinterest service), and load offline (in Ember) changed this perception. It supports the active collection of inspirational material by lowering the hurdle of structuring the material first. Keller et al.'s participants also mentioned the effortful retrieval of digital inspirational material as an obstacle to using digital storage options. However, current online tools and platforms offer gallery views of the content accumulated – specifiable by topic or another definition – for easier searching and retrieval of material. The functionality thereby not only allows designers to retrieve collected inspiration more easily but also supports serendipitous encounters with material. Examples are shown in figure 1, 2, and 4. In addition, some platforms support private profiles (e.g., Behance), with which users can upload material they want to store together with other digital material. The uploads can be digital material or digitalised physical material. These features speak to the first four criteria for designing inspirational collection tools that Keller et al.(2006) presented and allow designers to integrate digital inspirational material more easily into their current work practice.

5.5 Trust and Relatedness as Criteria for Inspirational Tools

In previous research, from their contextual enquiry into design practice, Keller and colleagues reported six elements as necessary considerations for designing inspirational tools (Keller et al., 2009). While computer and digital material was considered more as a means of storage and as 'look-up' inspiration, our results show that these practices have changed in recent decades. Hence, these guidelines, while still valid as presented above, should be updated in line with the current needs of design practice. Therefore, we propose extending the list of considerations for designing collection tools with the following requirement:

> 7) Support trust and relatedness
> By augmenting a design solution and material with additional information such as author, purpose, method, and approach used, designers are able to better understand and evaluate the quality of a given design as inspiration for their current purpose.

6 Conclusion

For this paper, we aimed to identify changes in design practice relative to that presented in earlier studies, with a focus on digitalisation-prompted change, especially with regard to digital inspiration. We looked at the changes in inspiration-seeking and material-saving practices and at concerns related to these practices. Comparing our findings on this topic to earlier results, we identified increased use of online material that inspires visual and problem-solving strategies. This development is not uncriticised by the design community. For example Santos (2016) points out that centralizing digital design sources in platforms like Dribbble, could create a general idea of 'good design' resulting in an increasing number of homogeneous design solutions. The positive and negative attention this article received reflects the critical discussion accompanying the shift towards digital design material.

However, the diversity of reactions might rather reflect the use of inspirational material depending on individual design expertise as elaborated in Lawson and Dorst's (2005) model. Within the initial expertise levels, from a novice to a competent designer, first rules, guidelines and examples are followed, then understood and finally abstracted as design schemata representing complex ideas. This requires designers to collect a large repertoire of design solutions to identify such solution patterns, which Lawson (2004) called gambits, within existing design situations. These skills enable designer to create situated design solutions through strategic thinking. The following levels of expertise diverse in their originality and innovativeness of solutions depending on the ability to increase and abstract presented design solution precedents to the current design situation and the personality and ambition of the individual designer. The role of inspirational material and its impact on the final result hence depends rather on the designer's ability to contextualize a presented design solution and to situate it in the solution space than the material itself.

Increasing the designers' repertoire and understanding of precedent solutions, schemata and gambits (Lawson, 2004) would hence support designers to extend their expertise. This correspond to our result where we identified a general need for additional information about designs that go

beyond the visual aspect. Hence, we offer an extension to Keller et al.'s guidelines for designing inspiration-collection tools with the requirement of supporting trust and relatedness. This could refer to additional information such as the author or work process but also encompass the target groups and intended purpose of a design. While that would support learning and exchange within this community of practice (Wenger, McDermott, & Snyder, 2002), designers using online design platforms are not only virtual colleagues; they are also competitors for originality and work. Identifying solutions that could strike a balance within this dichotomy of interests is a promising direction for future research.
Understanding designers' needs, along with concerns related to design in general and collection of inspiration material in particular, could also inform more sophisticated design tools. The trend of developing design-supporting systems is likely to generate more and more systems and machines that act as collaborators on common projects, acting together with the designers. For instance, in recent work, Woodbury and colleagues (Woodbury, Mohiuddin, Cichy, & Mueller, 2017) presented a parametric modelling tool that enables a machine to suggest design alternatives in the form of a gallery. However, for extending current work and building fully legitimate design partners in such an interactive scenario, scholars such as Koch (2017) have highlighted the need for a better understanding of the design process for development of intelligent collaborative machines. While Rogers (2004) underscores the need for more design-practice knowledge in HCI, Koch interprets this knowledge and looks at the design skills, knowledge, and behaviour required for an independently acting, collaborative design system. This paper is a step in a promising direction. In a world with burgeoning diversity of inspiration, sources of it, and connectedness, the need for credibility and relatedness of inspiration sources is a more important topic than ever before.

Acknowledgements: This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement 637991).

7 References

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An Ontology of Computational Tools for Design Activities

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doi: 10.21606/dma.2018.456

While able to automatically generate and optimise designs for variables provided by a designer, today's computational design tools do not specialise in the earlier, more tacit tasks such as gathering and sorting disparate information or generating hypotheses and identifying novel directions. This paper presents a review of computational technologies that could potentially play a role in these early stage design activities. Using a framework that deconstructs design activities into underlying tasks, an ontology that reviews the various computational tools that could be applied in these activities was created. Computational technologies such as neural networks and stochastic algorithms were found to provide features that could potentially allow for discovering and linking new information together in order to provoke the – often unexpected – inspiration that can guide designs in the latter phases of development.

computational design tools; creativity support; early design process

1 Introduction

Since the mid-twentieth century, computation has become increasingly intertwined with design, from abstracting the craft of the design process into models that use a more algorithmic logic (Alexander, 1966), to the development of automated Computer Aided Design (CAD) software that explores and optimises the range of different values a set of design variables could have (Papanikolaou, 2012). The paradigms of computation used in the design process have changed dramatically throughout the development of CAD technologies. Early tools such as Pro/ENGINEER allowed engineers to set clear parameters and relationships between a database of features, requiring designers to explicitly plan and describe their 'design intent'. In comparison, newer direct modeling CAD systems such as Autodesk Fusion 360 allow forms to be 'sculpted', enabling designers to integrate more of their implicit intuition into their creations (Tornincasa & Di Monaco, 2010).

Despite these advances, CAD tools are still more applicable to the latter, rational stages of the design process and less useful early on, where intuition is used to re-interpret a design situation, build analogies and look for emergent ideas (Bernal, Haymaker & Eastman, 2015). Emerging today are advanced computation techniques that could contribute to some of these more human-centered problem solving activities; design solutions can be generated and optimised to a set of input variables using genetic algorithms, and evaluative systems can derive inferences and insights from data using statistical models (Sjoberg, Beorkrem & Ellinger, 2017).

How far is it possible for these new computational techniques to play a role in the tools used in the design process? This paper will review a range of computing technologies and suggest how they might relate to the design process now and in the future. Establishing the opportunities and challenges of integrating computational tools into the early stages of the design process, we describe an approach through which to identify potential computational technologies relevant to design activities. We then offer an ontology of computational tools for design, considering the capabilities of these tools by reviewing several case studies that offer new technical approaches as part of their creative process. Highlighting a few of these computational tools, we conclude by considering how they might be applied to tools fitting the early phases of the creative process.

2 Computing the Design Process

Computation—both as an epistemological framework and a digital technology—can be a powerful tool. Despite the increasing use of computational tools in design, their limitations at engaging with tacit knowledge and abstract definitions mean they are only sparsely used in the early stages of the creative process. This section reviews the various phases in the design process to consider what types of activities are carried out in the early stages, and presents an approach to deconstruct these less rational activities to understand if it is possible to map new computational technologies to them.

2.1 A brief review of the literature

There has been much research into defining the many phases and activities of the design process; Dubberly (2004) collected a staggering 88 of them. This is partly due to the fact that design can have many meanings; no longer just focusing on the aesthetics of an industrially produced artifact (McCullough, 1998), the design methods movement expanded the definition of the design process to include the activities of design research and idea generation (Michel, 2007).

However, as this plethora of different approaches shows and as commented on by Wynn and Clarkson (2005): "there is no single model which is agreed to provide a satisfactory description of the design process [and] no 'silver bullet' method which can be universally applied to achieve process improvement." Despite this lack of agreement, the many attempts to review and synthesise the different models into an overarching taxonomy (Mendel, 2012; Wynn & Clarkson, 2005; Design Council, 2007) generally divide the overall design process into four phases—discover, reframe/define, envision/develop, and create/deliver—that are often concurrent and cyclical (Lawson, 2006; Schön, 1983; Blessing, 1994). In the discovery phase, designers build on initial hunches to collect diverse information and intuitively structure the often disparate data to reveal patterns and gather insights. In the reframe/define phase, designers use their imagination to juxtapose the information in non-obvious ways to "reveal new salience, relationships, and meanings" (Mendel, 2012). These opportunity areas are the focal points for envisioning new designs, i.e. the creative brief to guide the next phases. Potential solutions or concepts are generated and evaluated in the next envision/develop phases, converging from many extreme envisionings to a few more concrete forms and final solutions in the final create/deliver phase.

Throughout these phases, designers change from considering concrete information to more abstract interpretations then back (Fulton Suri, 2008). Especially in the early phases that focus on design research and idea generation, designers bridge "the space in-between research and concept" (Robinson in Dubberly & Evenson, 2008). Moving between analysis and synthesis, designers use abductive reasoning to translate models about what the current situation is into a preferred future of 'what could be' through creating and playing with abstract concepts (Steinfeld, 2017).

This focus on abstract interpretations may explain why computational tools are rarely used by designers in the early phases. Taking Gero's (1990) definition that design "can be modeled using variables and decisions made about what values should be taken by these variables", we suggest that it is in these first two phases—where intuition and playful exploration guide the creative leaps that synthesise information in new ways and “liberate thinking from old habits so as to break through to the Aha! moment of inspiration” (Schneiderman, 2007)—that the ‘variables’ that guide the rest of the design process are defined (Fulton Suri, 2008; Pahl & Beitz, 1996, in Wynn & Clarkson, 2005).

The latter stages which assign values to these variables involve a more well-bounded deductive process that is much better suited to current computational tools that can iteratively test huge numbers of different values for those variables (Steinfeld, 2017; Papanikolaou, 2012). In comparison, the early phases contain more tacit problem-solving activities, such as collecting diverse information and reframing it in novel ways, that are not served by many computational tools. Figure 1 shows this dearth of computational tools in the activities in the early phases of the design process, underlining our premise and the need for this review of technologies that could inform future CAD tools.

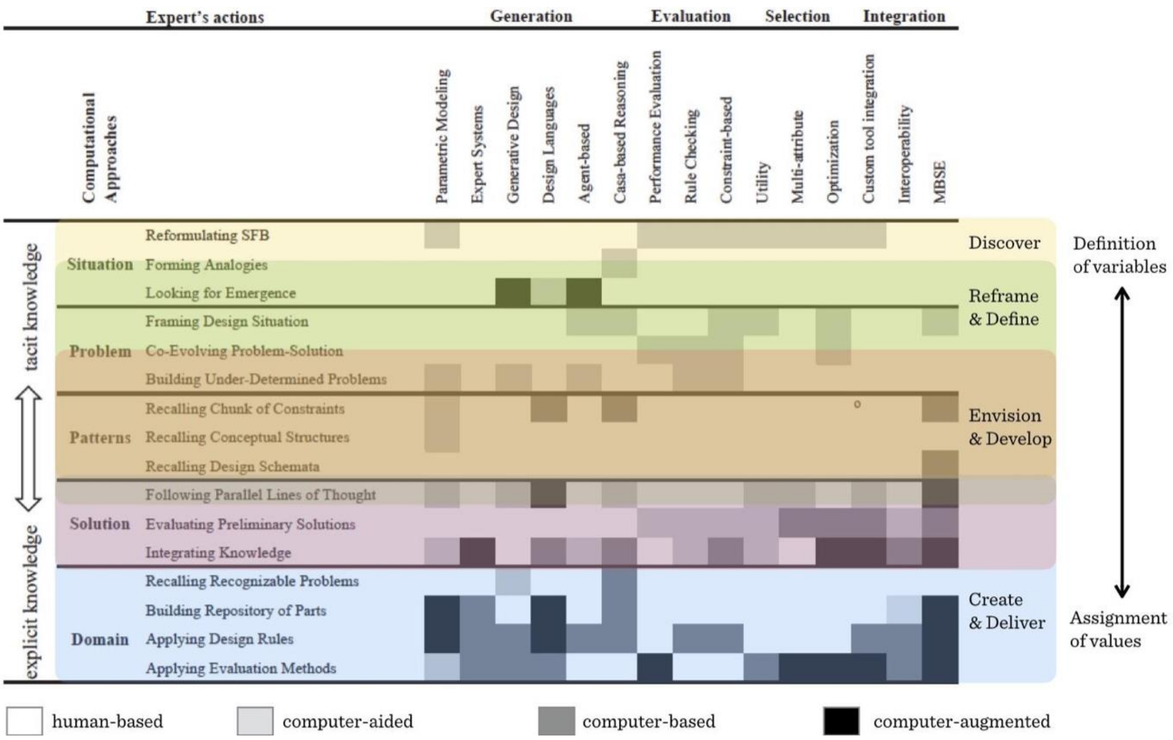


Figure 1. Bernal et al’s (2015) diagram of human and computational tools available for the ‘actions’ in the design process with additional coloured bands added to show the four overlapping design phases

2.2 An epistemological framework for understanding the role of computational technologies in the design process

Considering the lack of computational tools that exist in the early phases of discover and reframe/define, what approach might help us understand how to meaningfully utilise these new tools? CAD tools today specialize in the automatic generation and optimisation of the values for a set of variables defined by the designer and related through an explicitly understood and code-able algorithmic logic (Loukissas, 2012). In comparison to this very structured affordance, the meandering ad hoc experiments carried out in the early creative process appear abstract and loosely defined (Mitchell, 1993; Schön, 1983). These discrepancies highlight the challenges—and opportunities—of applying computation in the early stage of the design process.

However, some of the fundamental attributes of computation and design tools are closer than we might first imagine. A tool is not merely a utilitarian instrument; it can be any physical, digital, or co-nceptual mechanism that enhance our design abilities (McCullough, 1998). And while many modern computational design tools are indeed digital, computation can be more broadly considered as a process to “reckon things together” (Yalınay-Çinici, 2012) using ‘algorithms’ that are simply sets of instructions (Algorithm, n.d.). In our view, a computational design tool is therefore an aid that uses a somewhat defined set of instructions to guide the process of designing something, and hence can include anything from the rules of brainstorming to a complex optimizing CAD program.

This somewhat rationalist approach has been taken further by other researchers such as Simon (1969) who strove to integrate cybernetics into the design process. We agree with Margolin (2002) that this very positivist view of the design process is “too remote from actual design situations” and overly mechanistic models of prescribed activities can actually be restrictive to creativity due to their lack of generality (Wynn & Clarkson, 2005; Finke, Ward & Smith, 1992; Schneiderman, 2007). However, we also believe that computation can be a powerful tool—especially new technologies such as machine learning that use a more systems-based approach—and developing strategies to reveal patterns of logic within even the most tacit design activities can help identify areas where these more rational functionalities can potentially enhance our creativity.

Analysing how tools can be used in the design process, Spier (1970) writes: “The use of an artifact is direct and immediate and may be profitably distinguishable from function. The use of a pencil is to make marks on suitable surfaces; its function is to communicate ideas and sentiments.” This breakdown is not dissimilar to the ‘three levels of analysis’ models used to describe perception in cognitive psychology (McClamrock, 1991), where a much larger goal, e.g. communication, is contributed to by smaller tasks, e.g. mark making, and low-level tools, e.g. a pencil. Although this approach breaks down a design activity into the underlying elements, we do not consider this an overly cybernetic model; the affordances of a particular tool may have a certain functionality, but it’s output and application can be flexible depending on how it is used by the designer, thus incorporating the more ad hoc principle of bricolage that is more readily used in early phases.

Taking inspiration from this balanced approach to modeling the design process, we propose the following as an epistemological framework for designers and researchers to more easily understand how computational tools might be applied in various activities in the design process:

- **Design activities** i.e. ‘what’ is being carried out in the design process. Identifies the higher-level activities in which the overall problem or goal is described but not the underlying structures for how it might be achieved. As a designer, you might consider: “The goal of this [design activity e.g. mood board development] is to use [inputs e.g. extreme design themes] to generate [outputs e.g. extreme concept mood boards]...”
- **Design tasks** i.e. ‘how’ the design activities will be achieved by breaking down the activities into a series of specific tasks, e.g. an algorithm. These tasks describe actions that can be carried out but do not detail the exact tools that will be used. A designer might add to the above sentence by considering: “... using [design knowledge, e.g. contextual understanding] and [specific processes, e.g. image search]…”
- **Design tools** i.e. ‘what’ will be used to execute the design tasks. The tools (physical or digital) that can be used to many different design tasks and therefore contribute to a range of design activities. A designer might add to the above sentence by considering: “... with [specific media, e.g. fashion magazines, and tools, e.g. Pintrest]”

We believe this could be an instructive and generative framework for considering the potential of computational tools throughout the design process. The following sections use this framework to review the design activities and tasks present in the creative process, and identify a range of computational tools that can be used in these activities.

3 Defining the design activities in the early creative process

A collection of the activities and tasks within the discover and reframe/define phases of the design process as referred to in the literature is shown below in Figure 2.

Author	Discovery phase design activities and tasks	Reframe/define phase design activities and tasks
Alexander (1961, in Dubberly, 2004)	Understand context from actual world *Create mental model of context*	Connect mental models to visual stimuli *Create and connect visualisations of contextual mental models to visual stimuli*
Banathy (1996, in Dubberly, 2004)	Create divergence of information and ideas from an initial genesis *Create alternative images*	Converge information by envisioning possible futures *Create alternative images* *Synthesize and hypothesise image of future system*
Bernal (2015)	Frame the focus of interest Rapidly identify relevant aspects of a problem *Forming analogies* *Looking for emergence*	Shift the direction of design development *Analogy* *Trigger unpredictable inferences* *Reformulation* Frame the design situation
Cross (1990, in Dubberly, 2004)	Decompose the existing situation *Break existing information into constituent parts*	Recompose into a new situation *Reassemble the parts in a new way*
Darke (1978, in Dubberly, 2004)	Collect and generate information	Conjecture new ideas from that information
Doblin (1987, in Dubberly, 2004)	Gather information *Carry out interviews, data searches, field research* Structure the information *Create lists and matrices of data*	
Dubberly & Evenson (2008)		Devise stories about what could happen *Create hypotheses* Model alternatives *Create imagined speculative alternatives*
Finke (1992)	Generate diverse and novel information *Find associations* *Find attributes and infer functions* *Reduce information into categories and exemplars* Find novel interpretations *Shift contexts to reframe information* *Find incongruous info to inspire new understanding* *Find what won't work by finding limitations*	Allow new and unexpected features to emerge *Use analogical transfer, contextual shifting and conceptual interpretation to find new meanings* *Keep ambiguity in the information to allow for reinterpretation* Synthesise and transform information into new ideas *Create conceptual or verbal recombinations*
Fulton Suri (2008)	Collect information from many interpretations *Consider information from empathic, speculative, and interpretive views as well as descriptive and factual.* *Reference analogous situations* *Find extremes and boundary conditions* Learn from subjective experiences and interaction *Integrate personal perspectives from yourself and the team as well as externally* *Challenge interpretations* *Build on information responsively*	
Gero & Maher (1993)	Consider idea from first principles Reframe ideas *Consider information analogies several levels of abstraction away from the original context*	Reinterpreting the existing design *Mutating the features of the original information* Recombine ideas in surprising new ways
IDEO (2004, in Dubberly, 2004)	Gather information through observation *Use shadowing, behavioural mapping, consumer journey, extreme user interviews, story telling to gather and represent information about the project*	Use brainstorming to generate and reframe ideas *Create a large quantity of ideas* *Build on ideas and make them wild* *Represent the ideas in a visual way*

*Figure 2. The design activities and tasks in the discovery and reframe/define phases (activities in **bold**, tasks in italics)*

Author	Discovery phase design activities and tasks	Reframe/define phase design activities and tasks
Jones (1970, in Dubberly, 2004)	Explore the design situation	Perceive or transform the problem structure *Consider alternatives (combine with other elements, new concepts, partial substitution, reduction)*
Lawson (1980, in Dubberly, 2004)	Identify the first insight Prepare for new ideas by exploring that initial insight	Allow for incubation of that information Provide tools to provoke and highlight the moment of illumination
Mendel (2012)	Gather disparate sets of data *Collect information in a semiotic framework/database (labeling and tagging, etc)* *Create structural schemes and frameworks for organising and juxtaposing (bi-polar axes, dimensions, grids, matrices, persona models, etc)* Create questions about the data	Understand relationships and gaps Consider data from multiple perspectives *Deconstruct data and relationships and recombine* *Compare data to similar and dissimilar aspects* *Visually map information in ways to reveal new salience, relationships, and meanings*
Polya (1945, in Dubberly, 2004)	Find and sort the unknown data *Introduce suitable notation* *Separate the various parts of the information*	Find the connection between data and the unknown *Find related problems* *Restate the problem differently*
Schneiderman (2007)	Gather information *Exploratory search of previous and related work* *Create mechanisms for organizing search results* *Use tools for annotation, tagging, and marking* *Find distributions, gaps, and outliers* Draw on knowledge from other designers Rapidly generate multiple alternatives	Explore implications Generate hypotheses Produce some initial ideas Draw on opinions from other designers

Figure 2 cont.

A summary of the main design activities and tasks related to the discover and reframe/define phases are described in Table 1. This list is not proposed to be exhaustive; they are merely 'primary generators' (Darke, 1979) to act as a guiding structure for analysing which computational tools may have potential in the early phases of the design process.

Table 1. Summary of the main design activities and tasks related to the discover and reframe/define phases

Design phase	**Design activity**	**Design tasks**
Discover	Gather disparate information	• Use initial insights to find related information • Think about initial insights and information in different contexts • Create divergence using associations, abstractions and analogies
	Sort information	• Collect information in a way that allows easy analysis and comparison, e.g. annotating, tagging and database structures • Decompose information into related attributes/categories • Use structure and categories to look for patterns and questions
Reframe/ define	Generate hypotheses	• Present and recompose information in many representations (word/image) to create stories for possible design alternatives • Allow for ambiguity in these hypotheses to encourage multiple interpretations
	Identify novel directions	• Use analogy or different contexts to interpret information in new ways • Recombine/mutate/substitute the information in new ways to create wildly unexpected inferences and moments of illumination

4 Computational technologies relevant to discovery phase activities

Drawing inspiration from several real world design projects, this section reviews the computational tools that could be applied to execute the tasks in the design activities described in Table 1.

4.1 Design activity: Gather disparate information

4.1.1 Design task: Use initial insights to find related information

The discover phase involves searching for and organising the information related to a design situation in unexpected ways; tasks that even advanced optimising parametric CAD tools such as SolidWorks or Autodesk Dreamcatcher do not provide extensive support for (Bernal et al, 2015). The computational tool that designers often use to help them find information related to their initial prompt is the now ubiquitous semantic search engine such as Google. In this technology, the machine learning technique of dimensionality reduction abstracts a large database that uses many dimensions to connect all of the information into a smaller, more manageable set of key features using linear and non-linear mapping (Barysevich, 2017); not dissimilar to how designers navigate the information related to their projects to learn from related fields (Finke et al, 1992; Mendel, 2012).

A tool that can execute these operations on a corpus of text, and one that forms the basis of many Natural Language Processing tools, is word2vec (www.tensorflow.org/tutorials/ word2vec) (Mikolov et al, 2013). Words are assigned a number based on their connection to others, forming a vector that can be used to compare words in different contexts and find similarities through it's direction and location. A similar strategy can be used to compare images, with a popular algorithm being t-SNE (Maaten & Hinton, 2008); Figure 3 shows how sketches from Golan Levin and David Newbury's (2018) Moon Drawings project can be sorted into similar styles (McDonald, 2016).

Taking this further, Yossarian ([www.yossarian.co)](www.yossarian.co) adds a 'metaphorical distance' to this vector to return connected words and images with a more diverse interpretation of the initial word and image input by the designer (Figure 4). The details of the technology are not public, but we postulate it does this by adding a factor to change the distance or direction in the vector mathematics connecting the entities in the database. Working with poet Helen Mort to help provide inspiration to write a poem a day ("Helen Mort's poetry challenge with Yossarian", 2015), Yossarian allowed Mort to more quickly connect diverse themes, a crucial part of the early creative process (Minissale, 2013). This computational tool of dimensionality reduction with a vectorising factor to extend the metaphorical search capabilities could therefore potentially help designers find unexpected information in their search activities, leading to more novel design solutions.

