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An Integrative Model of Design Thinking

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This paper presents a study and synthesis of commonalities and variations among effective approaches of design thinking, based on interviews to twelve global experts. Common fundamental knowledge is needed, as design thinking increasingly becomes a field of knowledge in its own and a liberal art. Therefore, this study proposes an Integrative Model of Design Thinking, focusing on principles underlying current methods and tools, and integrating complementary aspects from different approaches into an overarching view of design thinking. The author's expectation is for this Model to contribute to the establishment of a field of design thinking and support its multidisciplinary practice. Furthermore, this paper provides significant insights into the nature of design thinking, according to the convictions of experts who are at the forefront of its research and practice. Further research is needed to expand on some of the principles presented.

***Keywords**: design thinking; innovation*

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Introduction

Many organisations use design thinking to innovate and solve complex problems, and a few researchers anticipate it becoming general knowledge, a liberal art. However, barriers to developing a common and well-founded field of knowledge are significant: most research focuses on particular aspects of design thinking rather than on holistic practice; approaches vary, and practice tends to stay at superficial levels.

After interviewing twelve global experts, the author extracted, synthesised and defined design thinking's fundamental principles and proposed an Integrative Design Thinking Model.

The study evidenced the need for further research into some of the proposed principles, to strengthen them and establish them as an essential part of design thinking.

Background

Despite wide dissemination, design thinking is still an evolving field facing significant challenges. Two stand-out: First, even though several authors and institutions share a common understanding of design thinking, variations abound, especially on approaches from different disciplines. Differences are evident in the choice of terms and their meaning, the importance given to one aspect over the other, the sum of aspects that make up design thinking, and the nature of design thinking solutions (product, service, interaction, strategy, policy, or else). These differences hinder effective multidisciplinary collaboration. The second significant challenge design thinking faces is that its appropriation has, for the most part, stagnated at a superficial point, i.e. taken as an inspirational approach or a step-by-step model sharing "little things that one can do" (Dorst, 2015; Leifer, 2015). Leifer sees the d.school's 5-step model, together with other "superfluous methods", as a learning tool to "help newcomers cope with design thinking" (Leifer, 2015). However, several experts worry of practitioners acquiring a narrow understanding of design thinking while, according to Buchanan (2015), its essence is in the strategies for thinking about design problems.

Methods

This study aimed to obtain a deeper understanding of the meaning, commonalities and differences of the foundations of various influential design thinking approaches, and synthesise an integrative model of design thinking principles. Interviews with twelve leading global design thinking researchers and practitioners from different fields provided the data for this study (see Table 1). This paper refers to the twelve experts from now on as the "Expert/s". The author chose unstructured interviews as the method of enquiry, as the open-ended questions allowed pursuing a deeper understanding of the Experts' line-of-thought, their influences and convictions (Firmin, 2008).

Table 1 Experts interviewed: detailed list

Interviewee	Position	Country
Christian Bason	Director, Danish Design Centre. Former Director, MindLab.	DENMARK
Richard Buchanan	Professor, Weatherhead School of Management, Case Western Reserve University. Former Head of Carnegie Mellon School of Design.	USA
Kees Dorst	Professor, Faculty of Transdisciplinary Innovation, UTS Former Director, Design Out Crime Research Centre, UTS.	AUSTRALIA
Paul Hekkert	Professor and Chair of the Industrial Design department, Delft University of Technology.	NETHERLANDS
David Kelley	Founder, Hasso Plattner Institute of Design at Stanford (the d.school) & IDEO.	USA

Larry Leifer	Professor & Founding Director, Center for Design Research, Stanford University	USA
Roger Martin	Institute Director of the Martin Prosperity Institute at the Rotman School of Management	CANADA
Don Norman	Director of The Design Lab at University of California, San Diego. Former Vice President of Apple.	USA
Bernie Roth	Professor, Co-Founder and Academic Director Hasso Plattner Institute of Design at Stanford (the d.school).	USA
Anders Skoe	President at ICS Interactive Coaching Services Sarl. Geneva. Former advisor of IATA and SITA, the world's leading specialist in air transport and telecom.	CANADA/NORWAY/ FRANCE
Marco Steinberg	Founder and CEO of Snowcone & Haystack. Former Director of Strategic Design, SITRA, Finnish Innovation Fund.	FINLAND
Aalto Design Factory academics, at Aalto University	Five academic staff in directive, teaching and research roles.	FINLAND

The author analysed the interview transcripts through qualitative content analysis (QCA) and thematic coding and analysis, enabling an initial systematic process of information coding, summarising, and categorising (see Fig. 1), increasing the research validity (Ayres, 2008; Krippendorf, 2013, pp. 25-28, 126; Schreier, 2012, pp. 1-8, 58-71, 104-105). Subsequently, the author used conceptual mapping to define relationships among concepts, identifying low-level and high-level (foundational) design thinking concepts, and their connections (Morgan & Guevara, 2012) (see Fig. 2). Furthermore, the author mapped the concepts' rationale, intentions and characteristics, resulting in the integrative model of design thinking principles (see Fig. 3).

Fig. 1 Visualisation of a section of the QCA process, showing how the author clustered the data. She used a spreadsheet to log QCA codes and then converted them to sticky notes using an online digital whiteboard software. She first clustered information of each interview and then brought it all together and re-clustered, allowing themes to emerge as seen in this figure.