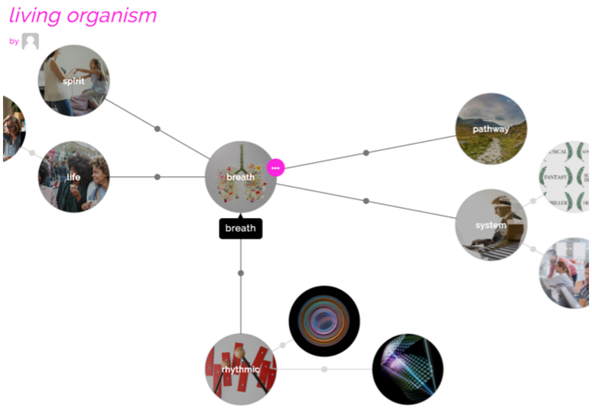


Figure 3 (left). MacDonald's (2016) sorting of Levin and Newbury's (2018) Moon Drawings project sketches
Figure 4 (right). Yossarian metaphorical search engine

4.1.2 Design tasks: Think about initial insights and information in different contexts & Create divergence using associations, abstractions and analogies

Traditional CAD tools often use very structured procedural knowledge and pre-defined geometric relationships to automate certain actions (Bernal et al, 2015), e.g. automatic patterning of shapes in SolidWorks or Adobe Illustrator. This limits the ability of these tools to integrate analogical information into their operations; an important feature to allow for divergent thought and idea generation (Gero & Maher, 1993).

Computational tools with this ability are the machine learning techniques such as convolutional (CNN) and recurrent (RNN) neural networks that are prevalent in image and language processing tools such as IBM's cognitive system Watson. CNNs are useful for image recognition as, after 'learning' patterns from a large training set of tagged images, they can distinguish parts of images related to different categories. RNNs use feedback systems to help them continually learn about the information they are training on and modify the patterns they are seeing, making them very good at parsing and generating new text.

'Living Sculpture' by SOFTLab is a project that used these tools to broaden the perspective of the designers while exploring and identifying trends in the materials, shapes and colours that Gaudi used in his work to influence development of a new sculpture (Lewis, 2017a). Feeding hundreds of tagged images of Gaudi's work, Barcelona and its culture into Watson's Visual Recognition tool taught the system how to recognise the components of those images that 'looked' Gaudi-esque and those that didn't. The system could then compare them to other unrelated images in the database to see if there were any similarities, e.g. it recognised that many of the Gaudi images had depictions of spiders in them. Similarly, Watson's AlchemyLanguage tool analysed various documents about Gaudi and his work as well as Catalan culture, nature and design to identify the most prevalent keywords and concepts. The concepts highlighted using these tools included objects such as 'waves', 'arches', and 'spiders' which were very obvious to the designers familiar with Gaudi, but Watson also helped identify less immediately apparent but very inspiring connections such as the forms, materiality and colours of 'crabs', 'shells' and 'candy' (Wiltz, 2017). The similarity of SOFTLab's work to these elements in Gaudi's designs can be seen in Figure 5 below.

SOFTLab designer Michael Szivos described how Watson's cognitive tools helped them to carry out the tasks they normally do without computers in the early conceptual design stage of a project such as "look at references and try to extract fundamental ideas that we then re-translate into a specific project" (Lewis, 2017b). Integrating these computational tools of CNNs and RNNs into design tools could help designers to not only expand the initial information they were exploring but also quickly parse it to identify both expected and unexpected findings.

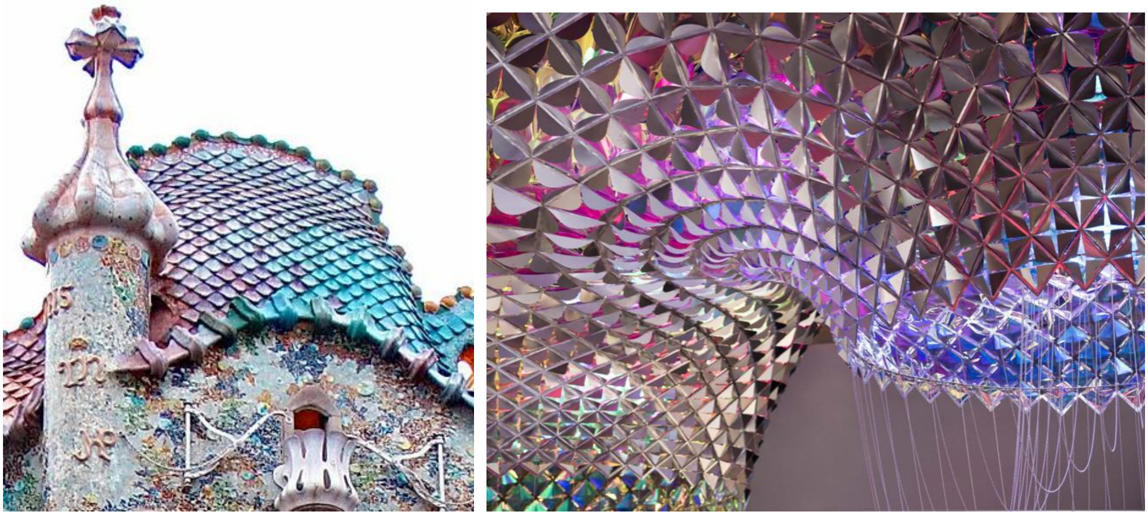


Figure 5. Gaudi's Casa Batlló (left) by Amadalvarez (CC) and SOFTLab & IBM's Living Sculpture (right) showing similar iridescent patterns (SOFTLab, 2017)

4.2 Design activity: Sort information

4.2.1 Design task: Collect information in a way that allows easy analysis and comparison, e.g. annotating, tagging and database structures

Computer assisted qualitative data analysis (CAQDAS) tools to aid the tagging (or coding), sorting and analysis of information collected during research in a design project, such as ATLAS.ti and NVivo, allow researchers to search and pull out common themes from their data, but also require a very manual coding process (Saldana, 2009); the computational tools described above, on the other hand, only require some of the data to be tagged. A subset of these techniques called unsupervised learning algorithms help automate this process; tools that use CNNs and RNNs, such as the Clarifai application (www.clarifai.com), can learn from a training set of data to automatically tag a wider corpus of images or video and understand the categories present.

Overlapping coding with other stages of the research process can help generate new hypotheses (Eisenhardt, 1989). What if the tools that helped us code the research could also inspire new ideas? An interesting development of this technique created by Fito Segrera is The Treachery of [Soft] Images (2016); a homage to Magritte's painting of similar name where an image of a pipe is described as not being a pipe. Here, images found on the internet are put through a neural network that labels them with humorous—and potentially very inspiring—misinterpretations.

4.2.2 Design tasks: Decompose information into related attributes/categories & Use structure and categories to look for patterns and questions

Traditional CAD systems such as SolidWorks often require a design to be decomposed into its underlying attributes, often limited to geometric properties, in order to store and relate them to each other parametrically, e.g. specifying the points which make up a curve (Tornincasa & Di Monaco, 2010); the decomposition required in the early design process requires different computational tools to identify attributes, find patterns and inspire related categories.

As with the projects described above, it is the combination of CNNs with a dimensionality reduction algorithm that can help decompose and structure the text and image-based information used early in the design process. One such tool is t-SNE (Olah, 2014) which allows an image to be assigned a numerical description associated to the different categories that it is related to. This numerical description can then be compared to others and the images grouped on their visual and contextual similarities (as Karpathy (n.d.) has shown in Figure 6). Taking this further, McDonald (2016) has used t-SNE to place all of the underlying categories of the images in a database next to each other, showing what objects are often found in similar contexts despite being visually different, e.g. pill bottle, band aid and lipstick are grouped closely due to them being found in bathrooms (Figure 7). These tasks—understanding the underlying attributes of images and sorting them based on their classifications—are currently very human-based; integrating this computational technology into a design tool could help designers more quickly structure their research into constructive categories.

Figure 6 (left). Karpathy's (n.d.) visualisation of the similarity of images
Figure 7 (right). McDonald's (2016) representation of the similarities of image categories

5 Computational technologies relevant to reframe/define phase activities

5.1 Design activity: Generate hypotheses

5.1.1 Design tasks: Present and recompose information in many representations (word/image) to create stories for possible design alternatives & Allow for ambiguity in these hypotheses to encourage multiple interpretations

In the early phases where ideas are being defined, designers often imagine how the information collected in the discovery phase could be considered and recombined in new ways to inform future design solutions. Creative writers and artists have often used tools that incorporate chance to provoke ambiguity or absurdity and help them to generate new possibilities for their work (Gaver & Dunne, 1999; Dorin, 2013). Accessing the higher powers through the I Ching, the ancient Chinese method of interpreting a divination text through the random throwing of sticks or dice, has also been used to inspire creative paths for artists such as John Cage and Philip K Dick (Mountfort, 2016).

Computational tools that integrate these chance processes to provoke new design ideas include story generator algorithms (Gervás, 2012) where a predefined structure of a short story or letter or plot is randomly assigns nouns, verbs, adjectives etc. provided by the user into appropriate places (https://www.plot-generator.org.uk/). Despite being so simply structured and often generating ridiculous, unrefined compositions, the ambiguity of the output creates very unexpected and inspiring juxtapositions of concepts and themes. Taking this further, the short film Sunspring used a RNN machine learning algorithm to learn the structure and style of sentences used in dozens of sci-fi screenplays and then generate the content of the script from scratch (Newitz, 2016).

Applying these tools to the design process, these combinatorial technologies could also be used to "trigger unpredictable inferences" in the early phases of the design process (Bernal et al, 2015). Inspired by similar tools that use chance such as Eno and Schmidt's (1975) Oblique Strategies, we developed a website (designhumandesign.media.mit.edu) that uses a stochastic algorithm to recombine variables related to the designer's research into a creative prompt sentence, e.g. "Design [an object, a website, an image, etc.] inspired by [cameras, fashion, healthcare, etc.] that is [approachable, contrasting, responsive etc.] through [personas, layouts, textures, etc.] using [foam, paint, collage, etc.]" (Mothersill & Bove, 2017).

Considering how we might recompose information related to images, much can be learned from the field of data visualisation (Tufte & Robins, 1997). CAQDAS systems integrate some simple visualisation features but are limited in the creative explorations that designers require in these early phases (Bhowmick, 2006). Data visualization artists such as Jared Tarbell have created tools that explore more creative ways of representing data using computational processes that randomize the fonts, sizes and positions of text and images (Figures 8, 9 and 10). These computational tools could help designers juxtapose unexpected concepts from their research by allowing them to intuitively 'find' the elements that inspire them, like gazing at Leonardo's paint stained wall that inspired deliberate accidents (Turner, 2011) but with more purposeful information embedded in it. These visualisations could even become an immersive experience as CAD systems that integrate virtual and augmented reality technologies become more readily available (Arnowitz, Morse & Greenberg, 2017).

Figure 8. Cylinder Image Display by Jared Tarbell (http://www.levitated.net/daily/levCylinderImageDisplay.html)

Figure 9 (left). Text Space by Jared Tarbell (http://www.levitated.net/daily/levTextSpace.html)
Figure 10 (right). Emotion Fractal by Jared Tarbell (http://www.levitated.net/daily/levEmotionFractal.html)

5.2 Design activity: Identify novel directions

5.2.1 Design tasks: Use analogy or different contexts to interpret information in new ways & Recombine/mutate/substitute the information in new ways to create wildly unexpected inferences and moments of illumination

Once the diverse information related to a designer's initial ideas has been collected, and categories have been identified and presented in novel ways, it must all be synthesised into original ideas that can guide the design as it is developed. These new ideas often come from reframing, recombining or mutating the original information and categories into new contexts or interpretations (Gero & Maher, 1993). Despite the real-time manipulation and generation that direct modelling and generative CAD tools such as Autodesk Fusion 360 and Dreamcatcher respectively offer, they merely present a range of options that hope to provoke the 'Aha' moment of inspiration; the human designer is still needed when engaging with these tools to think critically about what is being designed and 'nudge' the algorithm in the preferred direction (Bernal et al, 2015; Bruner, 2016).

The lack of accuracy in predictions generated by the computational tools discussed above can actually help provoke a more inspiring range of design ideas related to the information collected in the discovery phase. Google's Quick, Draw! App (https://quickdraw.withgoogle.com/) is a tool that runs a CNN in real time while the user is sketching a picture and offers many speculative guesses as to what is being drawn (Figure 11); like a game of Pictionary. As the system continually provides guesses of incomplete images, the user is presented with a range of interpretations not associated to the initial intent of the drawing. This creative misinterpretation is not an unfamiliar activity in the design process; a designer's colleagues may see a half drawn sketch and interpret it as something different to the designer's original intent, often inspiring a new idea for their design (Stacey, Eckert & McFadzean, 1999).

Taking this idea further, the AutoDraw app (https://www.autodraw.com/) guesses what the user might be drawing and then uses CNN to find many different illustrations of a similar context from a database (Figure 12). Again, this offers the designer an interesting real time interpretation of the information they are inputting into the system. Adding RNN to this tool, as in Magenta's sketch-rnn demo (https://magenta.tensorflow.org/sketch-rnn-demo), allows these alternative illustrations to be generated from the actual sketch that the user draws (Figure 13).

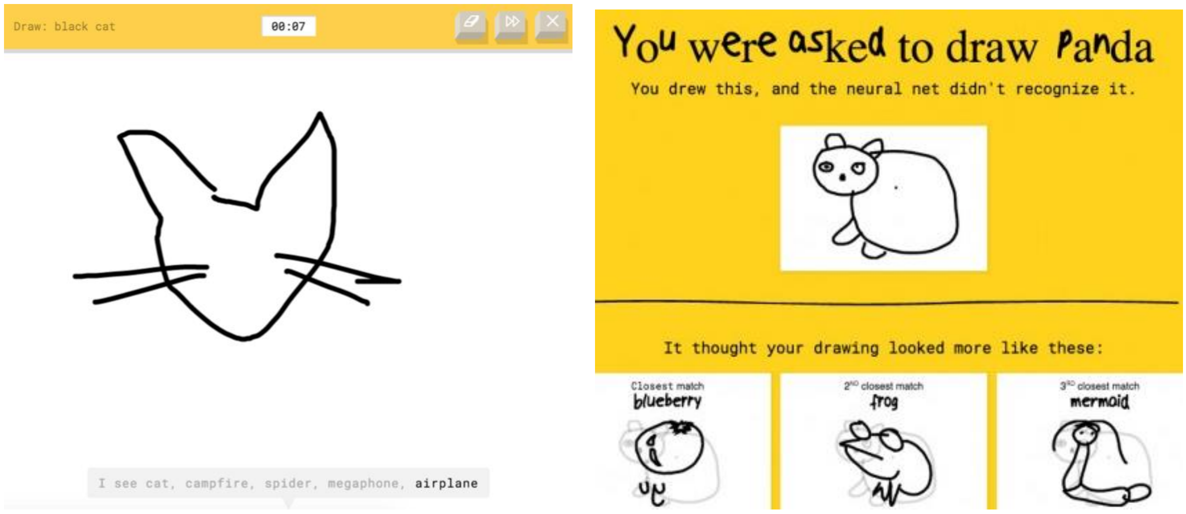


Figure 11. Google's Quick, Draw! app showing interpretation of a cat sketch also as a spider, airplane, campfire, etc.

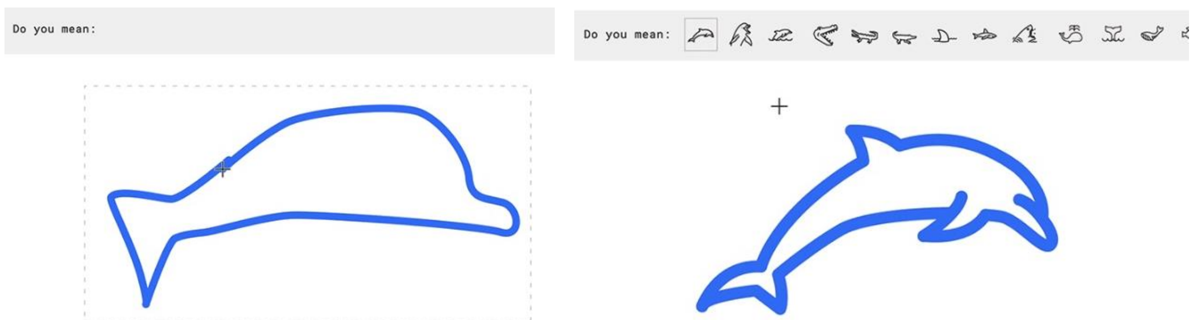


Figure 12. AutoDraw suggesting alternative illustrations for a sketch of a dolphin

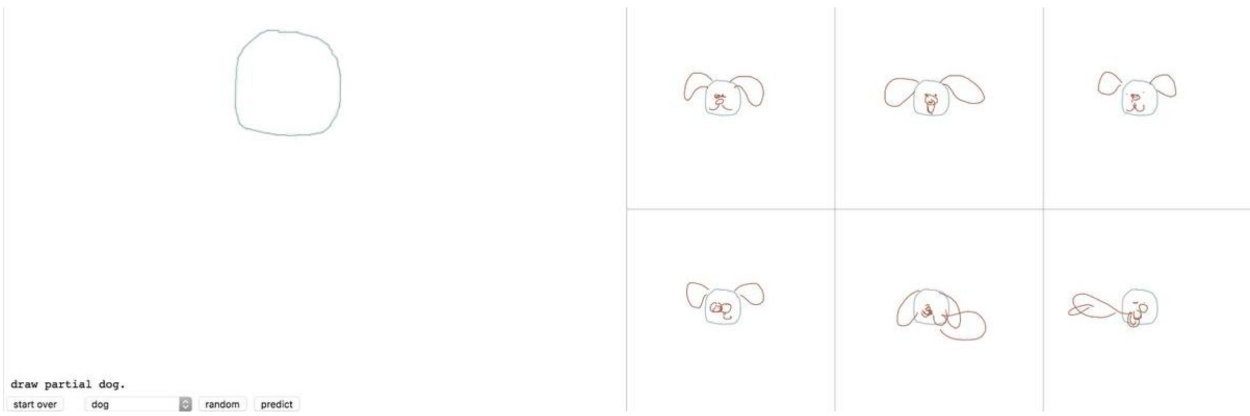
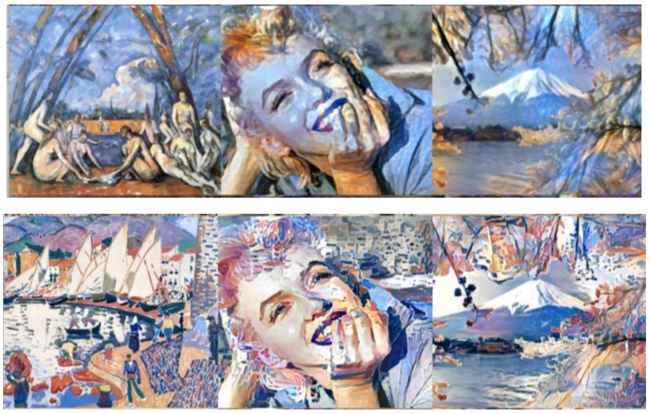


Figure 13. Magenta's sketch-rnn generating sketches of a dog from an initial basic sketch

A more advanced version of these sketching tools are the style transfer algorithms like Google's DeepDream that have become popular in the last few years (Steinfeld, 2017). In these "design by example" tools, CNNs are used to detect the set of context and style features in different images and a feedback technique is used to slowly change the style features of one so that the difference between the two images is reduced (Tejani, 2016). McDonald (2016) has explored this technique extensively, transforming an image of Marylin Monroe and Mount Fuji into versions that could have been painted by all of the artists throughout history (Figure 14). Refining this technology, Korsten and Flores (2016) 'learned' the style of 17th century master painted Rembrandt and generated a completely new artwork in his style. Integrating more of the user's input as to which areas should be 'transferred' between images, Champandard (2016) uses the idea of analogy to demark areas that have certain categories in the style image, e.g. marking a tree with brown pixels. The user then 'paints' a sketch of a new composition using the same colour scheme, and the CNN transfers the style learned from that section of the style image to only those areas of the new composition (Figure 15).

What is exciting about these computational tools is that these techniques are not unfamiliar to artists, who have been learning, integrating and modifying other artist's styles for centuries. While not achieving the standards of a professional artist, these algorithms provide enough of an idea of what one image in another style would be like—similar to the analogies that designers often apply in their early experiments (Hey et al., 2008)—to inspire the aesthetics and 'feeling' of the design that they will develop.



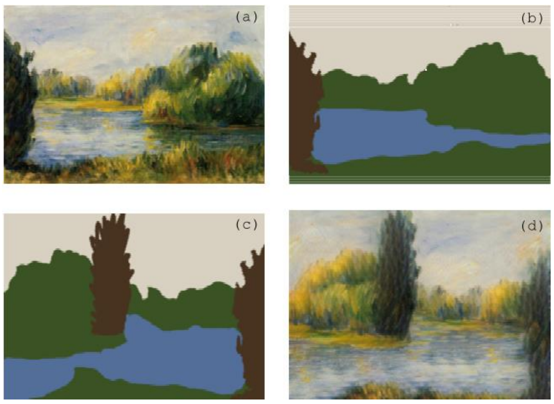


Figure 14 (left). McDonald's (2016) style transfer studies (see more at www.kylemcdonald.net/stylestudies/)
Figure 15 (right). Champandard's (2016) analogy style transfer examples, (a) Original painting by Renoir, (b) semantic annotations, (c) desired layout, (d) generated output.

6 Discussion

This framework helped us review the field of computational tools so as to suggest through examples how these technologies could be implemented in and further developed for the activities in the early phases of the design process.

From this ontology, we can suggest some key computational technologies that could contribute to the development of computational tools applicable to the early phases of the design process. In the discover phase, the activities involved gathering and sorting disparate information. Machine learning algorithms such as CNNs, RNNs and dimensionality reduction techniques are excellent computational tools to parse and categorise the initial information that a designer inputs into a design tool, such as their design research notes, interview transcripts or even inspirational images. Integrating factors that allow for a looser connection between the classification of the data can help the system to search for more analogous information, extending the range of material that the designer can be inspired by. In the reframe/define phase, the activities focused on generating hypotheses and identifying novel directions. Here we suggest that computational tools using stochastic processes to juxtapose the information from the discover phase in new ways, e.g. using visualisation tools that play with the position, size and style of the text and images, could help designers to imagine unfamiliar concepts and novel design ideas. CNNs and RNNs used in story generators and style transfer algorithms can also be used to generate new design 'prompts' for designers to consider and hopefully be inspired by.

While these computational tools offer the potential to enhance our abilities in the early activities, we must also be aware of the limitations of these technologies. Many of the technologies described above often use symbolic categories within a narrow problem-solving paradigm which are very powerful at analysing text and images from a mathematical point of view, but may be limited when applied to the tacit behavioural thought processes that guide a human designer during the more exploratory and generative activities of the design process (Pfeifer, 1996; Colton & Wiggins, 2012).

Given this critique of these potentially very powerful computational tools for the design activities in the early stages, we would like to propose a few design principles for the use of these technologies and the development of future CAD tools. While machine learning allows for the analysis of much larger collections of information than a designer might be able to when discovering and linking new information together, creating interfaces that are transparent in their computational processes and allow information to be presented as unexpected inspirations, rather than design solution prescriptions, can make these tools more useful in the more exploratory phases of the design process (Colton & Wiggins, 2012; Mothersill & Bove, 2017). Considering the ambiguity present in the ad hoc bricolage nature of the early design phases, these tools should also integrate a "margin of error" in their representations to allow for creative misinterpretation (Bernes, 2017) and thus generate new approaches—or variables—for the design.

As well as applying these principles in our own work developing new computationally-enabled design tools for early phases of the design process, we are currently evaluating the wider potential of the framework described above. Initial feedback from workshops at the Royal College of Art in London (UK) and IDEO design consultancy in Boston (USA) highlighted that more guidance is needed to help other designers and researchers identify appropriately scoped design activities and break them down into the underlying tasks in order to connect to specific tools. Showing a large range of examples of computational technologies helped provide analogies for how computational tools have been applied in unexpected situations and therefore could contribute to very different activities. Building on this feedback, a 'bottom up' application of this framework—where the multiple affordances of tools are described and then applied to other tasks and activities—could be a more generative approach; an approach which actually maps more seamlessly to the historically bricolage tool use that Spier (1970) describes. We hope to keep developing this framework as a new epistemology for understanding the role of computational tools in the design process so as to further empower designers and researchers to impact the development of these future technologies.

7 Conclusion

The CAD tools available today specialise in manipulating and automatically generating optimised designs for a set of pre-defined variables, i.e. they are proficient at the latter phases of the design process where concrete forms and final solutions are envisioned and developed. These tools require very explicit descriptions of a design and as such are not suited to the more abstract, tacit activities present in the early discovery and reframe phases of the design process. This paper considered how new computational technologies could potentially play a role in these early stage design activities.

Using a framework that deconstructed design activities into underlying tasks, we presented a range of computational tools with features appropriate for the more tacit activities present in the early phases of the design process. Such tools included machine learning algorithms such as CNNs, RNNs and dimensionality reduction techniques to help sort information related to a design in the discover phase and stochastic algorithms to help juxtapose the information in new ways in the reframe/define phase. Designing the interfaces of these tools to allow for a more transparent and ambiguous representation of the information can ensure that they are not overly mechanistic or prescriptive and allow for the creative misinterpretations and bricolage nature of the early design process.

Early feedback on this framework as an epistemology for understanding the potential use of computational tools in the early design process has shown that a 'bottom up' approach that demonstrates many computational tools in different design tasks and activities can help provide intuitive knowledge of how the tools work but also inspiration for alternative applications. Developing this work further through workshops and application to the development of new design tools, we hope this framework and review can help other designers and researchers understand the potential for these computational tools in even the earliest phases of the design process, and offer suggestions for how we might develop future CAD tools that are more appropriate and considerate of the tacit and ambiguous nature of creativity.

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Section 11.

Physical and Digital Materials in Creative Design Practice

DRS 2018 Design Research Society 2018 Catalyst

University of Limerick
25th – 28th June 2018

Editorial: Physical and Digital Materials in Creative Design Practice

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doi: 10.21606/dma.2018.010

Physical and digital materials are in design practice used both as the material out of which designers craft products but also as catalysts that are only part of the design process. The latter kind of materials are used as externalizations (Dix and Gongorra 2011) while developing ideas. For example, Post-It notes on whiteboards are used for brainstorming, grouping and organising idea during the early part of the design process. Designers also use cardboard and paper to sketch out a proposed solution, each sketch building on the previous ones as she/he works through the design space. The successive sketches are temporarily used materials that designers discard at some point in the design process. Another example is the use of prototypes, which are used to explore alternatives, or illustrate ideas, much like an architect uses his sketchpad to explore and communicate alternatives for the design of a building. In other phases the architects may experiment with different materials like concrete, wood and glass in order to examine the qualities of the materials.

Key components of design methods for creative design practice may be organized around three main aspects: concrete aspect, conceptual aspects and aspects related to managing the design space (Biskjaer, Dalsgaard, & Halskov 2017). The concrete aspects includes the materials, which is the key theme of this track, that are employed as part of the design process, as well as tool applied in the process. Of particular relevance for creative process are the conceptual aspects, which include use of analogy, metaphor and combination. Design space may be defined as a conceptual space that bound all potential designs and which is framed, constructed and transformed through a complex process of divergence and convergence (Dove, Biskjaer and Halskov 2016).

To advance the understanding of the role of materials in creative design processes the track *Physical and Digital Materials in Creative Design Practice* examines and discusses the role and nature of materials in creative work, and explore how to use material to support and augment creative design processes.

More specifically, the objective of the track is to 1) to explore the potentials of integrating multiple digital devices and physical materials in a shared environment to support individual and collaborative creativity, and 2) to develop the theoretical foundation for generative design materials, including, creativity constraints, emergence of design ideas, and creative methods in design processes. More broadly the track contributes to a set of key creativity research questions, see also (CIBIS 2018):

- What kind of software infrastructure can handle a dynamic mix of personal and shared devices?
- How can we conceptualize the emergence and transformation of design ideas across devices in creative design processes?
- How can generative design materials, digital as well as physical, spur ideation and create momentum in a creative process?
- How can creativity methods be supported and augmented by digital tools and materials?
- What is the nature of creativity constraints in generative design materials and how can they be balanced and managed in a creative process?

The track opens with the paper 'How Materials Support Conceptual Blending in Ideation' by Biskjear, Fischel, Dove and Halskov, which investigates how conceptual blending supported by digital design material unfold during a design workshop. The authors show empirically how the design materials help stabilize the conceptual blend as it emerges during the workshop.

In 'Co-located Team Designing' Christensen and Abildgaard dive into 23 hours of team activity amongst 25 high-school students and provide us with detailed insight into how joint attention is established through physical and digital materials during creative sub-processes, such as information search, problem defining, idea generation, and decision-making.

In 'Designing Idea Management Tools' Inie, Dalsgaard and Dove identify a set of challenges for designers working with idea managements tools based on an interview study with 16 professional designers, which they us a platform for offering directions for the development of next-generation idea management tools.

In the final paper 'How Emerging Technologies Influence Designing' Ward, Stoltermann and Beck broaden the scope of the track and present and discuss a series of studies of the design and use of conversational agent. One of the key findings is that interaction design must be observant and willing to change its practice in relation to changes in its material, i.e. technology.

Acknowledgments: This research has been supported by the Innovation Fund Denmark (CIBIS 1311-00001B).

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DRS 2018 Design Research Society 2018 Catalyst

University of Limerick
25th – 28th June 2018

How Materials Support Conceptual Blending in Ideation

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doi: 10.21606/dma.2018.242

While combining materials as sources of inspiration is a familiar strategy in design ideation, the intricacy of how materials affect the emergence of concepts has not been fully examined. This paper offers a detailed analysis of a sequence of a design ideation workshop using conceptual blending as an explanatory model to pry open the complexity of this activity, showing how research on design materials improves insight into how a design concept emerges. We show this empirically in a second-by-second analysis of a card-based design ideation episode using a multi-touch surface table. We offer process-analytical evidence for the case that manipulation of design materials helps stabilize an emerging concept, as conceptual blending research has shown by analyzing artifacts, and extend this work by showing the dynamic interplay between the emerging conceptual blend and participants' collaborative interaction with the materials. Our study advances understanding of interaction with materials in design ideation and aims to facilitate future research on how materials support conceptual blending as a useful model of how design concepts emerge.

design materials; conceptual blending; sources of inspiration; ideation

1 Introduction

The relationship between design ideas and sources of inspiration is a familiar topic within design research (e.g., Bødker, Nielsen, & Petersen, 2000; Dove & Jones, 2014; Maiden, Manning, Robertson, & Greenwood, 2004; Warr & O'Neill, 2006). A key finding is that the interactions between group members and design materials affect how creative ideas emerge (Halskov & Dalsgaard, 2007; Shaw, 2010). Sources of inspiration in design workshops often take the form of cards (Lucero, Dalsgaard, Halskov, & Buur, 2015), and at least eighteen card-based methods can be discerned (Wölfel & Merritt, 2013), including PLEX Cards (Lucero & Arrasvuori, 2010), Oblique Strategies (Eno & Schmidt, 1978), i|o Cards (Carneiro, Barros, & Costa, 2012), and Inspiration Cards (Halskov & Dalsgaard, 2006). Whilst card-based methods are common in design research, exactly how cards as generative design materials inspire new design ideas has not been investigated in greater depth than the identification of high-level strategies such as selection and combination (Halskov, 2010).

Here, we look in detail at a card-based design ideation workshop to examine *how materials affect the emergence of a design concept*. We review research on combinational creativity (e.g., Cohen & Murphy, 1984; Finke, Ward, & Smith, 1992; Ward, Smith, & Vaid, 1997; Wisniewski & Gentner, 1991) as the main area of research on how combining materials is linked to a creative outcome. Although relevant, such theory does not exhaust the complex ways in which materials are combined to spark ideas in design specifically. We thus introduce Fauconnier and Turner's (2002) *conceptual blending* theory as an explanatory cognitive model of how new concepts emerge. While acknowledging the role of materials, current research has focused on materials as 'anchors' (Hutchins, 2005) to stabilize the concept being formed, and analyses have been based on distinctive artifacts. In response, we look to research on design materials (e.g., Ashby & Johnson, 2014; Dix & Gongorra, 2011; Basballe & Halskov, 2012; Dalsgaard, Halskov, & Basballe, 2014; Dror & Harnad, 2008; Bjögvinsson, Ehn, & Hillgren, 2012; Star & Griesemer, 1989) to capture more of the complexity of how participants in design ideation interact with materials. To underpin this empirically, we *analyze a design ideation episode* that employs a digital version of card-based ideation using a multi-touch surface table.

We see the paper's *main contribution* as this analysis, since it offers new insight into how materials, not only as stabilizing factors, but also as generative sources of inspiration, affect the blending process through which new design concepts emerge. This *extension of current conceptual blending theory* enables a more nuanced understanding of the complex role of design materials, including inspiration cards, in design ideation as a step toward further research on how materials support conceptual blending in the emergence of design concepts.

2 Related work

2.1 Sources of Inspiration and the Emergence of Ideas

We define sources of inspiration as elements specifically brought into the design process to trigger ideation. A conceptualization of inspiration contains three elements: inspiration implies *motivation*, is *evoked* rather than initiated directly, and involves *transcendence* of ordinary preoccupation of human agency (Thrash & Elliot, 2003).

In design, sources of inspiration are seen as necessary for continuing creativity (Eckert & Stacey, 2002) and integral to design (Sanders, 2005). The effect of introducing external sources of inspiration to designers is a well-known topic (Bonnardel & Marmèche, 2004; Halskov & Dalsgaard, 2007) with studies in knitwear design (Eckert & Stacey, 2000; Petre, Sharp, & Johnson 2006), product design (Kelley and Littman, 2001), car design (Mougenot, Bouchard, Aoussat, & Westerman, 2008), education (Gonçalves, Cardoso, & Badke-Schaub, 2014), and Web-design platforms (Chan, Dow, & Schunn, 2015), etc. As a strategy, using sources of inspiration seems to have a positive effect on ideation, but the process depends on the nature of the sources of inspiration and the designers' expertise (Bonnardel & Marmèche, 2004).

Despite this familiarity, the *specific ways* in which sources of inspiration are brought into and combined in design ideation have not been studied in greater depth. In interaction design, Halskov (2010) identified four strategies for relating sources of inspiration to emerging ideas—selection, adaptation, translation, and combination—but did not address in detail how sources of inspiration are combined creatively, e.g., aggregating elements. The practice of combining such elements must thus be explored, which points to creativity research.

2.2 Combinational Creativity

Creative cognition is integral to design activities (Cross, 2002) and includes, "conceptualization, visualization, memory, problem solving, language, decision making, and several areas of implicit cognition" (Smith & Ward, 2012, p. 457). Processes involving combination have mainly been studied by cognitive psychology with a focus on language acquisition. This is referred to as *conceptual combination*, i.e., "the problem of how word-level concepts combine to produce the meanings of larger linguistic units" (Rips, Smith, & Medin, 2012, p. 190). This study area contains several models (e.g., Cohen & Murphy, 1984; Finke, Ward, & Smith, 1992; Taura & Nagai, 2013a, 2013b; Ward, Smith, & Vaid, 1997; Wisniewski & Gentner, 1991). While the act of combination is often deemed creative, the originality of such combined concepts is often limited (Smith & Ward, 2012, p. 457).

On a basic level, *combinational creativity* can be conceived as unfamiliar combinations of familiar ideas (Boden, 2004). Its central goal is to:

> *discover new and potentially useful emergent properties; that is, properties not commonly seen in the component concepts, but that emerge only in combinations (Smith & Ward, 2012, p. 469).*

In cognitive psychology, studies have shown that the more *conflicting* the concepts are, the greater the chance of emergent properties (Hampton, 1987; Wisniewski, 1997; Wisniewski & Gentner, 1991). This might be because: “discrepancy forces people to attempt to resolve the contradiction between the component terms” (Smith & Ward, 2012, p. 465). Many models of *creative conceptual combination* have been proposed (e.g., Rips, Smith, & Medin, 2012, pp. 190-92; Sawyer, 2012, pp. 114-19), but the crux of this combinational creativity approach is that is revolves around (advanced) forms of *complex creative problem solving* (Sawyer, 2012, p. 116). While the notion of emergent properties might suggest a bridging of concepts, the core idea remains that some initial discrepancy must be present for a truly creative, i.e., novel and useful (Runco & Jaeger, 2012), result to arise.

This assumption is problematic in design, where ideas inspired by cards tend to be fused or blended in various ways rather than just combined. It is accepted that any design problem must be explored in depth to reach a creative design result (Schön, 1983), which is quite different from quickly moving to combining pre-existing, conflicting elements. Indeed, design activities such as ideation are more often a question of problem-solution co-evolution (Wiltschnig, Christensen, & Ball, 2013) than solving a creative problem by combining X with Y. This points to the important role of *meaning-making* in design activities, especially in ideation.

According to Schön (1987), a design process is a unique conversation through which the designer constructs his/her understanding of the situation and creates meaning in a process of framing that guides his/her design moves. Krippendorff (2006) adopted a related discourse-centered view on design: “humans do not see and act on the physical qualities of things, but on what they mean to them” (p. 47). If we see design activities such as ideation in situated, constructive, and semantic terms, it is useful to consider combination a way of making new meaning from existing concepts.

2.3 Conceptual Blending

Building on work by Koestler (1964) and Lakoff and Johnson (1980) amongst others, Fauconnier and Turner (1998, 2002) developed *conceptual blending* as a theory of linguistics to explain how *new meaning* is constructed from familiar situations. It has since been applied to other areas, including interaction design (Imaz & Benyon, 2007), e.g., the dynamics, complexity, and potential of using blends for predicting and anticipating use in design (Bødker & Klokmose, 2016), user perception of user interfaces (Jetter, Reiterer, and Geyer, 2013), and has even been proposed as a theory of creativity (Turner & Fauconnier, 1999; Turner, 2015). The basic principle takes inputs from two or more domains that share counterpart connections. These counterparts provide a shared generic space that allows for projection into a ‘*blended’* space containing an emergent structure beyond that present in a simple combination of the two inputs.

Fauconnier and Turner (1998) used an example of inferential problem solving, taken from Koestler (1964), to illustrate conceptual blending. The problem—or riddle—states:

> *A Buddhist monk begins at dawn one day walking up a mountain, reaches the top at sunset, meditates at the top for several days until one dawn when he begins to walk back to the foot of the mountain, which he reaches at sunset, Making no assumptions about his starting or stopping or about his pace during the trips, prove that there is a*

> *place on the path which he occupies at the same hour of the day on the two separate journeys (Fauconnier & Turner, 2002, p. 39).*

The authors then explained that:

> *The basic inferential step to showing that there is indeed such a place, occupied at exactly the same time going up and going down, is to imagine the Buddhist monk walking both up and down the path on the same day. Then there must be a place where he meets himself, and that place is clearly the one he would occupy at the same time of day on the two separate journeys (Fauconnier & Turner, 1998, p. 137).*

We use this example, with reference to Figure 1 below, to outline conceptual blending. In Figure 1, each circle represents a mental space. In this simple network there are four spaces: two inputs, the generic space, and then the blend.

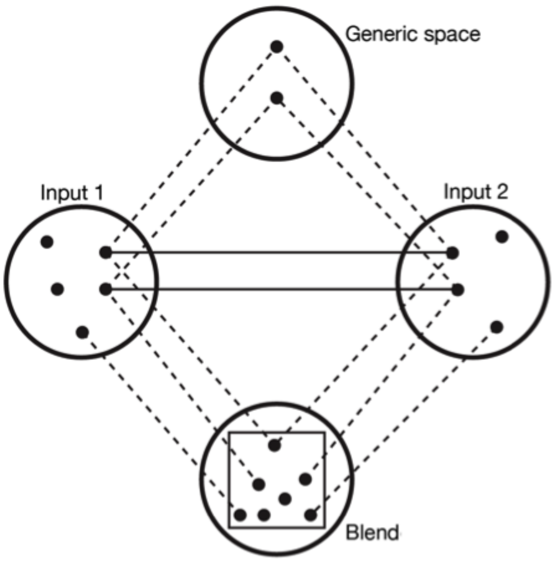

Figure 1. Conceptual model of a blend (adapted from Fauconnier & Turner, 2002, p. 46).

2.3.1 Inputs

Each of the input spaces, Input 1 and 2, is a partial structure corresponding to one of the monk's two journeys. The solid lines between Input 1 and Input 2 represent counterpart connections. In the Buddhist monk riddle, these might represent the mountain, the monk, the act of walking, etc.

2.3.2 Generic Space

The generic space refers to the structure recognized as belonging to both inputs, i.e., elements they have in common such as the mountain and the monk, etc. Aspects such as the day and direction of travel are not included.

2.3.3 Blend

The *blend* contains the structure captured in the generic space as well as more specific structure taken from each of the two inputs. However, it also contains *new structure* created through the development of the blend. This new structure is emergent structure and is represented by the square inside the blend circle in Figure 1. Using the monk example, each of the two input spaces has a single journey and these are completely separated in time, whilst the blend has two simultaneous journeys carried out by two instances of the same Buddhist monk.

The construction of a blend involves *three operations*: composition, completion, and elaboration.

- **Composition:** the process of bringing *selected elements* from each of the two inputs into the blended space, either separately or fused into one element. This makes new relationships available that did not exist in the original inputs. An example of this would be the two separate days that are brought into the blend, now fused as a single day.
- **Completion:** the process through which *background knowledge* is brought into the blend. Cognitive or cultural frames of reference from familiar situations 'complete' the blend with structure inherited from a larger, more detailed pattern. In the monk example, completion is achieved via the scenario of two people journeying toward each other on a path.
- **Elaboration:** the process in which the blend is further developed via *imaginative mental simulation*, or 'running the blend'. This can be extensive, and lead to many new elements recruited into the blend. However, this is only successful if the *direction* of elaboration fits the internal principles and logic of the existing blend. Using the monk example, Fauconnier and Turner illustrated elaboration by stating, "the monks might meet each other and have a philosophical discussion about the concept of identity" (1998, p. 144).

Conceptual blending offers a valuable lens through which it becomes possible to examine a specific design activity that relies on *inputs*—such as *sources of inspiration*—and what *emerges* from such cognitive processes (e.g., Imaz & Benyon, 2007; Jetter, Reiterer, & Geyer 2013). Conceptual blending thus lends itself well to *collaborative ideation* where participants contribute ideas and concepts that must be fit together to reach a shared, mutually meaningful design concept. It is important to stress that design ideation rarely builds exclusively on processing of mental images, concepts, or thoughts. Rather, it often involves carefully prepared *design materials* as means to spark new design ideas.

2.4 Design Materials

Design materials are critical across domains and can be defined as the physical artifacts that are used and consumed as part of a design process (Biskjaer, Dalsgaard, Halskov, 2017, p. 842). Materials range from very basic items, such as pen and paper and sticky notes, to more advanced types tailored to fit a creativity method. Materials play several roles in design activities (Ashby & Johnson, 2014). They can carry various types of content, serve as props (Brandt & Grunnet, 2000) to help workshop participants enact scenarios, and function as boundary objects (Dalsgaard, Halskov, Basballe, 2014; Star & Griesemer, 1989) by holding enough shared meaning for participants to collaborate. Design materials can help explore and capture evasive ideas and concepts (Stolterman & Wiberg, 2010, p. 110) and represent them in a useful, perceptible form that enables collaboration among participants. In all instances, the key feature of design materials is not the experiential qualities of their tangibility (or materiality) as such, since materials can be analog (physical) or digital (Jung, Blevis, & Stolterman, 2010). It is the way materials enable *externalization* of concepts and structures (Dix & Gongorra, 2011; Carneiro, Barros, & Costa, 2012) by offering cognitive offloading (Dror & Harnad, 2008) by acting as an external memory deposit of ideas of concepts that can then be combined—or blended. Cognition in a design ideation workshop thus goes beyond what happens in each individual participant's thought process, which is what Hutchins (1995) referred to by '*distributed cognition.*'

Since conceptual blends often lack stability, Hutchins (2005) proposed the idea of '*material anchors*.' This designates an input space from which material structure, typically from a physical object, is projected into the blend:

> *the physical objects themselves are input to the conceptual blending process. This is what I intend when I speak of 'material anchors' for conceptual blends (p. 1560).*

The problem Hutchins observed is that conceptual structures that must be represented in the blend may often be so complex that an individual cannot accomplish this using his/her cognitive resources alone. Therefore, the conceptual elements must be kept stable or anchored:

The 'holding in place' is accomplished by mapping the conceptual elements onto a relatively stable material structure. This is how a material medium becomes an anchor for a conceptual blend (p. 1562).

Hutchins raised a critique of the previous understanding of conceptual blending as a purely internal cognitive process. Materials are directly connected to an individual's (internal) cognition and might help to anchor an unstable or highly complex conceptual structure so that an individual can reach a useful, cognitively manageable blend. However, Hutchins' proposal does not address a *design ideation process* whose included physical materials are not *only* meant to anchor complex conceptual structures. Rather, they take on a *dual* role by also igniting new design ideas and divergent thinking. Here, design materials are not (only) meant to anchor a very complex structure as part of an evasive blend. They are (also) meant to evoke as *many creative ideas as possible* during ideation. This prompts the need to *expand* upon conceptual blending theory's understanding of materials as stabilizing factors. Design materials are also generative, even disruptive, sources of inspiration that would seem to be *entwined with conceptual blending* in the process whereby new design ideas emerge. To explore this empirically, we carried out the following study.

3 Method

We present a detailed process analysis of a videoed sequence (Bødker, 1996) of a *digital Inspiration Card workshop* (Halskov & Dalsgaard, 2006) from two perspectives: The development of conceptual blends in the analyzed sequence, and participant's corresponding physical interactions with the design materials. Whilst other DRS studies have taken a diachronic view on materials in a design process (van der Linden, Dong, & Heylighen, 2016) or analyzed design diaries to examine form generation (Chafi, Rehammar, & Rahe, 2012), we offer a *second-by-second video-based analysis*.

3.1 Design Brief and Materials

The workshop took place as part of a course on Advanced Interaction Design at our home university, and its goal was to create initial concepts based on the design brief: "Design an interactive, digital artifact that uses light to enhance the sensory perception of non-sexual, pleasurable intimacy."

While the original Inspiration Card method employs physical cards, pen, and paper, this workshop used a digital iCard table (Figure 2) developed by our research lab, CAVI (Halskov, 2011). This is an interactive, digital, touch-enabled tabletop display where participants can create concept posters by arranging digital Inspiration Cards (iCards) and annotate them through free-hand drawing and writing, and machine-typed labels. As in a standard Inspiration Card workshop, facilitators can select a set of iCards by uploading them to an associated website. Once a concept is completed, participants can save it as a poster that can be accessed through the same website.

Figure 2. Digital Inspiration Card (iCard) Workshop.

As Figure 3 below shows, the table is divided into two areas: A peripheral area (gray) where the iCards are loaded, and a central area (dotted) where participants develop their ideas. When they press the Save button, only the content in the central area is saved as a concept poster.

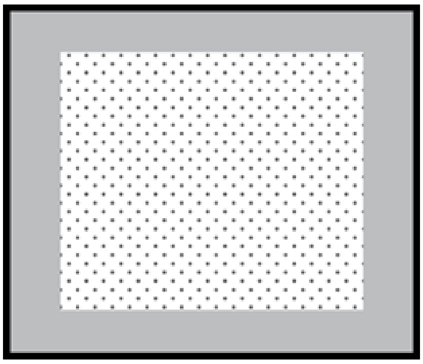

Figure 3. Diagram of an iCard table. The gray area represents the peripheral area, the dots the central area.

Once a set of iCards has been loaded, the iCard table supports the following interactions:

- Moving iCards on the table, including rotating them.
- Scaling iCards up and down.
- Basic free-hand drawing and writing, similar to basic image-editing software (four different brush sizes, five colors).
- Eraser brush for erasing free-hand drawings and writing.
- Writing, placing, and moving machine-typed labels, typed on a touch-keyboard on the tabletop.
- Undo last action.
- Save a concept as a concept poster.
- Reset the tabletop, which moves all iCards back to their original positions at the periphery of the table and deletes any labels and free-hand drawings and writing.

3.2 Participants

As part of the course curriculum, the workshop was planned and executed by four graduate students, denoted A, C, J, and M, supervised by senior researchers. As opposed to studies comparing concept development among students from different disciplines (Jiang & Yen, 2010), all participants were from the same discipline, Digital Design. The team selected iCards within three categories: Cards representing forms of intimacy, light-focused technologies, and other potentially relevant digital technologies.

3.3 Procedure

While the entire workshop lasted approx. one hour, we focused our in-depth analysis on a particular sequence covering the development of the second concept produced in the workshop. The selected sequence spans a period of a little less than *eight minutes*, starting at 6m:3s and ending at 13m:54s.

Our analysis was guided by the key components of the conceptual blend model and focused on a detailed process analysis of participants' interactions with the digital design materials of the iCard tabletop. For each blend, we identified the inputs providing the structural elements, highlighted the elements comprising the generic space, and described the emergent structure created by the blend. We identified the blend composition, showed frames of reference used for its completion, provided details of its elaboration, and documented the interactions with the design materials corresponding to central passages in the development of the blend.

We worked with a second-by-second timeline covering the sequence in question. We transcribed communication between participants, focusing on verbal or otherwise explicit communication. Also, we videoed all significant interactions with the iCard table, using the above list of interactions as an initial coding guide. As a threshold guide for determining significant vs. irrelevant interactions, we used Dix and Gongora's (2011) categorizations of externalizations to narrow down the interactions to those that could meaningfully be interpreted as significant in the ideation episode observed. Figure 4 shows a segment of the finished timeline with all interaction codes used in our analysis.

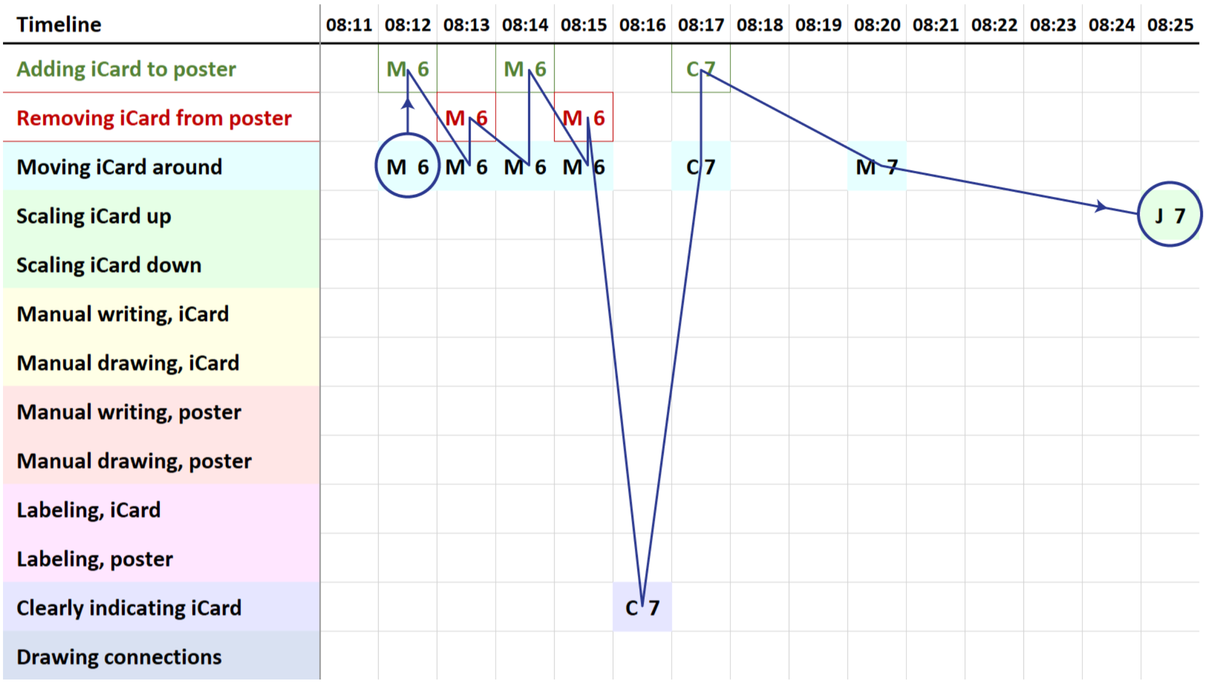

Figure 4. Overview example of all rows in the coding timeline with additional annotations (blue circles and lines between cells) to indicate the order in which the figure should be read.

For each cell in Figure 4, two things are noted: The participant (A, C, J, or M) interacting with the iCard table, and, when applicable, the iCard (1-10) that s/he interacts with. To ensure readability, we have, for this figure, added a blue line indicating the progression along the timeline. All codes were timed when an interaction was started, even if the interaction lasted more than a second. Some operations on the table were coded as one interaction if they were of the same type and leading to the same outcome. To aid our analysis, we added a row to the timeline with indications of the beginning of all transcription events (not depicted here) to ensure a clear interpretation of the interactions in cases where studying only the video would leave uncertainty.

4 Analysis

The episode of the workshop we focused on consists of two parts: A first part where the main blend is created, and a second part, focusing on an additional blend to give further ambience to the main blend. In Figure 5, the first two images are from the creation of the main blend, while the last three are from the creation of the additional blend.

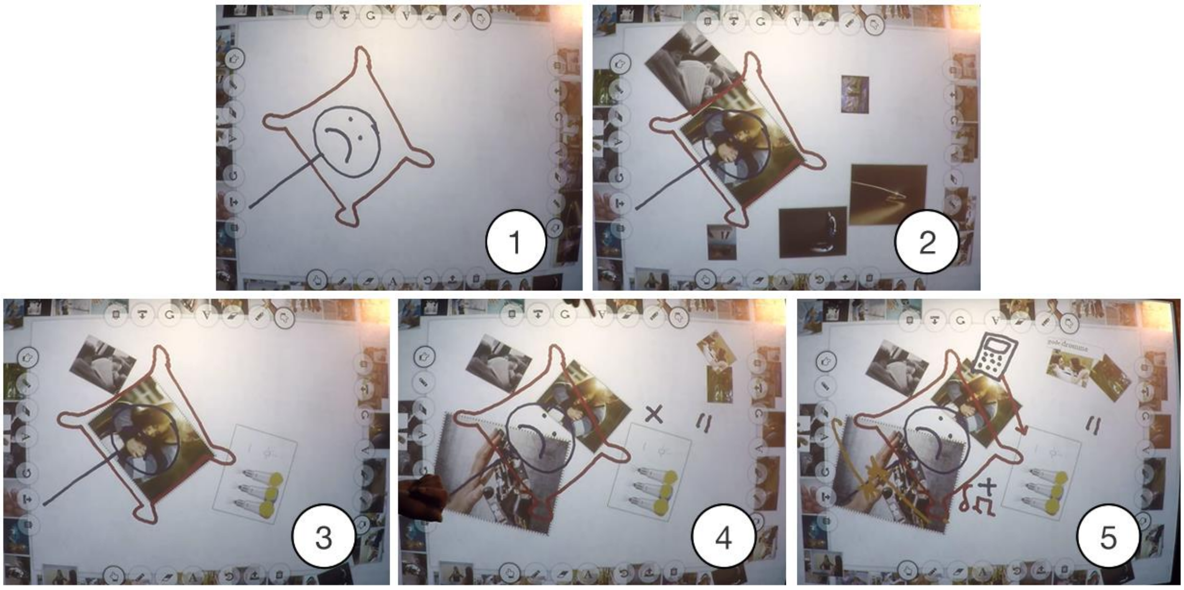

Figure 5. Timeline of the 'bed that hugs you' design ideation activity.

4.1 Part 1: The 'Bed That Hugs You' Main Blend

The activity starts with participant C proposing a frame by saying, "I think it would be interesting to have something to do with having trouble sleeping," drawing a sketch of an unhappy face on a pillow on the tabletop surface (Figure 5, image 1). For the next minute or so, participants try out ideas in search of a suitable form of interaction, with additional cards being tentatively proposed. As Figure 6 shows, J moves card 1 into the central area, adding it to the concept poster, while M does the same with 2. J then scales 1 up, while M moves 3 around hesitantly before adding it to the concept, scaling it up. Lastly, J adds 4 to the concept and scales it up.

Timeline	06:50	06:51	06:52	06:53	06:54	06:55	06:56	06:57	06:58	06:59	07:00	07:01	07:02	07:03	07:04
Adding iCard to poster		J 1	M 2					M 3				J 4			
Moving iCard around		J 1	M 2		M 3		M 3					J 4			
Scaling iCard up				J 1							M 3			J 4	

Figure 6. The participants test out ideas by moving cards into the central area of the tabletop.

It is not until C expands on the original framing that a design idea begins to take shape. First, C says: "if you've got a feeling of restlessness in your body and you aren't aware of it yourself because you are thinking all sorts of thoughts, and you are very stressed, isn't that why people have trouble sleeping?" and then shortly afterwards suggests: "another type of smart mattress, that doesn't just shape itself to fit you, but perhaps hugs you from below."

As Figure 7 shows, this is followed by M who adds 5, of a man hugging a woman from behind, to the central area, moving it into position behind the sketch of the unhappy face on the pillow (Figure 5, image 2). At the same time, J scales up the previously added 1, which also shows a man hugging a woman from behind. C responds by saying: "Yeah, sort of like that," indicating 1. This is followed by a period of card reorganization where participants move, scale up, and scale down the cards. This ends with M removing 2, 3, and 4 from the central area. The idea for the 'bed that hugs you' blend is verbalized by A and C simultaneously, as they say: "a bed that hugs you". This is the *composition* of the blend.

Timeline	07:39	07:40	07:41	07:42	07:43	07:44	07:45	07:46	07:47	07:48	07:49	07:50	07:51	07:52	07:53	07:54	07:55	07:56	07:57	07:58	07:59	08:00	08:01
Adding iCard to poster	M 5																						
Removing iCard from poster																					M 2	M 3	M 4
Moving iCard around	M 5			J 3	J 5	A 3		A 4	M 5	M 5		M 5									M 2	M 3	M 4
Scaling iCard up	J 1					J 5			M 5														
Scaling iCard down					A 3		A 4			M 5		M 5						J 1					
Clearly indicating iCard		C 1																					

Figure 7. The concept stabilizes, and participants reorganize and remove cards in response.

The two *input*s for this blend are sleeplessness, as signified by the sketch of the unhappy face on the pillow, and the hug, represented by 5, after 2, 3, 4 have been explored—and removed again. The *generic space* contains the mattress as the site of restlessness and the physical and emotional comfort provided by the hug. The blend creates the new structure in which interactive technologies will enable 'a bed that hugs you.'

The 'bed that hugs you' blend is almost immediately *completed* and then *elaborated* by A. First by saying: "that is one of the things that work for people with trouble sleeping, that thing with having a heavy duvet," and then by adding: "a latex mattress could easily do things like that if it had space-age fibers in it that can be controlled depending on whether there is a current running through them or not." A thereby first provides a familiar setting that enables the group to *stabilize* the blend, then brings in new ideas, with new structures, adding further detail to the blend.

4.2 Part 2: The Additional 'Atmosphere' Blend

The remainder of the ideation is concerned with adding atmospheric features to the 'bed that hugs you' main blend. Participants first explore ideas of lighting, with 7 showing smart light bulbs (Figure 5, image 3). Different colors of light are discussed, as is the use of light to delineate room space.

As Figure 8 shows, C first indicates 7, representing smart light bulbs, then moves it into the central area. Once added, both M and J manipulate the card, moving it and scaling it, respectively. Last, A draws on 7, filling out the smart light bulbs with color to indicate a specific type of lighting.

Timeline	08:16	08:17	08:18	08:19	08:20	08:21	08:22	08:23	08:24	08:25	08:26	08:27	08:28	08:29	08:30	08:31	08:32	08:33	08:34	08:35	08:36
Adding iCard to poster		C 7																			
Moving iCard around		C 7			M 7																
Scaling iCard up										J 7											
Manual drawing, iCard																					A 7
Clearly indicating iCard	C 7																				

Figure 8. Participants explore adding light to the concept.

A little over a minute later, M introduces 9, depicting a forest setting, and says: "what about creating an atmosphere with these as well?". As Figure 9 shows, the sequence starts with M indicating the (not-yet-added) 9 as a reference to creating atmosphere, followed by C moving 9 to the central area, adding it to the concept. M then indicates conceptual connections between the cards by writing an equal sign between 9 and the elements of the 'bed that hugs you' main blend.

Timeline	09:58	09:59	10:00	10:01	10:02	10:03	10:04	10:05	10:06	10:07	10:08
Adding iCard to poster						C 9					
Moving iCard around						C 9					
Manual writing, poster										M	
Clearly indicating iCard		M 9									
Drawing connections										M 1, 5, 7, 8, 9	

Figure 9. The first interactions related to the atmosphere blend.

The atmosphere theme is further developed by J: "atmosphere could also be that you are suddenly somewhere with people you feel very strongly for." This focus on atmosphere prompts C to ask:

"would there be sound at this location as well?", to which C adds: "the sound of rain is fantastic." As Figure 10 shows, J first introduces 10, depicting an intimate picnic, to convey the idea of being with people you feel strongly for (Figure 5, image 4), then moves it next to 9 to show that it is similarly meant to represent the desired result of the concept. J adds a label with the words "good dreams," and moves it next to 9 and 10. A says: "there are smartphone apps that can register whether you are awake or not," and, to clarify, adds: "okay, you have a smartphone or iPad or something that automatically registers that you are restless, which says 'you've asked me to turn down the lights when you are restless and make it look like a green forest in the summertime and play some sounds that remind you of your family.'"

Timeline	10:16	10:17	10:18	10:19	10:20	10:21	10:22	10:23	10:24	10:25	10:26	10:27	10:28	10:29	10:30	10:31	10:32	10:33	10:34	10:35	10:36	10:37	10:38	10:39	10:40
Adding iCard to poster	J 10																								
Moving iCard around	J 10		J 10																					J 10	J 9
Labeling, iCard																						J 9, 10			
Labeling, poster								J																	

Figure 10. Social elements are added to the atmosphere blend, and a label is added for clarification.

As Figure 11 shows, J draws a smartphone on the tabletop, and, after M points out that it should be connected to 7, draws an arrow connecting the smartphone with the smart light bulbs. This is the *composition* of the 'atmosphere' blend (Figure 5, image 5). The only significant changes to the concept poster after this point is the addition of drawings of music notes by J and M to show that the design also uses sound to produce its effects.

Timeline	12:20	12:21	12:22	12:23	12:24	12:25	12:26	12:27	12:28	12:29	12:30	12:31	12:32	12:33	12:34	12:35	12:36	12:37	12:38	12:39	12:40
Manual drawing, iCard																					J 7
Manual drawing, poster	J																				
Clearly indicating iCard							M 7														

Figure 11. The final elements of the concept are added through drawings.

The *inputs* for the 'atmosphere' blend are lighting that helps you relax, represented by smart light bulbs (7), soothing restful sounds, and friendly people, illustrated by the forest (9) and picnic cards (10), automatic control, represented by the drawing of the smartphone, and the earlier 'bed that hugs you' main blend. The 'atmosphere' blend is *completed* by reference to the comforting atmospheres. This blend is sophisticated and complex, so there is only limited *elaboration*. Still, M refines the idea of the hug: "perhaps it knows that sudden movements don't work, but instead it should use long smooth strokes to calm you." Finally, C adds: "it shouldn't work in a way that you have to set it up yourself because then you'd be constantly lying in bed occupied with the question 'What do I want?' I have no idea what I want."

5 Discussion

Reaching a creative result by combining various, discrepant elements can be as self-explanatory as Homer's (1924) notorious chimera in *The Iliad*: "in the fore part a lion, in the hinder a serpent, and in the midst a goat, breathing forth in terrible wise the might of blazing fire" (book 6, lines 179-182). However, as we have now seen, the practice of using design materials as sources of inspiration in conceptual blending in collaborative design ideation is rarely so straightforward.

Previous analyses of related activities have studied which cards participants draw inspiration from (Mougenot et al., 2008), or focused on identifying salient junctures, e.g., selection or combination of cards as design materials in the process (Halskov, 2010). Whilst both approaches are valuable, they say less about the *cognitive processes* involved, which is essential for understanding how design concepts emerge. Our analysis pays closer attention to the actual ways in which design concept generation develops over time in ideation and describes in more detail how materials as sources of inspiration provide fuel for conceptual blending in the process toward a new design concept. Our work thus entails a departure from the combinational creativity approach of cognitive psychology-based creativity research, which is built on creative problem solving using often conflicting materials (Sawyer, 2012) with less attention given to the specific ways in which participants in the ideation activity interact with these materials.

Our analysis has shown how provisional and tentative some of the participants' suggestions were as collaborative interactions, with iCards being prepared at the tabletop periphery, then proposed in the central area of the table, and later negotiated and (re)interpreted in order to install *stability* in the (still) ephemeral design concept that the participants were developing together. We saw this progression clearly in the beginning of our analysis, in relation to Figure 6. Here, participants paired the cognitive process of considering the different structures offered by the iCards with the physical interaction of moving an iCard into the central area and scaling it up. While the iCards function as anchors for conceptual structures, their inclusion in the central area yields a clear challenge for the participants to overcome—the conceptual structure(s) embodied by each card must be incorporated into the common concept, i.e., the emergent main blend, or else the iCard(s) must be removed.

Interestingly, participants were not able to meet the challenge they themselves created before C defined the problem and introduced a potential solution—the 'hugging mattress.' Once this concept had been introduced, participants immediately worked together to capture the essential structure in the design materials, as exemplified in our analysis related to Figure 7. The re-organizing and clearing of the central area of the iCard tabletop corresponded to the re-organizing and clearing of participants' understanding of the emerging conceptual blend, illustrating *completion*.

Demonstrating this use of materials offers *process-analytical evidence* for Hutchins' (2005) theory of how (physical) artifacts can serve as anchors if the emergent conceptual blend is highly complex and, potentially, exceeds the cognitive faculties of the individual engaged in the process. However, our study also *extends* Hutchins' work by grounding the notion of material anchors, not on exemplary analyses of the anchoring potential of distinctive artifacts, which has been a cornerstone in his work (2005), but on a *detailed, second-by-second analysis* of a sequence of a videoed design ideation episode. Also, by presenting, moving, scaling, and interacting with the iCards in this ideation session, it is evident how participants engage in rehearsal within a design activity, showing what Schön (1983) described as 'move experiments.' Following Stolterman and Wiberg (2010), we believe it is critical to further explore how design concepts might fruitfully be anchored in design materials; not least among design students and less seasoned designers who have yet to build up a proper *repertoire* of: "ideas, examples, situations and actions" (Schön, 1983, p. 138). Here, it is relevant to further examine differences and overlaps between conceptual-design *artifacts* and *materials*.

The participants' more *experimental, less stabilizing* use of design materials is most obvious in the transition from the initial main blend to the atmosphere blend. This period mirrors the earliest part of the sequence, in that participants created a challenge for themselves by adding new structures to the concept, here embodied in iCard 7. In Figure 8, it is distinctive how every participant interacts with this iCard in a way that signals its inclusion in the final blended concept; first by calling attention to it directly, then moving it into the central area, later by moving it further, scaling it up, and lastly by further specifying the structure it embodies by drawing on it. The challenge arose here because the potential structures embodied by this iCard had not *yet* been incorporated into the initial main blend but had nevertheless been accepted into the central area by the participants.

This process of *introducing new structures* that *create tension* to be resolved and then creatively *resolving the tension* is also evident in the addition of social elements, represented by iCard 10, as seen in Figure 10. In both cases, participants signaled that the tension had been resolved by indicating the relationship between the newly added elements and the existing blend, through manually drawn symbols in the case of iCard 9, and by placing 10 next to 9, labeling both. This leads to the end point of our analysis: The 'bed that hugs you' main blend has been augmented with 'atmosphere' elements, and an original design concept, informed by several kinds of collaborative participant interaction with the iCards as sources of inspiration, has emerged.

5.1 Limitations

We have prioritized a detailed, second-by-second analysis of a sequence of one design ideation episode to ensure analytical depth at the expense of the breadth that analyzing more activities in less detail might have brought. As educators, we find it important to involve students in research to inform their learning, and so we have based this study on graduate students. Therefore, we can only speculate if analyzing a professional design team using the iCard tabletop might have presented a slightly different result. We appreciate that the way a design team is composed, including the team members' different personalities and levels of experience and domain knowledge, etc., will affect the course of a design process; however, such perspectives lie beyond the scope of this paper. It is generally agreed that creativity is a highly complex phenomenon (Sawyer, 2012), so we do not claim that creativity can be exhaustively conceptualized as combination of materials. Rather, our aim has only been to explore how design materials—as one relevant process component among many—might support conceptual blending specifically in the ideation phase of a creative design process.

Since the iCard tabletop is an interactive prototype, we have yet to explore how the affordances of this digital environment, e.g., the ability to scale iCards, undo last action, and reset the tabletop, might affect participants' behavior and interaction with the cards compared to analog (physical) inspiration cards as devised by Halskov and Dalsgaard (2006). Finally, we accept that focusing on a longer time span might have yielded more insights to further bolster our analysis. Despite such limitations, we argue that the 'bed that hugs you' with its 'atmospheric' augmentation serves as an illustrative example of the explanatory power of conceptual blending as a model to help explain how design materials as sources of inspiration affect, but certainly not entirely direct, the emergence of a conceptual blend in a design ideation process.

6 Conclusion

Through a close analysis of a sequence of a digital card-based design ideation workshop, we have shown how manipulation of design materials not only helps stabilize an emerging conceptual blend, here, a new design concept, but is also entwined with this emerging conceptual blend through the ways in which participants interact with the materials. Our work advances insight into the complex role of materials in design ideation and aims to encourage more studies on how materials might support conceptual blending as an explanatory model of how design concepts emerge. We plan to pursue an even deeper understanding of the dynamic interplay between materials and conceptual blends and find new ways to operationalize the application of this theory. A promising perspective would be to identify in detail salient patterns of material-based conceptual blending in different professional design situations.

Acknowledgments: This research has been supported by the Innovation Fund Denmark (CIBIS 1311-00001B).

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DRS 2018 Design Research Society 2018 Catalyst

University of Limerick
25th–28th June 2018

Co-Located Team Designing: the oscillation between individual and social processes

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doi: 10.21606/dma.2018.387

Contemporary approaches to the study of design teams tend to assume that teamwork is entirely social, thereby failing to examine the extent to which design team processes involve the assumed joint attention and social collaboration. Nowadays mobile devices enable a situation where almost the entire design process is carried out in a team co-located setting, which allows for both individual and social creative processes during teamwork. In this perspective, this article explores the oscillation between co-located individual and social design activity. To study the shift from individual to social activity *within* design teamwork, we surveyed 23 hours of team activity amongst 25 high-school students by coding and analyzing captured video of their teamwork while working in a self-imposed manner on a design task. We found that different creative sub-processes, such as information search, problem defining, idea generation, decision-making, and feedback, foster different degrees of joint attention, and that the joint attention may be established more successfully through analogue and shared digital communicative resources.

team designing; individual creativity; social creativity; joint attention; co-located teamwork

1 Introduction

Theoretical models of designing differ in whether they conceptualize design as an individual activity, or a social endeavour. Early theoretical models of design and creativity processes tended to rely on conceptualizations of individual expert designers as creators working in isolation, i.e., the lone stoic thinker (Fischer, Giaccardi, Eden, Sugimoto & Ye, 2005; Sawyer, 2007; Cross, 2011). As design theory and practice has evolved into collaborative forms, such an individual conception was supplemented (some would say replaced) by the idea that design was first and foremost a social team endeavour (Cross & Cross, 1995; Kleinsmann, Valkenburg & Buijs, 2007). The current theoretical mainstream on team designing and creativity, tend to fall into one of three distinct approaches. (1) Team efforts are compared to individual efforts in order to establish which is superior. For divergent production specifically, the creativity literature has debated whether individual vs. social production is more efficient, with some evidence that individual ideation (Diehl & Stroebe, 1987) or a hybrid of individual and social activity leads to more ideas (Korde & Paulus, 2017). (2) Team activity is viewed as a form of input-process-output model (Reiter-Palmon, Wigert, & Vreede, 2012). (3) Team social micro-processes are studied (e.g., Cross, Christiaans & Dorst, 1996; Christensen, Ball & Halskov, 2017). These recent approaches tend to assume that teamwork is entirely social, and hence fail to examine the extent to which team processes actually involve the assumed joint attention and collaboration. While the third – process based - approach to the study of designing is well suited to address fluctuating levels of social collaboration over time, in effect such studies typically involve only observations containing team-dialogue, thereby failing to explore flipside of the coin: individual team-related activity. Current design team research thus ignores the fact that a large part of collaborative design sub-activities are done by lone individuals (both inside and outside social meetings), albeit in some form of prior or concurrent coordination with the other team-members.

The present paper attempts to address this research gap by offering a first analysis of oscillations between individual and social activity over time *within* team designing. Coming from the field of cognitive and social psychology within design research, we take an integrated approach to examine real-life team interactions across different design episodes and sub-activities with both quantitative analysis of interaction patterns and types of design activity, and qualitative microanalysis of team member interactions.

Specifically, this paper explores how individual and social dimensions of design team activity shifts across different sub-activities. The empirical study involve 25 high-school students and their teamwork, which entails sub-activities such as idea generation, information search or decision-making, where technology and physical materials feature in their ongoing work. This also makes it relevant to examine how the individual team members use digital and analogue communicative resources to attract and establish joint attention.

When the design research literature shifted from the study of individuals to teams, it may in part have been fuelled by shifting design practices into ever more open, complex, dynamic and networked forms of organizing (Dorst, 2015). Similarly, the present paper also finds inspiration in ongoing changes in design team practices, in the form of increasing team co-located activity due to new ways of working, partly driven by new mobile technologies. Twenty years ago, digital tools for collaboration were located in complex stationary setups, tying them to specific locales, unsuitable for mobile collaboration (Heath & Luff, 1998). Ubiquitous mobile digital design tools are, however, changing the nature of organizing for designing, allowing for the full range of design team activities to be carried out on brought-along mobile devices. Consequently, design team members need no longer change location back to their desk after a meeting in order to continue individual work, allowing for a co-located design process oscillating between individual work and social dialogue.

Theoretically, we seek to inform descriptive models of design team processes on the issue of self-selected oscillation between individual and social team activity over time. While joint attention (Harvey, 2014), shared representations, and team mental models have been deemed important process characteristics for design (Kleinsmann et. al., 2007), it is not clear how joint attention may fluctuate across design sub-activity types or over the course of designing. Further, while joint attention may be mediated through shared analogue media (co-sketching, collaborative prototyping) or gesturing, it is unclear whether and how joint attention may be established in the context of ubiquitous personal mobile computing. We sought to explore the effectiveness of the communicative resources deployed in attempts at establishing joint attention.

1.1 Design Team Processes

A team process is defined as "members' interdependent acts that convert inputs to outcomes through cognitive, verbal, and behavioral activities directed toward organizing taskwork to achieve collective goals" (Marks, Mathieu & Zaccaro, 2001), and centrally involves member interaction. The state-of-the-art temporally based *recurring phase model* of team processes (ibid.) is based on the idea that teams perform in temporal cycles of goal-directed activity, called episodes (Bush, LePine & Newton, 2017). Episodes are sequenced distinguishable temporal units which teams perform on their path to goal accomplishment. Centrally, they are iteratively structured by identifiable periods of action and transition periods between actions. Action phases are periods of time when teams are engaged in acts that contribute directly to goal accomplishment, while transition phases are periods of time when teams focus primarily on evaluation and/or planning activities (Marks et. al. 2001).

The special nature of designing, devising courses of action aimed at changing existing situations into preferred ones (Simon, 1969), shifts much of team activity towards transition phases (involving, for example, goal specification, problem definition, strategy formulation, and planning for design). In such transition phases, the team needs to reach a shared understanding of their goals and processes, before commencing with action phases. Fundamental to collaborative design activity is the sharing of representations, which serve as the basis of subsequent sub-goaling, and individual design activity. Shared understanding may be defined as a similarity in individual perception of actors about either how the design content is conceptualized or regarding team transitive memory (i.e., 'who knows what'; Kleinsmann et. al., 2007). Reaching a team shared understanding in the context of creating novel design is tricky (Cross, 2011). Even when information is apparently shared, misunderstanding and misinterpretations are evident which means that common, shared understanding cannot always be assumed in team work (ibid; Kleinsmann et. al., 2007). It has been shown that analogizing (Christensen & Schunn, 2007) and mental simulation (Casakin, Ball, Christensen & Badke-Shaub, 2015) in teams can play an important part in reaching shared team understanding and support team mental models.

Descriptive studies of design activity place centrally activities related to problem clarifying, planning, gathering and sharing information, and generating and adopting concepts (Cross & Cross, 1995; Cross, 2011). The experimental setup in these studies involved short time-frames and depriving the participants of their usual tools and working environments. Such conditions may have shielded the above studies from finding design activities stretching over longer durations, or involving activities crossing organizational or physical boundaries. Consequently, longitudinal descriptive models from engineering design often entails a descriptive separation between conceptual design (early) and detailed design (later) (Cross, 2008). Further, the design sub-activities identified by Cross (2011) need not be thought of as constituting a normative linear progression, given the iterative nature of design, with co-evolution of problem and solution, that has been stressed as fundamental to design (Dorst & Cross, 2001; Wiltschnig, Christensen & Ball, 2013). Lawson (2006), in his descriptive model similarly argued for four types of design sub-activities: Assimilation, general study, development, and communication.

For the present purposes, of examining oscillations between individual and social activities, we examined episodes of transitions from individual to social activity for their design sub-activity content. In principle, the opposite oscillation (social to individual) is equally theoretically interesting, but they do not easily lend themselves to analyses of design sub-activity due to the lack of verbalizations. Hence, we restrict our analysis to examine the oscillations from individual to social team activity.

We hypothesized that these sub-processes fall into the categories of either transitory or action phases, with differing in needed levels of joint attention for their completion: sub-activites involving transitory phases (problem definition, planning, and concept development) should contain more and longer episodes of switching from individual to social activity. The action phases would more frequently involve individual sub-goaling, and information search should thus less frequently entail such social episodes, while the action phase of detailed design should be constituted by a number of short team monitoring checks, with the purpose of quickly checking for whether individual work was on track with the shared understanding in the team (i.e., faster oscillations over time).

1.2 Communicative Resources and Joint Attention

A second research question regards the contextual factors and communicative resources influencing whether attempts at attaining social dialogue actually succeeds. A prerequisite of reaching a shared team understanding is to attain joint attention in the team to initiate a dialogue (Harvey, 2014). Joint attention may be defined as participant's being mutually oriented to a common part of their visible environment, and are aware that their conversational partners are also looking at it (Whittaker & O'Conaill, 1997; Zhang et al., 2017).

In a co-located setting, any diversion away from individual work activity will involve a team member intruding or interrupting other member's individual attention. In a work context, interruptions are usually thought to be negative as they hamper individual productivity, but they may equally have beneficial effects (Jett & George, 2003) such as causing minor conflict, which can foster creativity (de Dreu, 2006). An individual being interrupted may feel counter-productive in the moment, but the presence of communicative resources establishing that the cause of the intrusion has a team benefit, may help make the attempt to attract attention successful. Communicative resources can involve analogue (e.g., sketches) or digital (e.g., screen content) media, and visual or not currently visible referents to team generative materials, as well as gesturing. Intruding work using analogue media may help communicate shared understandings, since the referent would usually have been pre-generated collaboratively, while digital referents change visual content rapidly, and hence needs further individual examinations before social meaning may be extracted. A consistent issue in co-located team work, observed in our data, was how the screen of a laptop, tablet or smartphone was oftentimes shielding the individual member from the others, making it difficult for all members to keep track of each other's work. Visibility of the actions of others has been argued to be of central importance in co-present collaboration (Cole & Stanton, 2003). Visual referents should be more effective at attaining joint attention, but in the case of referring analogue media (which carries a consistent visual meaning across situations), referring to both visible and hidden (i.e., not currently visible) analogue media may both be effective in attaining joint attention. For digital shielded content, intrusions might be less likely to lead to joint attention as the potential team benefit from the intrusion would be harder to assess.

2 Methodology

We apply a video ethnographic approach (Heath, Hindmarsh & Luff, 2010, Heath & Hindmarsh, 2002) to collect data of naturally occurring group activity, recording the design teams' processes in-situ.

2.1 Participants and Case Description

We recorded twenty-five Danish high-school students working in seven self-selected groups of three or four people. The students were aged between fifteen and eighteen years, with fifteen female and ten male. The school is one of Denmark's leading IT and media high schools, and their teaching is 100% digital, meaning the students only need their laptop or tablet during class. We followed a 2nd year class during a week-long interdisciplinary project aiming to train creativity and innovation competences. To facilitate the course, the teachers employed a process tool designed to encourage creativity and innovative thinking. The students were assigned the task to design an innovative solution with multimedia to "brand Danish contemporary art for a foreign audience". The design brief focussed on a specific Danish artist who experiences difficulties reaching an American audience. The students were to make a mind map, a mood board, personas, and a prototype, visualization, or sketch of their final solution.

2.2 Video observation

We recorded a total of 39 sessions of group activity, capturing each group with a 2-GoPro dual-audio camera set-up. This setup enabled the capture of all group members face-on along with their use of analogue and digital materials. All groups were recorded in several iterations, and at each time point 3 out of the 7 different groups would be recorded simultaneously in a counterbalanced collection design. Each group was recorded in 5-8 sessions throughout their design process, and the dataset involved data from all groups the first two days, and from 5 groups the third day. The students were not asked to organize or locate themselves in any particular way. Instead, we sought out the groups wherever they themselves chose to sit in the open class environment and working on whatever they found relevant.

2.3 *Analytical approach*

We approach interaction analysis from a multimodal perspective, a broad interdisciplinary approach, which analyses communication as more than speech and text (e.g. Streeck, Goodwin & LeBaron, 2011, Heath et. al., 2010, Goffman, 1964). When communicating, we use language, gestures, gaze, our bodily position in a particular environment, and materials in our surroundings, which we in this article refer to as communicative resources. Communicative resources, like multimodal utterances (Goodwin, 2006), contains both verbal and non-verbal elements that we employ, when communicating with each other when trying to make sense and establishing a shared understanding of what is going on.

Since we have an interest in addressing the material and digital aspects of the social organization of collaborative work, our focus is not just *which* materials and technologies are in use during group activity, but for which purpose and *how* they are activated during interaction. When applying a multimodal approach to interaction analysis, communicative resources like pointing, gaze direction, and the material that the pointing is directed towards, becomes important features as they are used to establish when a particular space becomes a shared focus for the organization of cognition and action (Goodwin, 2003: 219; Goodwin, 1994).

The typical analytical strategy deployed in multimodal analysis is qualitative in-depth analysis of micro-events. Here, we supplement this approach with a protocol-analysis (Ericsson & Simon, 1999) inspired approach to quantifying and understanding interactional patterns.

A typical protocol analysis approach would involve transcribing, segmenting, and coding verbal data, for example in the study of ‘think aloud’ protocols (Ibid.) or naturalistic creative (Dunbar, 1995) or design team meetings (Christensen & Ball, 2014). However, for the present purposes of understanding shifts from individual to social activity, we diverged from transcribing and segmenting verbal data by dialogue turn-taking, and instead segmented data by shifts in activity coded directly from the video.

2.4 *Coding*

To make data available for quantitative analysis, three independent coders assessed the videos. All transitions and time spent on social activity in each group was marked with timestamps.

Attention was coded in three categories: 1) *Individual activity* was coded in case the group members focused their attention on distinct tools or objects (typically mobile devices), but did not interact verbally or non-verbally. 2) *Attempt to attract attention* was coded when a member tries to draw attention from one or more members to initiate social activity, either verbally (e.g. calling a name or asking a question) or non-verbally (e.g. gestures). Finally, 3) *joint attention* was coded when two or more group members interact, maintaining a shared focus (e.g., on a prototype or a screen). The activity is coded for the duration of the shared focus, leading to *episodes of joint attention*. An episode is started by a shift from individual activity to joint attention, typically initiated by an attempt to attract attention, and ends when the group reverts to individual activity. Episodes of joint attention constituted our main unit of analysis.

Episode topic was coded as on- or off-task, where off-task was coded if the dialogue revolved around personal talk or was unclear. For all episodes containing verbalizations, we utilized a coding scheme for design sub-activity drawing on the works of Cross (1995) and Lawson (2006), containing seven distinct categories: Problem definition, searching for information, planning (decision making, delegation of tasks), concept development (idea generation, feedback), and detailing. We narrowed our analytical focus by concentrating on communicative resources as both verbal and non-verbal markers, which were actively involved during interaction. Episodes involving joint attention were coded for types of communicative resources in use. For the quantitative coding, the communicative resources could be digital (e.g., laptop), analogue (e.g. cut-outs, magazines, prototypes), and could be either 'visible' or 'not visible' to the intended receiver. Finally, it was noted whether the participant attempting to attract attention used gesturing.

2.5 Inter-rater reliability

Two independent coders coded 17.5 minutes of the video data for attempt to attract attention, and for joint attention. Reliability of episodes was calculated by segmenting according to each video second, for a total of 1046 segments. A Cohen's kappa coefficient of inter-coder reliability was calculated for each code. Attempt to attract attention Kappa= .65; Joint attention Kappa= .75. Further, two independent coders assessed on-task behaviour on 14% of the episode data displaying satisfactory reliability, Kappa=.62.

3 Results

The dataset contained a total of 23:30 hours of design team activity, 10:41 hours of which was coded as involving joint attention, and 12:49 hours was spent in the teams in individual activity. We identified 758 unique joint attention episodes in the dataset. Of these, 122 episodes were removed due to off-task dialogue, leaving a total of 636 episodes. The episodes ranged from 2 seconds and up to 13 minutes, with a mean length of 1:03 minutes, (standard deviation= 1:32 minutes). For 196 episodes a distinct attempt to attract attention was identified. Different communicative resources were used in the attempts to attract attention, with 52% of the episodes using digital and 23% using analogue references. Further, in 53% of the episodes communicative resources were visible, while in 24% of cases they were not visible (e.g., an unshared personal screen), and in the remaining 23% of episodes, no clear referent could be coded. Additionally, 17% of the episodes contained gesturing by the member attempting to attain dialogue.

Of the full set of episodes, 579 involved social dialogue. Based on the dialogue, the design sub-processes of the social engagement could be successfully coded in 505 cases, and of these 10% involved defining or framing the design problem; 14% involved searching for information; 48% involved concept development (idea generation: 24%, or request for feedback: 28%); 40% pertained to planning (decision making: 30%, or delegation of tasks: 15%); and finally 38% involved detailing the design.

3.1 Exploring Joint Attention Episodes by Design Sub-activity

A repeated measured GLM revealed that the prevalence of the seven distinct design sub-processes differed significantly from each other $F(6,3024)=26.42$, $p<.001$ (See table 1). The results revealed that from least to most prevalent design sub-activity: problem defining, searching for information, and delegation of tasks did not differ significantly from each other, but they were significantly less frequent than the remaining 4 sub activities. Idea generation did not differ from feedback, and decision making, but was significantly less prevalent than detailing. Finally, feedback also significantly differed from detailing.

In order to explore the length of each oscillation by design sub-activity, we compared the mean length of each episode containing a design sub-activity to a baseline of all other episodes not containing that design sub-activity. Two design sub-activities displayed significantly longer than baseline length while the remaining design sub-activities did not differ from baseline: Idea generation episodes (M=0 1:36, STD= 01:56), $F(1,504)=19.56$, $p<.001$, and problem defining episodes (M=02:25, STD=02:43), $F(2,504)=34.56$, $p<.001$.

Table 1. Mean, standard deviation, and parameter estimates for the prevalence of design sub-activities across episodes of joint attention.

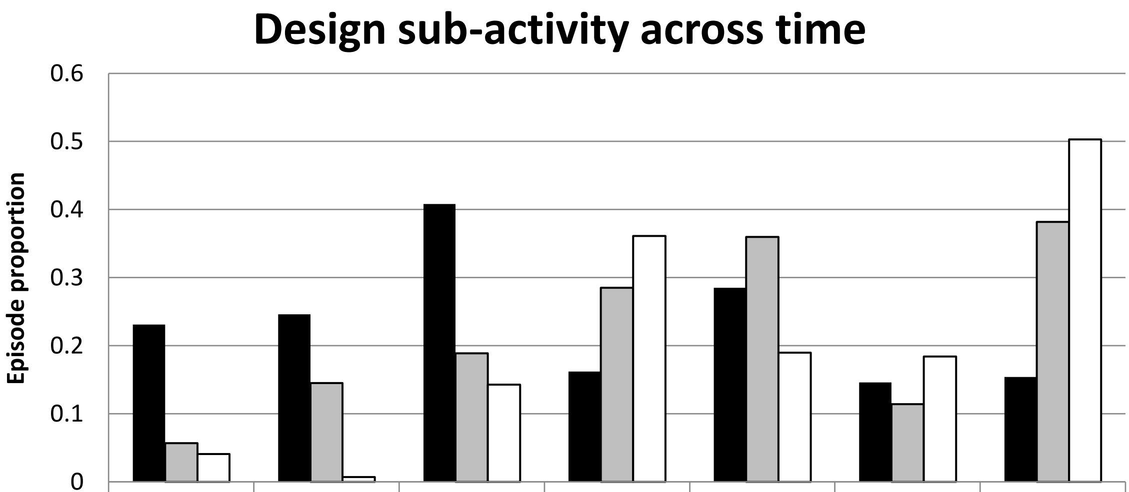
				95% confidence interval	
Design sub-activity	Mean	Std. dev.	*t*	Lower bound	Upper bound

Problem definition	.10	.30	7.36	.07	.12
Information search	.13	.34	8.71	.10	.16
Delegation	.14	.35	9.20	.11	.17
Idea generation	.23	.42	12.33	.19	.27
Feedback	.28	.45	13.84	.24	.31
Decision making	.29	.45	14.39	.25	.33
Detailing	.36	.48	16.78	.32	.40

The major observations appear in alignment with oscillation expectations: frequency and length of episodes of joint attention fluctuate across the type of design-sub activity. Especially activities associated with transition phases appeared longer and/or more frequent, while action phases appeared shorter and/or less frequent. As a notable exception, there were only few (yet lengthy) problem defining episodes.

3.2 Exploring temporal development in joint attention episodes

Across the three consecutive days of observing, all design sub-activity except for delegation (F=1.78) displayed significant distinct differences between the days (F's ranging from 6.33 to 19.27). Linear decreasing patterns over time were found for information search, idea generation, and problem definition. Conversely, linear increasing trends were found for feedback and detailing. And finally decision making displayed an inverted-U shape relation to time (see figure 1). To examine the length of episodes across time, we compared the mean episode length across days of design activity. The mean episode length differed significantly across days (M Day 1=01:22, M Day 2=01:05, M Day 3= 00:45), *F*(2,504)=5.69, *p*<.004. Follow-up t-tests revealed that compared to Day 3, Day 1 *t*(275)=3.91, *p*<.001 and Day 2, *t*(373)=2.09, *p*<.04 were significantly longer, while Day 1 and 2 did not differ. The analysis illustrated that across the design process, the speed of oscillation between individual work and team activity increased.



	Problem definition	Information search	Idea generation	Feedback	Decision making	Delegation	Detailing
■ Day 1	0.231	0.246	0.408	0.162	0.285	0.146	0.154
□ Day 2	0.057	0.145	0.189	0.285	0.36	0.114	0.382
□ Day 3	0.041	0.007	0.143	0.361	0.19	0.184	0.503

Figure 1. Proportion episodes with joint attention by design sub-activity across three time points.

The major observations of episodes of design sub-activity across time seem mainly in alignment with normative design models. Planning activities appeared at a constant high throughout the process, displaying an elevated level of decision making mid-way. At the later part of designing, a frequent (but short) set of episodes involved checking with the team for being on track.

3.3 Modelling successful and unsuccessful attempts to attract joint attention based on usage of communicative resources

The number of successful to unsuccessful attempts to attract joint attention did not vary significantly over the course of days, χ^2 (2, N = 196) = 1.99, p=.37. For the successful and unsuccessful attempts to attract joint attention, we carried out a logistic regression for the involvement of communicative resources. An evaluation of the final model versus a model with intercept only was statistically significant, χ^2 (4, N = 196) = 52.32, p < .001. The model was able to classify correctly, with an overall success rate of 75%. Table 2 shows the logistic regression coefficient, Wald test, and odds ratio for each of the predictors. The odds ratio indicates that successful compared to an unsuccessful attempt to attract social attention is more likely to be drawing on the communicative resources of visible and not visible analogue media, or visible digital media. Successful switches to social dialogue were also more likely to involve gesturing (as opposed to verbal only) attempts to attract attention.

Table 2 Logistic regression predicting successful attempt to attract joint attention from usage of communicative resources.

	B	SE	Wald	df	Sig	Exp(B)
Digital Visible	1.64	.44	14.03	1	.001	5.16
Digital Not Visible	.47	.42	1.27	1	.26	1.60
Analogue Visible	2.06	.68	9.01	1	.003	7.81
Analogue Not Visible	2.44	1.09	5.01	1	.03	11.51
Gestures	2.39	.76	9.76	1	.002	10.87
Constant	-.45	.29	2.35	1	.13	.78

In general, the deployment of communicative resources was effective at turning an attempt to attract into joint attention and social dialogue. Analogue media displayed larger effect sizes compared to digital ones. Only digital media that was not visually available or shared with the team appeared ineffective at mediating the relation between attempt to attract and joint attention.

This initial analysis surfaced characteristics of the shifts between working individually and socially in the groups, which prompted subsequent questions about what motivated the shifts, how shifts were initiated, established, maintained, and interrupted? And which mediators enabled these shifts and stabilized or destabilized the given activity? In order to explore these questions, we conducted in-depth qualitative analyses of illustrative episodes.

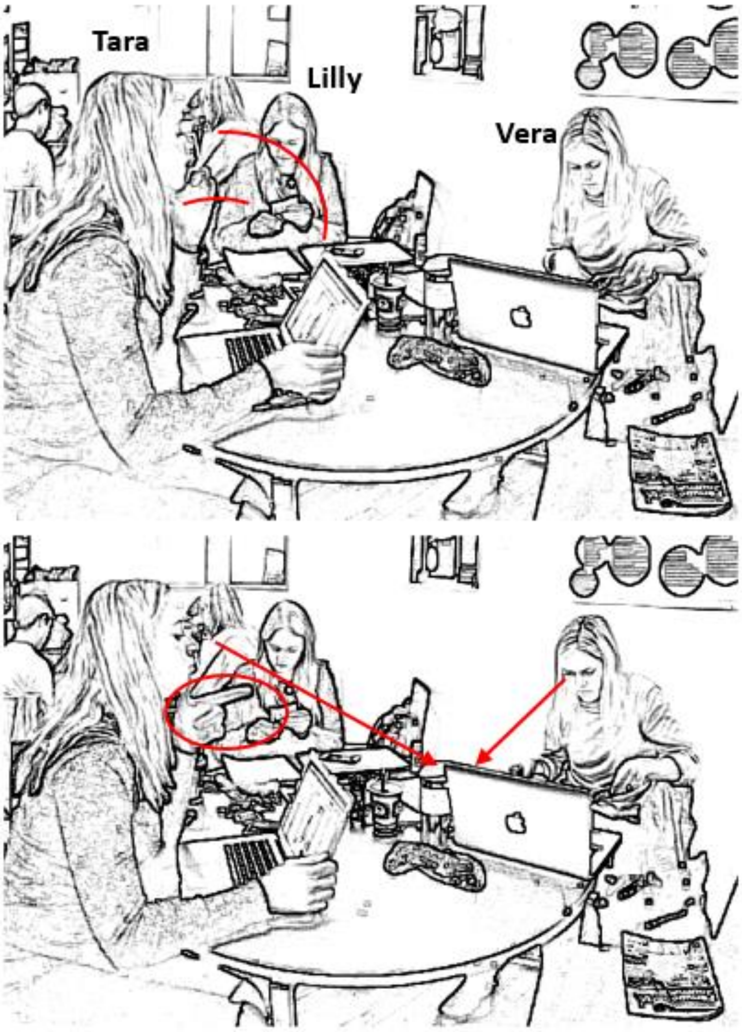
4 Qualitative analysis

4.1 Transitions in interactions

We provide here detailed descriptions and analysis of three data extracts, which demonstrate the dynamic shift from working individual to working collectively, how certain types of sub-activity moderates' attempts to attract attention, and how digital and analogue recourses are used to mediate joint attention. As these examples illustrate, the actions occurring in the episodes are constructed and mutually elaborated through the simultaneous use of multiple communicative resources. Speech and action is transcribed following a CA-inspired multimodal transcription notation (Jefferson, 1984, Heath et. al., 2010, pp.70-83).

4.2 Concept development and decision making using analogue materials

Our first example is a 15.4s video clip. It demonstrates how social action in terms of *concept development* and *decision-making* is built by combining different communicative resources. In this transcript, we see Tara working on her laptop. Lilly and Vera, the other members, are also engaged in individual activity, Lilly is cutting out images, Vera is flipping through a magazine. A poster with cutouts from magazines is placed in the middle of the table.



1

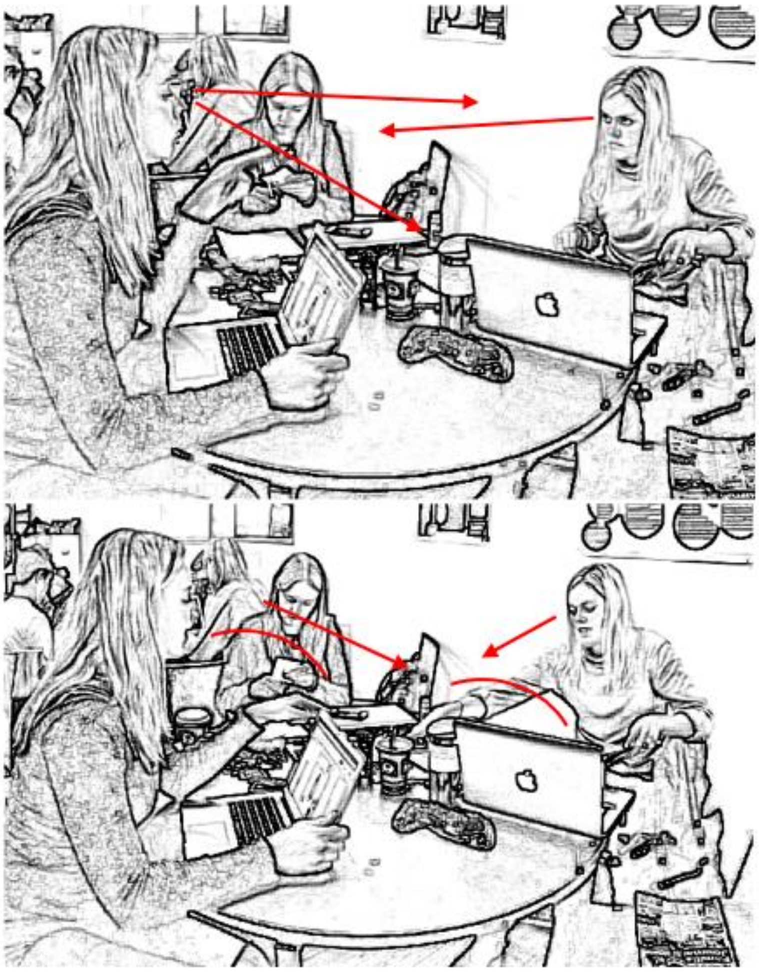
07.29.5
Tara: **Oka:y?** (1.8)

2

07.31.4
Tara: Why is there **a plane** (.) <u>there</u>?

Figure 2 Attempt to attract attention. Video captured images have been manipulated in order to retain participant anonymity.

In frame 1 Tara looks up from her screen facing Vera saying "oka:y?", while moving her left hand to her chin in a chin-stroking gesture. With a rise in intonation, head (and gaze) movement and a chin-stroking gesture, she indicates an attempt to attract attention, where her talk, simultaneously with her bodily organization, displays a questioning and possibly evaluating attitude towards something they are working on. Neither Vera nor Lilly reacts immediately to Tara's attempt. In frame 2 Tara ask a question "why is there a plane (.) <u>there</u>?", while gazing and moving her hand from her chin to a pointing gesture towards the poster. In frame 2, Vera reacts to Tara's question by looking at the poster, when Tara says "<u>there</u>" with emphasis while pointing.



3

07.33.6
Tara: **Should** the plane not be down there?

>why did you put the plane up there<?

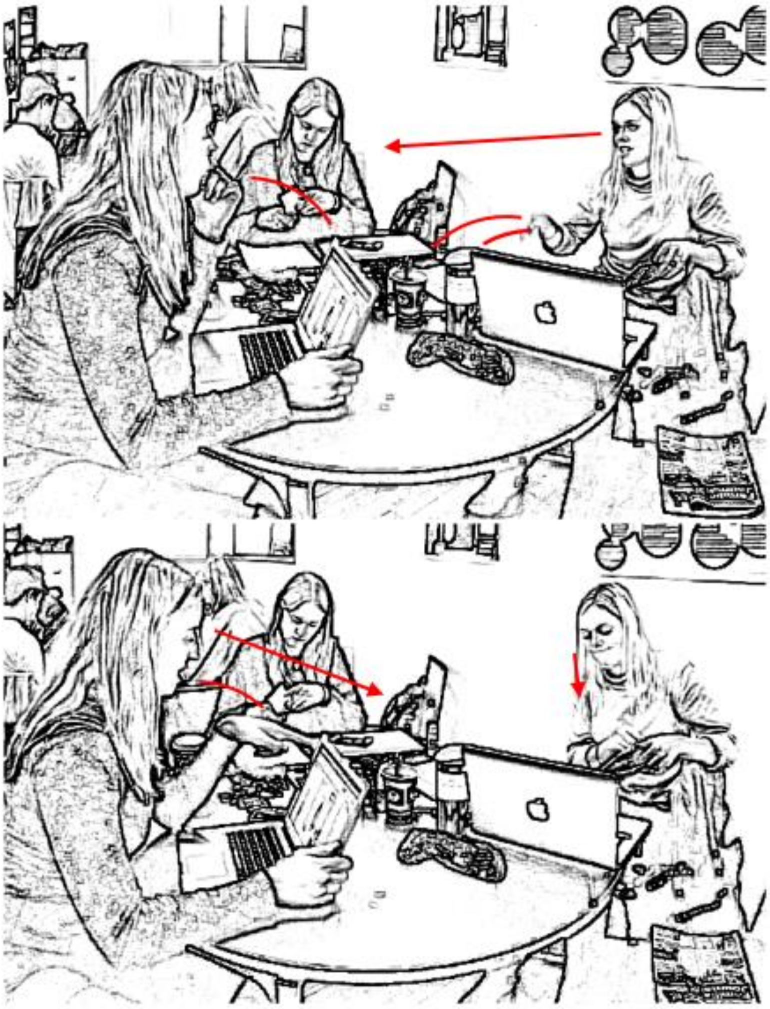
4

07.38.9
Vera: >because< I just began to **place::** it::: eh:

>what was it she said<?

Figure 3 Discussing the task.

In frame 3 Vera establishes eye contact with Tara, who continues her rhetorical questioning; “Should the plane not be down there?” while still pointing. Vera nods repeatedly while maintaining eye contact with Tara. Vera carry on nodding and smiling while Tara continues to question her directly in frame 3, where Tara rapidly says “>why did you put the plane up there<?”. In frame 4, Vera still smiles and looks down at the poster, and points, while explaining her reason “>because<…” for placing the plane this particular place. Vera’s pointing indicates to Tara a specific place on the poster, while visually searching for the argument, she uses the poster as reference point, while saying “>what was it she said<?”, not directed to Tara, but related to the topic of reference in the dialogue. In frame 5 Vera finds her argument on the poster; “likes to travel”, pointing with a tapping gesture at a particular place on the poster, displaying the argument for placing the plane here. Tara’s gaze follows Vera’s movement and she says “oh::” as she withdraws her hand to her chin, with her fingers in her mouth as if evaluating.



5

07.43.2
Vera: likes to travel (.)

Tara: oh::

Vera: But it should be **down** there

6

07.44.9
Tara: Oh: so I should **not make** a plane there? No.

Vera: No

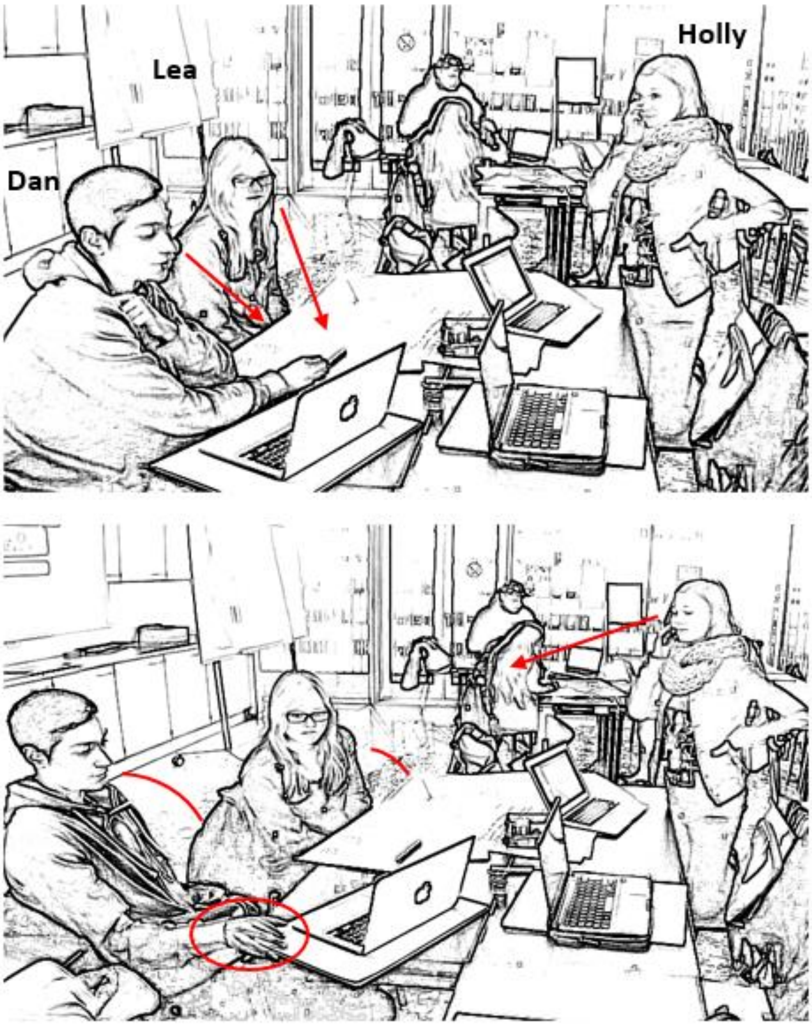
Figure 4 Reaching agreement.

Vera is building up her answer to Tara by combining communicative resources with different properties, which has advantages to the repertoire of possible action available to her in the situation (Streeck, Goodwin, & LeBaron, 2011, p. 2). In frame 5 Vera agrees with Tara's critique, saying "But it should be down there", while gesturing towards the place on the poster. In frame 6 Vera looks down, returns to flip through the magazine, she is holding, with a tight lipped smile as if demonstrating refusal to say no more (Ford, Thompson, & Drake, 2012). Tara takes a final look at the poster, while pointing, and then withdraws her proposal, accepting Vera's argument, while Vera confirms with a short "No".

In this excerpt, we see how Tara and Vera are drawing on a combination of communicative resources when negotiating the design and coming to a decision. The analogue material (the poster) is central for the course of action (the negotiation). The poster becomes a mediator for joint attention, and we see how they both actively are including the poster as a point of reference. What is interesting is how they continuously shift from working individually to addressing each other with questions or proposals to the task. It is also worth noting how the primary activity seems to be individual, and the social activity is only established shortly to align and decide details: Tara never loosen her grip around her laptop, and Vera never puts the magazine down.

4.3 Proposing an idea using digital resources

In the second excerpt, we show how joint attention is mediated by the use of a laptop during an *idea proposal*. The video clip is 9.6s in length. We enter into a group of three; Dan, Lea and Holly. Lea and Holly have just returned to the table and are talking about how to present their project. Dan, who have been working individually at his laptop, looks up, turns his head and nods in an attempt to attract their attention. In frame 1, he establishes eye contact with Holly and immediately initiates his proposal “I was thinking”, after which he turns to look at the screen of his laptop to show what he is “thinking”. In frame 2, Dan moves back in his chair as if to make space for Lea and Holly to see his screen, while slightly turning the laptop in their direction. He utters the proposal “about an email to eh:: Julie Nord”. This creates a focus for attention and locus for shared work (Goodwin, 2013) and the others display appropriate commitment to the joint activity (Bratman, 1992). Holly looks towards Dan, and in frame 3, she leans towards the screen.



1

10.30.8
Dan: I was **thinking** eh: (1.3)

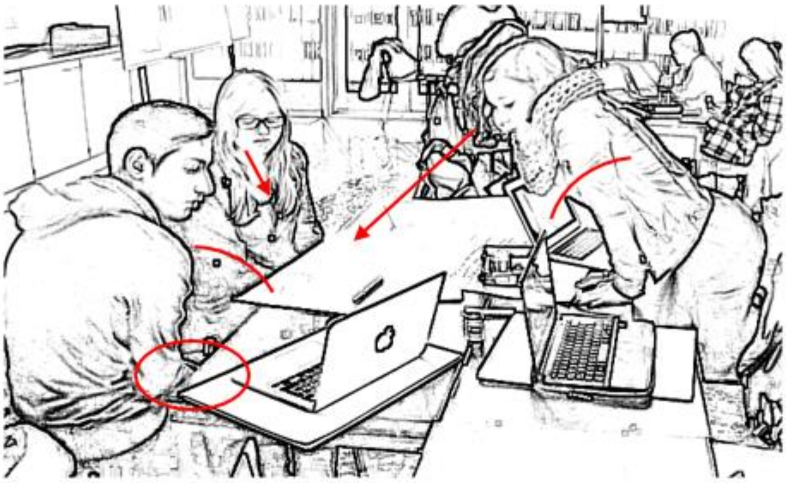
2

10.33.6
Dan: about [an **email**] to eh:: Julie Nord (.) right’?

Lea: [do you think]

Figure 5 Establishing contact and focus for attention.

Dan elaborates the proposal in frame 3. He talks fast and hesitates “>then we could ask if< she wants eh:: to:: (.) eventually”, while placing his hands between his legs and bending his body inwards, displaying a closed body language. He maintains his gaze towards the screen while uttering his proposal as if using what is displayed on the screen as verification in relation to the proposal. Lea interrupts with confirmative displays “it could be really cool [if we]”, orientated towards the screen, while Dan adds details to his proposal “[make a short] interview on (.)”.

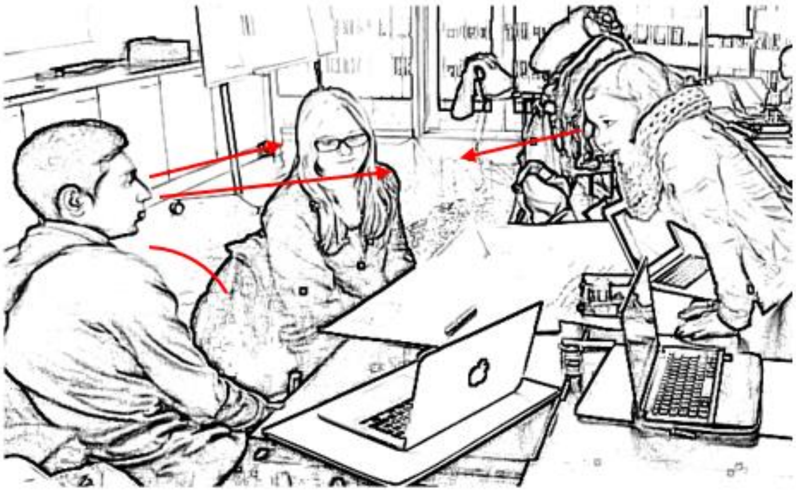


3

10.36.2
Dan: >then we could ask if< she **wants** eh:: to:: (.) eventually

Lea: yeah it could be co- really cool [if we]

Dan: [make a short] interview on (.)



4

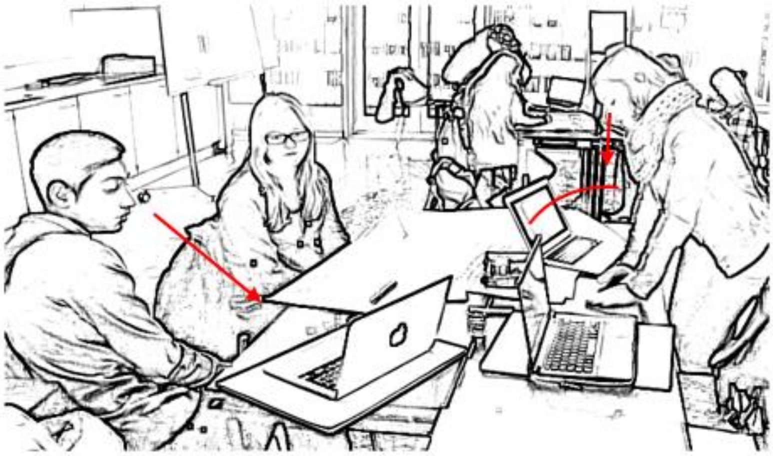
10.40.4
Dan: °the phone° **maybe**? >or something<

Holly: eh:: (0.5)

Figure 6 Rejection followed by withdrawal of proposal.

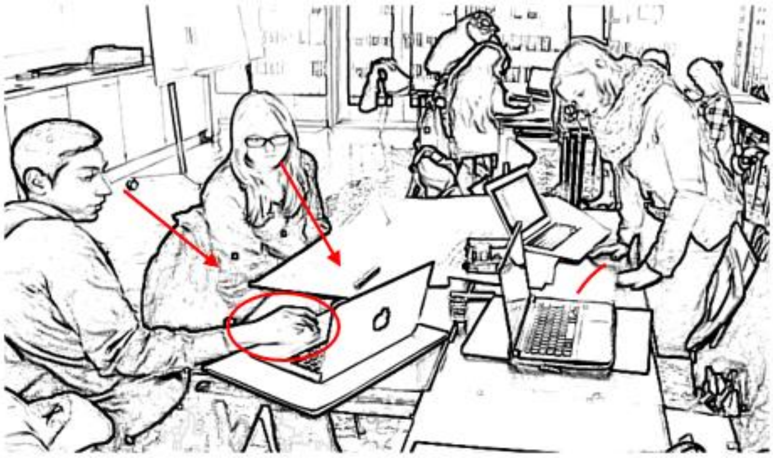
In frame 4, Dan lowers his voice "°the phone° maybe? >or something<", looks from Holly to Lea, while leaning slightly back, displaying uncertainty with a questioning and indefinite closing to his idea. Holly looks at him, while uttering a prolonged "eh::" followed by a pause. In the next frame she leans back, looks down and expresses a seemingly enthusiastic "Yes!" immediately followed by a "that might be" while lowering her gaze and wiping the table with her hands, which may indicate resistance rather that acceptance. Meanwhile Dan is already expressing a withdrawal of his idea with a whispering "°maybe°".

In frame 6 Lea is attempting to support Dan's idea, she lowers her voice, asking where the email is, seemingly ignoring Holly's hesitation. She refers to "the email" and gazes at Dan's screen as if to build up new action towards acceptance of the idea rather than dismissing it, by reusing resources provided by the prior action in frame 2 (Goodwin, 2013). Holly continues, saying they might "be lucky" and adds that they are "surely" not the first ones to come up with the idea, shaking her head slightly. A long silence follows (2.9 seconds), perhaps indicating disagreement or rejection (Pomerantz, 1984; Davidson, 1984). Lea then ads "but we can always try", glancing towards Holly. After this extract, Holly agrees to the idea and they decide to go with the idea of an interview.



5

10.42.1
Holly: [Yes!] **that might be**
Dan: [°Maybe°]



6

10.44.2
Lea: °where is the email?°
Dan: °**here**°
Holly: we got *lucky* >surely we are not the *first* ones to come up with that idea<

(2.9)

Lea: But we can always try

Figure 7 Reattempting to support idea.

What this excerpt exemplifies is how Dan is able to attain joint attention mediated by a personal laptop. The reason, we may assume, is that Dan actively draws on his laptop as a communicative resource during his idea proposal by organization his utterances around it (bodily orientation, gaze and verbal references). It is worth noting how he turns the screen towards the others. This seems like an effective way of establishing joint attention, making it possible for Dan to not only propose his idea, but also establish a common point of reference for decision-making when the need arises. In line with Goodwin's analysis on the discursive role of vision within different professions (1994), we argue that talk, gesturing, and image, mutually enhance each other in establishing joint attention.

5 Discussion

The present results contribute to procedural understandings of collaborative design practice, by honing in on oscillations between individual activity and joint attention in co-located design teams. By examining episodes of joint attention, we found that the frequency and duration of social episodes fluctuate over the course of designing in predictable patterns dependent on phases and activities involved. Descriptive models of design processes were informed by the theoretical separation of design sub-activities into transition and action processes, and the empirical evidence suggesting that many sub-activities carried out in transition phases seemed to contain more and longer periods of joint attention. We found that idea generation and problem defining activities were of longer duration, and the most frequent types of episodes related to concept development and planning. Conversely, action phases were mainly somewhat shorter and less frequent as illustrated by the infrequent joint episodes on information search, with later design phases characterized by decreased shared attention duration, possibly due to numerous short touch-back episodes to check with shared team goals keeping individual design activity on track. The findings illustrate that the currently held general conception of team designing as entirely social in nature is overly simplistic: much of team designing entails individual activity, albeit delegated to individual sub-goals, and less than half of co-located team designing in our data contained joint attention. Future descriptive models of team designing should incorporate the understanding that only a subset of activities taking place in collaborative design involves social interaction.

Further, in the context of ubiquitous personal mobile computing, the present paper attempted to examine the role of communicative resources in attaining the sought after joint team attention. We found that both visual and hidden references to analogue media effectively mediated the relation between individual attempt to attract attention, and subsequent joint attention. Similarly, visible digital media (e.g., sharing a screen) was also effective, but references to invisible digital referents did not support shifts to shared focus. Follow up qualitative examples helped illustrate that the frequent and inadvertent shielding of personal screens in co-located designing was unhelpful in providing visual cues to quickly gain an understanding of the cause of interruption.

The realization that team design efforts do NOT always involve social activity attenuates the battle for individual attention taking place in co-located team designing. Thus, the present findings have implications for the organization of design, and for the design of design tools, in educational settings. For example, the frequent, but short, joint attention episodes during later design phases may imply the need for continuing brief social team engagement even when many design teams would have delegated that activity to an individual. Further, quick visual access to cues for what is causing attempts to attract attention is important for establishing dialogue, and design process tools might do well to further consider how to incorporate shared visual cues, and allow for quick episodes of team touch-back at later design stages.

Future research should further investigate the oscillating nature of team design activity in professional design teams. The present study made use of a co-located in-situ educational design setting with high-school students and it is unclear to which extend the present findings will generalize to professional contexts. It is for example noteworthy that the student designers in the present study spent limited time exploring the design problem, which is unlike known design expert behavior (Dorst & Cross, 2001). Furthermore, for the present purposes, we restricted our analysis to shifts from individual to social activity, ignoring the opposing directionality due to difficulties in coding non-verbal individual design activity. Individual activities may be examinable in other ways than through verbalizations (e.g., though observational estimates of their functions), and hence their future study could help explore further the nature of individual-social oscillations.

Acknowledgements: The authors would like to thank Innovation Fund Denmark (CIBIS 1311-00001B) for supporting this research. Innovation Fund Denmark invests in cultivating and translating ideas, knowledge and technology for the benefit of Danish Society.

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DRS 2018 Design Research Society 2018 **Catalyst**

University of Limerick
25th–28th June 2018

Designing Idea Management Tools: three challenges

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doi: 10.21606/dma.2018.404

Designers have a broad range of digital and analoge idea management tools at their disposal. We know that designers have individual preferences for different tools, but we know very little about why this is, and which practices designers accomplish using different tools. This paper presents the results of an interview study with 16 professional designers, where we investigate the tools, designers use to manage their early stage creative ideas. The study reveals three perceived challenges for designers working with existing idea management tools. These challenges are: 1: Idea management tools are rigid in capture medium, 2: Idea management tools offer inflexible interfaces and representations, and 3: Idea management tools focus mainly on ideas, not ideation. We interpret the findings into operational examples of how builders of novel tools might embrace these challenges in the development of next-generation idea management tools.

idea management tools; ideation; idea management, design tools

1 Introduction

Designers employ a broad range of both digital and analog tools to capture and develop their creative ideas (Coughlan & Johnson, 2008; Inie & Dalsgaard, 2017; Vinh, 2015). The tools inevitably shape the work practices, and correspondingly, the preferred mode of idea representation affects the choice of tools (Kan & Gero, 2008; Stones & Cassidy, 2007). Why are these practices so different across designers? In 2015 Khoi Vinh (Vinh, 2015) did a large-scale survey identifying the most commonly used tools by designers for activities such as 'brainstorming and ideation', 'wireframing', 'interface design', and 'prototyping'. While the survey provides a statistical overview of the many different tools, designers use, it does not elucidate why designers prefer different tools for seemingly similar tasks. The current study explores the perceived challenges that designers experience when working with digital and analog tools to capture, store, retrieve, and collaborate on their ideas.

Coughlan and Johnson (Coughlan & Johnson, 2008) coined the term idea management as a way of describing the various practices, creative practitioners exhibit to keep track of their ideas. They identified three main purposes that creatives try to achieve in their management of ideas: 1: retention and organizing of ideas, 2: feedback, evaluation, and development of ideas, and 3: communication of and collaboration around ideas. These definitions provide a more detailed insight into the goals of creative practitioners, and suggest a lens through which to view the selection of various tools. In this paper, we share a similar understanding of idea management, and thus our definition of idea management tools is *any tool, digital or analog, that designers use to capture and/or keep track of their ideas*. When we describe idea management *systems*, we refer to an assembly of tools that a given designer has told us they utilize for idea management purposes. For instance, email might be mentioned as an idea management tool, but the designer might take a picture with their phone and then send it to an email account. The latter we call the designer's idea management system. An idea management system often consists of a combination of digital and analog tools, however the design opportunities in this paper focus on digital tools, as analog idea management requires more fundamental redesign of materials and processes.

This paper presents the findings of a series of interviews (N=16) that examine how creative designers use tools to manage ideas. We sought to discover patterns in the types of tools and strategies employed, to examine the use of different tools in combination, and to identify opportunities for supplementing or developing novel tools or applications for supporting idea management.

We identified three core challenges for designers working with idea management. 1: The capture of an idea is often defined by the tool, and designers therefore find ideas to be distributed across several media and archives. 2: Idea management tool interfaces often support only one way of representing ideas; this hinders flexible work with ideas that requires shifting between and combining different representations. 3: Most designers we spoke to were not looking for “yet another app” to help them brainstorm, but they were interested in tools that would help them *develop* their ideas. We also asked the designers to imagine novel, ideal tools for working with their ideas. The collective answer for these questions was a general desire to see more intelligent tools which could act as an active agent in their various work practices, for instance predicting outcomes of certain design choices ad hoc (P15) and automatically being able to present the designer with “the core concept” (P6, P8). Drawing on these insights, and designers’ imagined tools, we offer opportunities for developing novel tools and enhancing existing idea management tools.

2 Related work

Creative design practice is a complex phenomenon to study, and many researchers have tried to tackle this complexity by studying only a limited set of parameters in lab-based experimental setups (Kozbelt, Beghetto, & Runco, 2010), framing creativity primarily as a problem-solving cognitive activity. However, recent contributions have argued that what is studied in lab experiments (in vitro) is a poor model of the complexity of creative work in real world settings (in vivo) (Simonton, 2003; Wiltschnig & Onarheim, 2010). In real-world creative work, a defining characteristic of skilful practitioners such as interaction designers is that they often employ and combine a range of different tools in idiosyncratic ways in order to tackle specific challenges (Gedenryd, 1998). This typically entails a mix of analog and digital tools.

Designers capture their ideas both for recall and for retention purposes, as well as to explore their ideas (Dix & Gongora, 2011; Finke et al., 1992; Schön, 1983; Suwa & Tversky, 2002). According to Scheiderman (Shneiderman, 2009) the development of creativity support tools is one of the current “grand challenges” for HCI. In spite of this call to advance creativity-oriented HCI, it remains a niche field in comparison to research with a more functional and productivity-oriented focus. While there are several extensive overviews of creativity methods and techniques for designers (Saha, Selvi, Büyükcan, & Mohymen, 2012; Smith, 1998), we do not see similar overviews of tools that designers can use to manage ideas. This is a clear lacuna in research, since previous work has demonstrated that the use of such tools is crucial to creative work (Dalsgaard, 2017). In our work, we have designed our inquiries to account for these issues through open questions that can account for a variety of circumstances under which respondents work with ideas, while also focusing on the role of tools used in social practices.

An online survey among professional designers from different companies and locations (Inie & Dalsgaard, 2017) has previously identified common patterns between designers' use of tools, namely, all designers need and use tools for the processes of capturing, managing, and collaborating on ideas. These activities correspond with the activities that Efimova (Efimova, 2009) identified as the primary purposes of weblogging (which may be viewed as an example of creative ideation, even though the work was aimed at academic advancement and not design): low-threshold creation of blog entries, organizing and maintaining content, and engaging with others around blog content. In addition to these, she identified the activity of retrieving, reusing and analyzing content, which are activities practiced by designers as well. In fact, we found many similarities between idea management and information management, when we surveyed the field of personal information management (Boardman & Sasse, 2004; Kaye et al., 2006; Whittaker & Hirschberg, 2001). However, there are also differences between creative ideas and other types of information, one of them being that ideas are often captured outside of work settings, and in unpredictable circumstances, when the creative practitioner is not actively trying to ideate (Coughlan & Johnson, 2008).

When creative workers externalize their ideas, it allows them to explore and reinterpret their mental representations, refining their ideas (Dix & Gongora, 2011; Finke, Ward, & Smith, 1992; Schön, 1983). When the process is documented and archived (Moran, Carroll, & Others, 1996), these actions not only inspire the designer, but also allow them to retrace their steps along the way. This operation is essential for the reflective practitioner, because it allows the designer to not only reflect on the product, but also, and perhaps more importantly, the design process and rationale behind key decisions (Schön, 1983). Kirsh (Kirsh, 2009) described how much of our interactivity during sensemaking and problem solving involves a cycle of projecting, then creating structure. Projection is described as exploring a purely mental representation, entertaining possible actions and evaluating consequences. Externalizing a mental projection allows a designer to release some of their working memory, replacing it with a mental projection and then, if it seems fruitful, materializing it by marking the illustration. While we share an understanding of designing as a reflective practice, we know little about how reflective practice unfolds in everyday design processes and how tools support this. Dow, Saponas, Li and Landay (Dow at al. 2006) found that designers of experiences and ubiquitous systems often lack the tools to create adequate representations of ideas, because their ideas unfold over time and are not static images. Bernal, Haymaker and Eastman (Bernal et al. 2015) addressed this challenge by calling for computational creativity support systems to aim more for aiding the designer than the design alone.

3 Methodology

Our data consists of in-depth interviews with 16 professional interaction designers. The interviews lasted between 45 and 80 minutes and were structured in sections about capturing, managing, retrieving and collaborating on ideas. We enquired for which tools the respondents use at which times during their design processes. In each section, we asked the designers which tools they currently use and why, as well as encouraged the designers to envision and describe how they might imagine ideal tools for working with their ideas (see table 1 for an excerpt from the interview questions). Our goal was not to draw general conclusions but to unearth design inspiration, considerations, and questions. We approached our research questions with qualitative interviews because we found the approach suitable for accessing designers' attitudes and values. We were particularly interested in the interviewee's views, interpretation of processes, understandings, experiences and opinions (Silverman, 2006) (see figure 1 for examples of different ideas).

Figure 1 Different designers' ideas. These are only comprehensible if we can ask questions about purposes and goals.

Table 1: Excerpt from interview questions. For space purposes, not all questions are included in the table.

1: Capturing ideas	1.1 Which tools do you use to do capture your ideas? When you're at work? When you're at home? When you're at "inconvenient places" (i.e. on a walk, in the shower, at yoga class etc.)? 1.2 Can you remember the last time you captured an idea? Describe what happened. 1.3 Imagine the ideal tool, in your mind, for continuously capturing ideas. What would the interface of this tool be like? What key features would it have? 1.4 Why do you capture ideas? What's the end goal-product? And how does archiving contribute to that?
2: Managing ideas	2.1 Where do you keep your ideas? 2.2 How do your ideas look? E.g. sketches, audio files, texts, image collections etc. 2.3 Which tools do you use to make them look this way? 2.4 Imagine the ideal tool, in your mind, for storing ideas so they are easy to find and use when you need them. What would the interface of this tool be like? What key features would it have?
3: Retrieving ideas	3.1 Do you ever look at your old ideas? Why/why not? 3.1.a If yes: How do you use your old ideas for later projects? 3.1.b Take me back to the last time you went through an idea archive of yours. What did you learn from it?
4: Collaborating on ideas	4.1 Which tools do you use when you collaborate with others in generating/developing ideas? 4.1.a Why these tools? 4.3 Imagine the ideal tool, in your mind, for collaborating on ideas with your colleagues or team - what would the interface of this tool be like? Which features would it have?

3.1 Demographics and details about interview participants

We interviewed 11 male-, and 5 female designers working with interaction or digital design. Participants were recruited via the authors' personal networks, mailing lists, and Facebook groups for UX designers. The age span was between 22 and late 40s, with experience in design ranging between 2 and 11+ years. We didn't deliberately choose the designers based on their experience or demographics, but rather based on getting a varied sample of different types of designers, and we stopped at the point where the categories of information became saturated (Creswell, 2013).

3.2 Analysis and coding

All interviews were transcribed and coded with a grounded theory-approach (Creswell, 1998), (Glaser & Strauss, 1967) to identify prevalent themes. The initial open categories were based on identifying the actions and goals the designers were trying to achieve with the tools of their choice (axial coding) (Creswell, 2013). The initial categories are shown in table 2.

Table 2: Initial open categories

Idea forms and representations	To do-lists, visual vs. text, screen dumps, bookmarks, notes, sketches, information, prototypes, talking as prototyping, moving from analog to digital, moving from digital to analog
Software	Evernote, Reminders, Slack, PowerPoint/Keynote, Illustrator/Photoshop, Asana, Google Keep, Pinterest, email, tool personalization, one master tool, ideas for tools
Hardware	Sticky notes, paper, tagging, cloud, phone camera, phone dictation
Ideas-/inspiration archive	Revisiting ideas, naming conventions/archiving practices, idea bank, inspiration materials, finding ideas, folder organization, forgotten ideas, desk area
Collective ideation	Decision making process, ideation in a company, collaborating with a whiteboard, tools for collaboration
Communication about ideas	Challenge of collaboration and representing ideas, communication of ideas, flow of ideation
Personal ideation process	Ideation process, signifiers/markers to self

For this paper, we focused on all instances where designers mentioned experiencing *challenges* with the idea management tools or systems they utilized. Challenges were especially prevalent in the categories *Idea forms and representations* and *Ideas-/inspiration archive*, leading us to focus our analysis on these. In line with the description in Creswell 2013, we focused on identifying causal conditions for the core phenomena (the challenges), strategies applied in response to challenges, contextual and intervening conditions that influence the specific challenges, and consequences of the strategies taken in the process of managing ideas. We have summed up the following selective coding in the three core challenges we present in this paper, and the opportunities for idea management tools to address the challenges in table 4 are based on the strategies, the designers used in response to their perceived challenges.

4 Findings

Table 3 presents an overview over the idea management tools mentioned during this study, as well as the key idea management activities they are utilized for; idea capture, idea development, idea storage, retrieving ideas, and collaboration around ideas. These categories are not mutually exclusive (see example in figure 2). In the next section, we present the core three challenges designers experience in their idea management process in depth.

Figure 2 One software tool (Procreate) that lets the designer capture or save an image and draw/annotate on top of it in one or more layers which can then be turned on or off. This designer used Procreate primarily as a development- and presentation tool for clients.

Table 3 Overview of primary idea management tools (mentioned by at least two designers) and their key function(s) in creative idea management (as experienced by study participants)

	Capture	Development	Storage	Retrieving	Collaboration
Pen and paper	x	x	x	x	x
(Physical) sticky notes	x	x			x
(Digital) sticky notes	x		x	x	
Evernote	x	x	x	x	
Reminders	x		x	x	
Google Keep	x		x	x	
Screen dumps	x		x		
(Phone) camera	x		x		
(Phone) dictation	x		x		
PowerPoint/ Keynote		x	x		x
Illustrator/ Photoshop	x	x			
Procreate	x	x	x		x
Pinterest			x	x	
Email	x	x	x	x	x
Whiteboard	x	x			x
Slack	x	x		x	x
Asana	x		x	x	x
Dropbox			x	x	x
Google drive			x	x	x

4.1 *Challenge 1: Idea management tools are rigid in capture medium*

Designers often capture with a tool based on convenience and availability, and they choose tools for development of ideas based on the tool's visual representation. This means that the designer has to translate their idea from initial capture, which might be a camera photo or a sticky note, into a different piece of software that allows them to refine their idea into a product or prototype, for instance a wireframing tool or a piece of illustration software. The tool is usually chosen based on the ease of input if offers:

> *"I use voice memos a lot now when I'm in the car [...] or when I'm running. Running is really difficult because I don't like to stop to capture that thought (...) it becomes a repetitive thought, almost like a mantra if I think of something, and then I'll write it down when I stop." (P10).*

Because designers use different tools for idea capture, they often have very distributed idea archives. Several designers described this as a challenge: "***Do you ever go back and look at your old ideas? Why or why not?*** *Not often enough, and that's because they're not necessarily filed properly for me to find them easily*" (P13). The main peril is that potentially relevant ideas get lost or forgotten, because they are hidden away in folders that may never get looked at again. Often, the camera roll on the designer's phone would be such a place, where many photos of whiteboards from ideation sessions would be saved, but never returned to. Another example would be audio recordings of ideation sessions: while several designers described using audio recordings, they all agreed that nobody actually ever listened to these recordings again. In response to this potential loss of ideas, some designers deliberately build archives of ideas in tools that keep their idea archive restricted to one tool. Three designers described how they use their email accounts as idea management tools. This way, they are reminded about their ideas during their daily workflow, because their email client is always open and available. The email account also allows them to push content from different platforms to a shared database quickly, because they can send links, text, images and other files to the account when they are away from the desktop. The popularity of email as an idea management tool does not correspond with a general preference for visual tools. All designers we interviewed said they prefer extensively visual tools for managing their ideas when we asked them to imagine ideal tools. Email offers something particularly desirable to outweigh its limitations, namely that it is omnipresent and a natural part of the workflow:

> *"For some reason, right now I'm really stuck on typing everything into email, and I email myself everything. So, I use...I constantly... for my single reminder and my single go to, I have Wunderlist, and I created a Wunderlist, but for some reason, I can't find myself using to do lists or reminders as a consistent tool. I continue to go back to email, and I don't know if it's a crutch right now or if it's because that's what's always visible and that's the best way to remind myself. (...) email just seems to be the one consistent thing that helps me aggregate all of my thoughts and everything that's going on." (P9).*

Several designers mentioned an aspiration to tag their ideas more, but they found the process too inconvenient. In most of the cases we encountered in our studies, the archived content was in the form of snippets of information, often without metadata. This type of content is typically detached from the context in which it was originally captured, since it is not feasible to capture all aspects of a design process, as discussed in Dalsgaard and Halskov (2012). As a consequence, most designers rely primarily on their memory to find things, which results in ideas getting lost and being forgotten. One resulting strategy is that many designers rely on other contextual cues than tags:

> *"**So, for you the importance of idea is a little related to when it was created or modified?** Yes, well actually maybe not how important it is to me at any given time is sort of dictated by the time I've given to that idea. That's under the presumption that if an idea was important to me, I would have contributed to it more recently than others. However, that does leave room for ideas that I've put in the parking lot per say that I just haven't given headspace to in a long time. Although they may be important or have validity" (P6).*

Especially for handwritten notes and sketches, adding tags and annotation is experienced as difficult. While most digital idea capture tools offer a way to add tags or notes to individual files, most designers do not take the time to do so at the point of capture. Consequently, randomness can become the determining factor for whether the idea is ever revisited:

"I would love to think that I have one place where all my amazing ideas live, those ones that I haven't got to or I haven't had time to think about (...) it would be a lot easier to then go back, retrieve them and act upon them. Some ideas will sit dormant in a document for months if not years until sometimes you discover them accidentally" (P10).

4.2 Challenge 2: Idea management tools offer inflexible interfaces and representations

A core function for idea management tools is offering a representational structure of design ideas. Most often, the interface a tool is chronologically ordered with no other structure: "*But as you see it's just images that's placed underneath each other not much of a... And no title so there's not of a system which makes it a bit manual*" (P12). The same is the case for analog notebooks, which are inherently rigid in their interface. For many designers, malleability and movability are the major qualities of sticky notes, whiteboards and large sheets of paper. Several designers mentioned they would like some digital imitation of a giant whiteboard when asked to imagine ideal tools for organizing ideas:

"I would love a huge interactive touchscreen in my day where I could doodle, I could draw, I could swipe, I could write, I could pull up images from the net and having everything there at my fingertips." (P10).

While many idea capture tools focus on offering comprehensive overviews of files, they often do not offer the flexibility of moving things around and clustering them, which is a key element of many ideation sessions.

Most tools represent single files in their entirety and not parts of files or context of files. This challenge was also described by (Herring, Chang, Krantzler, & Bailey, 2009), who showed how designers experience difficulty with their example storing strategies because they have no way of keeping track of their thoughts at the point of capture. While, for instance, phone dictation is very suitable for quick capture of thoughts while a person is driving a car, an audio file is not an easy modality to work with after the capture, because it has no visual representation. One designer (P7), who used phone dictation for brainstorming with himself on his 45-minute commute to work, explained his frustration with not being able to mark or annotate specific points in the recording, because he would currently have to listen to the entire file to find 30 seconds of interest. Idea management tools in general do not offer ways to filter out selected parts of files, which designers mentioned as a feature they missed on various occasions.

4.3 Challenge 3: Idea management tools focus mainly on ideas instead of ideation

A key activity for designers is the process of *developing* ideas. One designer (P4) deliberately refused to keep any kind of archive of his ideas because he felt like it became a marinating jar where his best ideas would go to die. This designer suggested that maybe designers do not need another brainstorming tool, but rather a tool for moving ideas from paper and out into the world. When we asked designers to imagine tools they would like to use, most suggested some version of an intelligent tool that would be able to help process data to aid their cognition:

"if you don't have an idea of what filing system you're going to use, then it can actually be pretty daunting because you start from somewhere and it becomes a really mess real quickly because you have lots of files without categorization file folders or structure (...) I would love that intelligent interface to file my documents and thoughts without me having to think about it, so it'd be based on the content in there or the type of idea that I'm coming up with." (P10).

Most idea management tools are product-oriented rather than process-oriented, which means they are passive containers of files.

In extension to this, idea management tools in general do not promote reflection on the design process or future thinking. While they aid the designer in the creation and overview of files, they do not actively help the designer reflect. This could be a significant potential for idea management tools and for designers alike. Digital tools have the potential to record and track all ongoing activities of the designer and to use this data in a constructive way. In our interviews with the designers we asked them to share their thoughts on the idea management tools of the future. While some imagined well-defined features like better Natural Language Processing-search and automatic tagging, others called for entire design environments:

> *"So, it would be something maybe with VR because then I could just ... Okay, now I'm really out there. But something where I could actually draw when I was standing here, so I'm interacting with the pump, I'm building screen by screen and I'm not, again, caught into a tablet. I'm just drawing and (...) And then it would already know how the communication protocols between the pump and this would work. (...) That would be amazing. But that's- Utopia." (P15).*

What the ideas for novel tools had in common was that they were all process-oriented, which is a finding that has been suggested by previous studies in related contexts (Bernal, Haymaker, & Eastman, 2015; Dow et al., 2006).

5 Discussion and further work

After defining the core challenges described in the previous section, our analysis then focused on the strategies, designers employ to cope with the perceived challenges. In this section, the challenges are interpreted into practical opportunities for next-generation idea management tools (see table 4). These are by no means the only ways of approaching the challenges, but they are suggestions for how to operationalize of a set of potentially abstract challenges.

Although many interesting points emerged from the interview data, this investigation is of course not exhaustive given the vast amount of work practices in the field of interaction design. The next steps in this research are to test these features in practice. Our group is currently working on the development of prototypes that explore the opportunities presented in table 2.

Table 4 Opportunities for next-generation idea management tools

Challenge	Opportunities for novel features or tools
1: Idea management tools are rigid in capture medium	Support different modalities of capture and annotation and allow for saving to a shared idea database. Almost all designers described the challenge of their widely distributed idea archives. A consolidated archive from different tools would allow for designers to capture in the appropriate medium while not having to retrieve ideas from several locations.
	Build systems to tag ideas easier with other context indicators than words: time, place, temporal context, people involved in project, quality of idea etc. Designers currently utilize makeshift signifiers to themselves, such as an arrow in the document title or documents in different colours to achieve different (visual) forms of tagging. Alternative modes of tagging ideas would provide cues for bringing ideas up again in relevant future situations, as well as additional cues for retrieving ideas.
2: Idea management tools offer inflexible interfaces and representations	Allow for different views of ideas or files within tools, as well as maneuverability of files in relation to each other. Several designers highlighted the advantages of a large touchscreen that let them view many different files at once, as well as move them around. More flexible interfaces might encourage new clustering of files and lead to new discoveries and possibilities.
	Allow for different types of highlights of different types of files. Several designers mentioned the challenge of annotating different types of files. Letting the designer tag or mark part of an image of a whiteboard and a corresponding video file would allow the designer to highlight particularly interesting parts of a shared idea process.
3: Idea management tools focus mainly on ideas instead of ideation	Support the gap between capture and refining of ideas. A general finding was that idea management tools do not actively help the designer revisit their ideas or to translate them into actual design project. One way of doing this might be to allow the designer to mark ideas that they would like to get back to, and offer revisiting of the idea, for instance by push-notifications or encouraging the move from note into a sketch and sketch into wireframe.
	Help the designer reflect-in-action. Almost all design theory promotes the idea of the designer as a reflective practitioner, but despite this, few designers practice reflective thinking in a systematic way. Idea management tools might help the designer reflect on their own work by to encouraging the designer to answer short questions about their ideas or ask them to cluster their ideas in new patterns.

6 Conclusions

Although some research has cast light on the tools, designers use, no previous studies have thoroughly investigated why designers choose the tools they do to manage their ideas. Our approach was to conduct qualitative studies with professional designers through interviews to discover shared behaviours and perceived challenges they experience with current idea management tools. The study revealed three core challenges for designers as well as opportunities for tool builders of next-generation idea management tools. We concluded that idea management tools are rigid in capture medium, rigid in interface and representations, and that they focus on ideas rather than ideation. We then offered a list of ways to operationalize this knowledge into practical design features or future tools. We hope the challenges and opportunities will inform builders of creativity support tools in aiding designers' continuous work with idea management and inspire tool designers to support continuous ideation as well as ideas.

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DRS 2018 Design Research Society 2018 Catalyst

University of Limerick
25th – 28th June 2018

How Emerging Technologies Influence Designing – The Case of Conversational Agents and Interaction Design

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doi: 10.21606/dma.2018.330

Conversational agents are becoming an integral part of today's technological landscape. Their presence on our everyday devices (e.g. Siri on mobile phones and tablets) and as stand-alone devices (e.g. Amazon Echo and Google Home) changes the way people interact with each other and with their environments. Our investigation of conversational agents as a new emerging form of interaction has led to a realization that this new technology brings new challenges to the interaction design process that are not necessarily considered in traditional interaction design contexts. In this paper, we address some of the issues that our study revealed that we have found not to be included in traditional interaction design, but which may be particularly relevant to conversational agents. We also discuss this example of the emergence of a new technology (CAs) as a challenge to design research in general. We argue that design research has to pay serious attention to developments and changes in the technological field since it might radically influence core aspects of design practice. However, by doing this, design research could become a vehicle for research innovation – provoking new ways of understanding what it means to do research and, in parallel, new ways of understanding what is (or can be) designed.

conversational agents; voice assistants; voice; agent.

1 Introduction

During the last couple of years, we have been involved in a number of small studies relating to the new emerging field of conversational agents (CAs). These studies have each had different characters and focuses, such as: experimental studies, surveys, and analyses of existing and future consumer technologies through the lens of conversational agents. These studies have led to a set of findings, which we will briefly summarize in this paper. The primary finding that we will emphasize and discuss is that new emerging technologies (such as CAs) have the capacity to influence the way designing is practiced in a particular field, which, in our case, in interaction design. Our investigation of conversational agents as a new emerging form of interaction has led to a realization that this new technology brings new challenges to the interaction design process that are not necessarily considered in traditional interaction design[1] contexts.

CAs exist in a multitude of different forms. What we will argue in this paper is that the design of conversational agents involves several elements that are unconventional in relation to the field of interaction design, which is focused on interactive technology. To make our case, we will first discuss what conversational agents are and how they can be understood. We will then summarize some of the relevant findings from our ongoing research project. Next, we will outline what can be seen as traditional interaction design practice and explore how our findings might pose challenges for traditional practice. Finally, we will discuss what this case study can tell us about the relationship between design practice and the emergence of new technologies and what it may mean to the design research community.

2 The Field of Conversational Agents

Conversational agents are commonly defined as voice-controlled assistants, typically embedded in devices, that accomplish tasks on behalf of a user as a result of a vocal interaction. This definition is broad and includes a variety of modern devices and software assistants (Cassell, 2000). We will often refer to conversational agents simply as "agents" throughout the paper. By this action, we are not suggesting a different type of device or service, we are merely shortening the term so that the text is easier to read. Agents are becoming an integral part of today's technological landscape and are commonly experienced as part of our everyday devices (e.g. Siri on mobile phones and tablets) and as stand-alone devices (e.g. Amazon Echo and Google Home).

During the past several years, we have seen many new agents reach the consumer market. These new agents present designers with novel design challenges. *Should the agent sound friendly or aloof? How can always-listening agents' be made to respect users' privacy?* One of our early assumptions was that approaches to design, design practice, may have to be altered to better suit the growing field of CAs.

We began our research on CAs around the same time the Amazon Echo was released. Since then, Amazon has built a robust ecosystem of devices around the Echo, Echo Dot, Echo Look, and so forth. In addition, many other companies have designed and released agents, including Siri and the HomePod (Apple), Google Home (Google), Bixby (Samsung), among many others. Devices such as the Echo Look and the Echo Show could be seen to fall somewhere between traditional interaction paradigms with screens and physical devices, while at the same time leveraging agents to perform tasks.

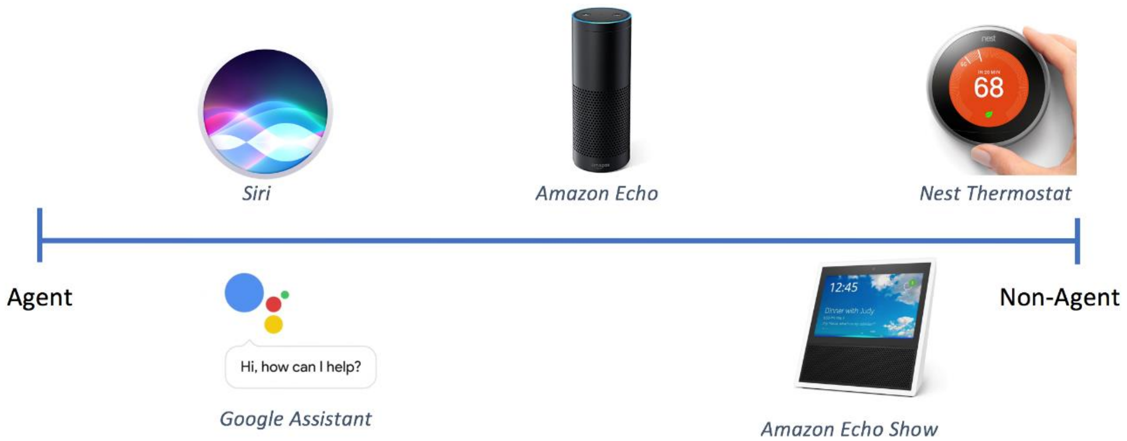

Figure 1 The spectrum of agents

[1] We use the notion of traditional quite loosely here. Interaction design is still a new field and it can be argued that there is not a clear understanding of what the dominant or traditional practice would be. We will discuss this more in detail later.

Most conversational agents exist somewhere in the middle of a spectrum with “agent” at one end and “non-agent” at the other (see Figure 1). In this diagram, we intend for “agent” to mean the level of control that can be achieved solely with voice that a device brings to the user. In other words, most conversational agents are not *entirely* a pure voice-controlled agent since they retain some physical means of interaction like a screen. But other examples clearly transcend the limits of traditional physical interaction in that the agents exist primarily as voice-controlled assistants that do not use screens or other traditional tools of interactivity. There is a middle-ground where we can see a fusion between known, traditional and comfortable interaction methods and new alternative forms of the interface or even no interface.

Designing conversational agents brings the challenge of balancing user familiarity and comfort with new, different forms of interaction. This contrast of old and new is what makes the study of agents fascinating and challenging to researchers and designers.

As we have studied this field, it has become apparent that the technologies driving conversational agents change quickly. Amazon rolls out regular updates to its Echo, and it is already a far more capable device than it was two years ago. In addition, we have learned that conversational agents can be presented in any form factor; they are no longer limited to a landing screen on a phone or a standalone speaker. The Google Assistant can be accessed in a chat application on a phone or through voice. Amazon has released the Echo Dot, for connection to other speakers, and the Echo Look for a camera and fashion advice.

This expansion of what agents can do and look like has fuelled our interest in studying what makes agents successful. If they’re being sold in a wide variety of form factors, then what makes one better than another? Does it even make sense to try and develop generalizable criteria for assessing their overall character? If they’re rapidly improving in voice recognition and in autonomous capabilities, are users capitalizing on even a fraction of the new features that are constantly introduced?

It seems to us that agents cannot simply be designed to meet the needs of the users they are created to serve. For example, if the Echo were designed to meet existing needs of its users, then it would either remain limited in its capacity and/or become obsolete as other artefacts and systems emerge to serve more user needs. Thus, agents must be designed to evolve with their users. The Echo’s physical form factor may remain the same, but then other aspects must change. This could be seen to complicate the design process. Furthermore, because agents often interact with users through dialogue, there is a certain level of human aspect introduced that presents a unique relationship and complicates the design.

Through our research, we have found results related to the dynamics between users and conversational agents. There are certain borders and social conventions that agents may seem to cross or ignore at times, and other instances in which agents seem unhelpful to their users. The true challenge of designing conversational agents does not only lie in the hardware or technologies powering them. Instead, it also lies in the boundaries that are inherent between user and agent. What is a user comfortable with? What do most consumers want from their agents? Do most people even want a conversational agent at all? These questions led us to perform a set of studies that we briefly present below.

3 Summary of Empirical Studies

In this section, we will summarize each of the three studies we have conducted to understand conversational agents. These include: (1) an observational field study of how users interact with physical agents (e.g. Amazon Echo, Google Home) in a home setting, (2) an artefact analysis of seven conversational agents, and, most recently, (3) a survey study of users (n=74) to better understand their comfort level when using conversational agents. It is important to note that the purpose of our studies was to examine and understand conversational agents and not to explore how they influence design practice. However, while engaging in these studies some more general insights emerged that led to this paper.

We will here only mention the purpose of our studies and the major findings and insights that we gained. We will later in this paper in more detail three insights from these studies. These insights should be seen as emerging from the three studies combined.

3.1 *Observational Study of Agents in the Wild*

In this study, we asked participants to perform everyday actions with an Amazon Echo in a home environment. We asked them to phrase commands in certain ways that we knew the device would not recognize, we hid the device from their view and asked participants to says commands, and we played a variety of conversational agents' voices for participants and asked them which ones were the most pleasing. This was our first analysis of agents, and it allowed us to gauge user comfort levels with interaction, revealing that users are often still uncomfortable asking their agents to help them, unsure of how to word requests, and timid about managing the new interface. (The full write up of this study is at the moment under review for publication.)

3.2 *Artefact Analysis of Seven Agents*

Following our study of agents in home environments, more agents had been introduced to the market. We decided to conduct a comparative artifact analysis of a core set of agents in order to survey the device landscape. We compared their physical embodiments, conversational quality, and reactivity to users' commands. This study yielded a set of contributions (which are currently under review for publication). These include a qualitative, analytical framework for organizing and evaluating conversational agents, which inspired an in-depth discussion of agent reactivity and device-boundedness. We discuss these concepts in a later section in this paper.

3.3 *Survey Study of Users*

We conducted a survey of university-aged participants to understand how they feel about conversational agents and how they currently use them. In addition, we wanted to know how they anticipate being able to use agents in the future. This study led to some insights about what users may or may not feel is inappropriate for an agent to do, as well as what users wish their agents could do for them. This study laid the foundations for our concept of the client-agent relationship discussed in more detail below. (A write up of this study is currently under review for publication.)

The combination of these three studies has allowed us to develop deeper insights about how consumers use, understand and react towards conversational agents. Moreover, we believe that our work has prepared us to envision certain gaps when it comes to traditional interaction design practice. But before we discuss those gaps more in detail, let's take a brief look at what we here call traditional interaction design practice.

4 Traditional Interaction Design and Conversational Agents

We recognize that there is no standard form of design for Human Computer Interaction that we could label "traditional." The field of interaction design has changed drastically over the last three decades. However, if we look at the field as it is defined today in some of its influential textbooks (Dix, et al. 2004; Preece, Rogers & Sharp, 2015; Shneiderman, et al., 2018) it is possible to recognize a core practice that contains certain elements.

Some of the fundamental elements of interaction design practice overlap with those of other design fields, including: knowing the audience (client and user needs and desires), knowing the context for design, and having a developed idea of purpose and intention. The process of designing also includes the acts of sketching, prototyping, and testing the design (cf. Buxton, 2007; Cooper et al., 2014).

Even though some of the fundamental elements of interaction design practice are common to other design fields, it has distinguishing features, too. One such feature is its focus on interface design. Interaction is seen as something that takes place between a user and an interface, and the interface is commonly understood as a screen, keyboard and mouse. Even with newer technology, such a gesture-based interaction, the focus remains on a surface with which a user physically interacts (e.g. Nintendo Wii, Microsoft Kinect, and Gest).

One consequence of this focus on surfaces is that interaction design has been a popular field for graphic designers since they have expertise designing the layout of a surface with information in a way that creates effective functionality and beautiful aesthetics. Interaction design practice has therefore been engaged with highly physical aspects of design, such as screens, input devices, buttons, and so forth (Janlert & Stolterman, 2017). Interaction design practice has also been primarily occupied with a view of interactivity as a form of control. That is, a user is supposed to control a device *either* by giving commands and receiving information *or* by empowering the device to perform certain actions.

However, as interaction designers and researchers shift their focus away from surfaces and toward conversational agents whose interactivity is *not* mediated through a screen or surface, then these fundamental elements of interaction necessitate reconsideration. When users interact with conversational agents they no longer interact primarily via an interface or surface. This development has led to what has been called "faceless interaction" (Janlert & Stolterman, 2017). Moreover, users do not necessarily interact via commands to achieve actions. So, the nature of conversational agents would seem to create new ways of understanding interaction and interactivity, which in turn create new challenges for interaction design practice.

5 Some Aspects of CAs (Not) Covered by Traditional Interaction Design

Our studies of conversational agents have showed us that there are some aspects that are crucial when it comes to the success of any form of interaction between people and conversational agents. We do not claim that these three are the only ones, or that they are the most important ones, but they emerged as influential during our studies.

The aspects we will discuss here are: (1) client-agent relationship, (2) proactivity vs. reactivity, and (3) device-bound vs. omnipresence.

5.1 Client-Agent Relationship

In this section, we address the user of the conversational agent as a client of the agent. The term "user" could be substituted for "client" throughout this section, but we chose to use the word "client" to make the relationship less one-sided than a "user and device" relationship. The relationship between a client and a conversational agent is quite unique. Most methods of interaction with technology have resulted in fairly standard relationships between all users and their devices. Clients using a laptop or desktop computer typically have an end-goal of productivity in mind. Clients using tablets are often seeking entertainment. And clients using phones are typically involved in some hybrid of both productivity (i.e. checking emails, texting, and phone calls) and entertainment (i.e. watching videos, updating social media, and listening to music). However, the uses for an agent have not been clearly defined yet. Do users actually ask Siri to play their music for them? Would they trust their agents with an important and sensitive email? Can they use a conversational agent to check their social media platforms? These same questions are constantly being asked by consumers, and the confusion is a large part of the reason that conversational agents are currently being underutilized. There is no clear relationship established that shows the user what he or she should be using an agent for.

In addition, the relationship between a client and an agent is further complicated by the audible component of agents. Because agents (the ones we have studied) can speak, they often feel closer to the user than the screen of the phone itself. While scrolling through an app is viewed as a utility, using an agent is viewed more as a dynamic relationship. Because of this, the relationships between clients and agents involve many components that are shared with relationships between people. In our research, we imagined a scenario in which an agent would overstep its boundaries slightly, pushing into an unwelcome dynamic of friendship. Perhaps the agent would share its opinion of a text a client was asking it to send. Or perhaps the agent would even correct the user's grammar in his or her message. These actions would likely seem offensive to the user, despite the fact that they are commonplace with other forms of interaction, such as text based, in the realm of human interaction.

This is because, while there is no clearly defined scope of what consumers should be using agents for, they are nonetheless seen as tools to accomplish some means. They are not friends, and they are not even acquaintances. They may have access through a client's phone to more information than any one of the client's actual friends, but they are forbidden from utilizing this information to better assist the client. Such an act would seem creepy and would likely prevent the client from using the agent altogether in the future.

The client-agent relationship is also complicated by the fact that people have nuanced preferences and uses when it comes to their conversational agents.

> **Example:** *Suppose Leah needs to send an email to her friend Kasper with her phone. When creating the email, Siri calls Leah by the casual nickname ("Lee-lee") that that Kasper sometimes uses. This nickname is an inside joke between the two friends and nobody else is aware of it. Suddenly, it may seem to Leah as if Siri knows something that nobody else knows; both personifying Siri and potentially making Siri unsettling.*

Our studies would suggest that users are made uncomfortable by such overreach. While some users may actually appreciate this attention to detail by the agents, the majority would be alarmed and irritated at their agents.

This example is something that contemporary agents could reasonably do with access to conversations between friends. It is also a sign that agents could "know" more about their users than any other person. This is an unsettling prospect to many users, and it is one reason why we propose the client-agent relationship as a difficult and unique design problem for conversational agents. Agents must not overstep, in order for their users to continue to want them in their lives, but they must also adapt to the variety of preferences that each user may have. While some may find the nickname unnerving, others might find it entertaining. This variety of reactions forms the basis of the client-agent relationship problem.

5.2 Proactivity vs. Reactivity

The technology behind conversational agents is rapidly improving and becoming more and more capable. As this occurs, designers must decide what these improvements will be used for. Agents can be more predictive of human behaviour, as evidenced by the rise in smart home equipment that adjusts based on users' habits and the predictive follow-up questions now asked by many conversational agents. Now that the agents can be more proactive and predictive of users' needs, should they act on their newfound knowledge *without consulting users first*?

In our survey study, we found that the vast majority of users are still very uncomfortable with their agents doing too much without their knowledge or supervision. For example, users still want to be included on decisions. Hence, the agent on your phone confirms several times with you before it ever actually sends a text to somebody. We find this quite limiting, since agents are capable of so much more and their capabilities are only growing day by day.

But how do we design agents that can utilize their full skillsets while preventing user discomfort? This is a second challenge for designing conversational agents.

> **Example:** *Nels arrives home after a long day, and, upon walking into his kitchen finds that his Amazon Echo has apparently coordinated with his smart appliances to preheat the oven in anticipation of his cooking dinner. The Echo App on his smartphone pinged the Echo (at home) to let it know that Nels was on his way. In addition to preheating the oven, the Echo assembled a playlist of "cooking songs" and, sensing his proximity, started playing one as soon as Nels walked into the kitchen.*

Some people may find this convenient whereas others may worry about the oven running without anyone in the house not to mention location tracking to coordinate activities. This advancement in technology means that the user could save time after getting home from work, but it comes at the cost of offloading responsibility to and trusting the agents.

Thus, we are left with the following design question: how much agent proactivity is acceptable? Should agents be proactive or purely reactive? Again, these questions are personal to each user and it is very likely that users would prefer a wide range of levels of proactivity. But how do we design for all, when all have their own personal preferences about how much their agents should be involved in their lives?

5.3 Device-Bound vs. Omnipresence

We have found that most problems currently discussed in human computer interaction design are commonly solved with the design, prototyping, and implementation of an app. Screens have become a wonderful method of interaction that seems comfortable to nearly all consumers and are easy for developers to expand device functionalities. However, conversational agents present us with a new interaction paradigm, known as "faceless interaction," (Janlert & Stolterman, 2017). This lack of a "face" or "surface" is due to the lack of a visual interface provided with conversational agents. The goal of a conversational agent is to perform tasks without the aid of a screen to assist in the communication process between the user and the agent. So what do we do when we are no longer able to create an app to guide users through a new process? How do we let them know what they can do with their agents, in a natural way?

These questions lead to the two main implementations of conversational agents that we have seen thus far. There are "device-bound" agents, as well as "omnipresent" agents. These categorical names are most certainly not concrete, as there are many agents that blur the lines between the two in their implementations. An example of a device-bound agent is the Amazon Echo. The Echo sits in a room and is inaccessible from most other devices. Conversely, an omnipresent agent would be the Google Assistant, which can be accessed from Android phones, Google Home devices, as well as several new offerings from the company. These two approaches don't seem to have any correlation to user satisfaction. They do, however, reveal interesting insights about the ways users utilize the capabilities of their assistants.

> **Example:** *Suppose Anna arrives home, and, while standing in the entryway, she asks her Amazon Echo to start playing music on the Bluetooth speaker system throughout the apartment. As she moves into another room she wants to change the music, but she doesn't have another Echo device in that room. So, she can either walk back into the entryway to tell Alexa to change the music or use the Alexa app on her smartphone, which would defeat the purpose of the Echo as a conversational agent.*

It seems as if it would be very convenient to install an Echo in every room. However, this omnipresent approach is uncomfortable for many users, who dislike the prospect of having "always listening" devices throughout their homes. Privacy is a significant concern for many users when it comes to conversational agents, and they may not be willing to sacrifice privacy for convenience. This example suggests reasons why both device-bound approaches and omnipresent approaches have their merits to individual consumers. It is difficult to tell, at this point, if one or the other approach will "prevail" or if there will be some balance struck. However, device-bound and omnipresence is a critical aspect of design to consider when designing conversational agents.

Taken together, there three insights has shown us that with the emergence of the new technology of conversational agents, new design challenges also appear. The insights are all a consequence of changes in the 'material' that interaction designers work with when developing new applications and solutions. When we compared these new challenges with what is covered in traditional interaction design methods and text books, it became clear that none of these new challenges are traditionally considered. Of course, some of these issues might be covered by more general techniques, such as

careful traditional user research, but we are convinced that some of the emerging challenges are not part of the everyday design practice in the field.
We take this observation as a sign that when the design 'material' in a field radically changes, design approaches, methods and techniques also have to change.

6 Discussion and Implications

Our studies of conversational agents have led to insights about how this new technology influences and challenges traditional interaction design practice, but has also led to some broader insights about the relation between design and technology in general. We discuss these insights below.

6.1 Interaction design insights

One of the key insights from our investigation is that interaction design, as any other design field, is strongly influenced by its 'material'. When new technology emerges, the field has to deal with new forms of materials. For interaction design, that means that moving from designing for a screen with keyboard input doesn't work so well for interaction with conversational agents. Interaction design has moved through a number of interactivity paradigms (screen and keyboard based, gesture based, and so forth) and with each of these different paradigms it is necessary to revisit the methodologies and methods used to do design work.

A key insight is that interaction design practice is itself a design, and designers could benefit from treating it as such. When interaction design is seen as natural process out there in the world (as opposed to an artefact that has been socially designed and iterated on by designers and researchers over time) then it becomes harder to see that the ways it has changed in relationship to different interactive paradigms have been wrought by designers themselves. Even using the word evolution to describe how it has changed undermines the effort to understand interaction design for what it is: an artefact. *We* made it, and *we're* constantly remaking it. But if we fail to acknowledge that, then it becomes difficult to see how much agency we have when it comes to iterating on the approach in order to accommodate new paradigms, such as conversation, and so forth.

Although traditional interaction design has, as our study shows, some limitations when it comes to supporting conversational agent design, we do not want be mistaken for suggesting that it lacks utility altogether. There are many useful design methods and tools that conversational agent designers ought to use. However, in our view, the most useful methods and tools are those that support designers interested in understanding how people make use of agents. For example, we conducted brief field studies and surveys and we synthesized the data from these studies into possible design insights. Field studies and surveys are applicable to a variety of design situations. Interviews, focus groups, and diary studies could also be valuable ways of collecting data for conversational agent design.

Usability may at first seem less apt for conversational agent design since conversational agents require us to reconsider whether there is a computer interface involved. Lewis defines usability testing as involving "… representative users attempting representative tasks in representative environments, on early prototypes of computer interfaces" (Lazar, Feng, & Hochheiser, 2010). What does it mean when conversation *is* the interface? In addition, how does usability testing account for the fact that much of what people do with conversational agents seems innovative?

While there seem to be a few core activities people do with the assistance of an agent, we were surprised by users' creativity in use. For example, some users asked Alexa to tell jokes at a dinner party. Others used Siri to convene in-car trivia games during long road trips. Conversation as an interface could be seen to *support* innovative use cases. As designers and researchers, we are inspired by this potential. And so we would be interested to ask how we might design future conversational agents to support more user innovation.

Ben Shneiderman (2009) identified creativity support as a grand challenge for future HCI research, and we find this challenge to be especially relevant to our line of thinking here. But, on the other hand, pushing creativity and innovation to the margins, it seems crucial to start studying how conversational agents might be influencing conversations amongst humans. Alexa and Siri are limited in how they make sense of and respond to user prompts. While it is possible to carry on a conversation with each agent, the conversation seems to us to be qualitatively different than a conversation one might have with another human. We know that other interactive devices have implications for our interactions with other people in the real world. Conversational agents present a uniquely focused interactive paradigm, which carries much potential for interaction designers and researchers to borrow theoretical frameworks and methods from the field of conversation analysis.

In short, while some existing interaction design research techniques may be well suited for conversational agent design, it seems to us that others might be limited in their utility. Moreover, it would seem like there is a need to innovate design approaches in order to support an existing trend in conversational agent use, which is innovative and creative use. Toward this end, it might be time for interaction design research to look for new theoretical frameworks and methods from other fields, such as conversation and discourse analysis. Through innovating new approaches to compensate for existing limitations and borrowing strong, relevant approaches from other disciplines we feel optimistic about the interaction design community's ability to excel in the face of coming design challenges.

6.2 Broader insights about design

How we do design is greatly influenced by technology development. Design work can be seen as a reflective conversation with its material, as famously shown by Donald Schön (1987). Designers are in conversation with technology (and thus technological development), but it is also important that they are in conversation with design itself.

As design researchers – researchers interested in design processes as well as in designing – we are aware of how we go about exploring questions, conducting experiments, and generating insights on the basis of those experiments. However, even in this description it may be apparent that we are committed to a certain kind of empirical, descriptive research that follows closely to traditional understandings of what research is or ought to be. Take a standard definition of research such as "a careful, systematic search." In most intellectual communities, the care and systematicity of research are well understood and agreed upon, but in design research there seem to be fewer constraints. Even the measures of success are not well defined. What does it mean to do interaction design research successfully (Fallman & Stolterman, 2010)? Is it the same as doing it successfully in other fields?

By some measures, the approaches we have taken to conduct research may appear to fall short. For example, when we conducted our first study of users with conversational agents we did so in order to get a better sense for the problem space. This is design research with the dual goal of defining a problem space and understanding users. Using this as a criterion, we see this study as a success since it inspired us to think about how different conversational agents might provoke different reactions from users, which motivated our subsequent artifact analysis.

When we conducted our artifact analysis of seven conversational agents, we did so partly as means to familiarize ourselves with the design landscape. As researchers with an interest in doing design work, it is imperative that we achieve some understanding of the artefacts in the design space. Towards this end, designers curate exemplar collections and generate annotated portfolios. As researchers we have different obligations. We must not only map the landscape of existing artefacts with an eye towards generating design insights, but we must also create value for the research community. Thus, we made the decision to develop an analytical framework that could be used to generate a more abstract model of core constructs that make up conversational agents.

We are aware that technological developments in some fields of design are examined in depth and also influential to design practice. But we are convinced that, in some design communities, there is an inherent resistance to the idea that technology and its development has the power to change existing traditional and well-developed design practices.

We see this example of the emergence of a new technology (CAs) as a challenge to design research in general. However, the realization that new technology imposes new requirements on the design process does not mean that design is being limited or restricted. Instead, in our view it can result in innovative approaches to designing that may also lead to new ways of presenting findings that do not adhere to traditional methods of designerly or scholarly communication. By paying serious attention to developments and changes in the technological field, design research could thus be seen as a vehicle for research innovation – provoking new ways of understanding what it means to do research and, in parallel, new ways of understanding what is (or can be) designed.

7 Conclusion

In this paper, we summarized three studies that we have conducted in order to understand how people interact with conversational agents. These studies include: (1) A study of agents in the wild, (2) an artefact analysis of conversational agents, and (3) a survey study of 76 users. These studies inspired us to think about the complex, changing relationship between interaction design approaches and the rapidly developing CA landscape. Based on this line of thinking, we synthesized a set of generative insights to strengthen and improve interaction design as it pertains to CAs. These insights include: (1) interaction design must be observant and willing to change its practice in relation to changes in its ‘material’ (technology) and (2) in order to accommodate emerging technologies, design practice must sometimes be altered in order to design new methods of interaction.

Our aim has been to produce knowledge that is practically applicable and useful for designers. Complex analytical frameworks and theories for designing conversational agents might be useful, but design practitioners are constrained by time and other resources to apply such things in their daily work. However, we have not tested the applicability of our insights in practice yet. This will be an important next step in our work. We believe that the varied nature of our three studies and the approach we took to synthesize insights at least has the potential for broad applicability across design disciplines.

Even though our primary research focus has been on interaction design and its changing technology we believe that our insights are of broader interest. We see our findings as supporting the idea that any design practice, in any field, has to pay close attention to technological developments and how the design ‘material’ in the field may be changing.

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DRS2018 is supported by