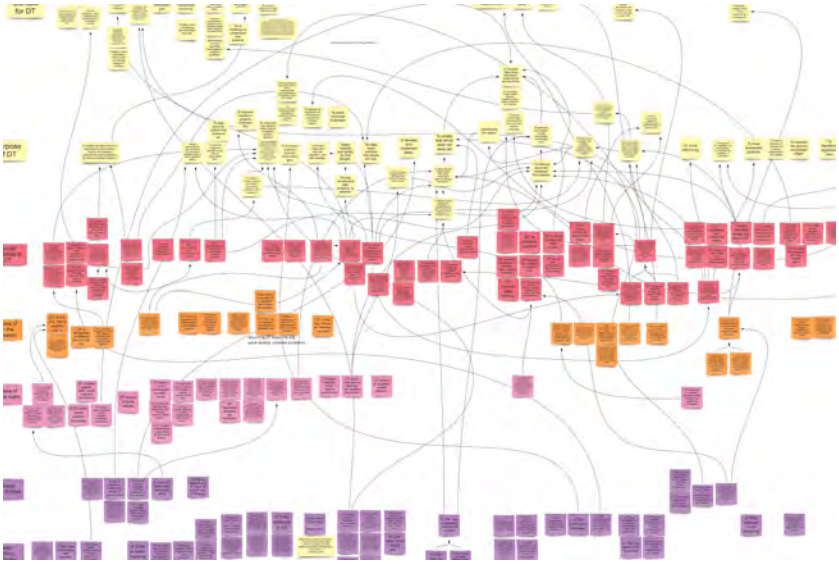

Fig. 2 Visualisation of a section of the conceptual mapping process, showing how the author organised and connected concepts.

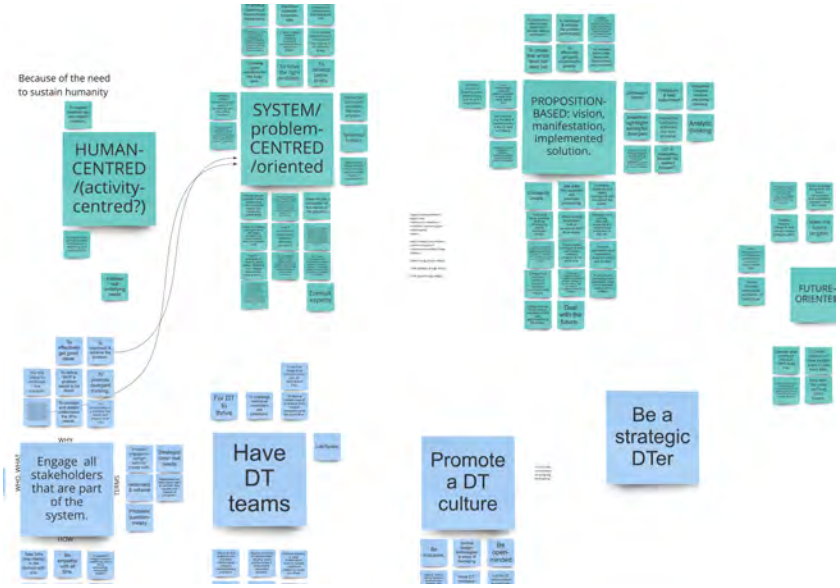

Fig. 3 Visualisation of a section of the mapping of the concepts' rationale, intentions and characteristics, towards the synthesised Integrative Model of Design Thinking Principles.

The Proposed Integrative Model of Design Thinking

The proposed Integrative Model of Design Thinking (from now on "the Model") contains three fundamental principles of design thinking, eight action principles, and five process principles (see Table 2 and Fig. 4). Next, the author presents in more detail these principles, their origins, and their significance.

Table 2. Visualisation of the composition of the Integrative Model of Design Thinking, including fundamental principles, their associated action principles, and the overarching process principles.

Fundamental Principles	**Action Principles**	**Process/Dynamics Principles**
Design thinking is system-oriented	Think comprehensively and ahead	Comprehensiveness Simultaneity Iteration Graduality Divergence/Convergence
	Pursue Harmony	
	Design Gradually	
Design thinking is human-centred	Genuinely empathise with all stakeholders	
	Work in functional teams	
Design thinking is creation-based	Create a vision, interactions and manifestations, and implement	
	Prototype iteratively and confidently	
	Alternate creative and analytical thinking	

Fig. 4 This figure shows a comprehensive view of the Integrative Model of Design Thinking. Fundamental principles manifest themselves simultaneously, through their respective Action principles. A process should take the practitioner from broad considerations to a central synthesis.

Design Thinking is System-Oriented

The Experts claim design thinking is the most appropriate approach for tackling complex organisational, political, environmental, and cultural issues like democracy, healthcare, energy consumption and transportation. These challenges "are also the ones which are most interconnected or systemic in nature" (Boyer, Cook, & Steinberg, 2011). Thereby, many of the experts suggest that design thinking should consider a systemic approach. Moreover, Di Russo (2015) identified the term *systemic thinking* as a commonly cited characteristic of design thinking, along with 16 others. Nonetheless, literature does not tend to designate systems thinking as an intrinsic part of design thinking, but rather as a complementary part of it or a tool (e.g. Brown (2010)).

Design Thinking is System-Oriented: *Think Comprehensively and Ahead*

The Model suggests design thinking is system-oriented, a comprehensive approach to understanding complex problems. The term comprehensive in the context of this study finds its roots in Buckminster Fuller's Comprehensive Anticipatory Design Science (CADS) (A.C. Edmondson, 1987, pp.23). This study found Fuller to be a significant influence on several Experts. Therefore, the Model is to some extent inspired by his work. Fuller believed being comprehensive implies considering all stakeholders and issues involved in the problem (Ben-Eli, 2007, pp. 38-39), and the Experts agree. Furthermore, to be comprehensive we need to challenge our perspectives and understanding (Bason, 2015), and transcend viewing problems only in materialistic terms (as opposed to human terms) (Skoe, 2015). Nonetheless, we also need to consider non-human aspects of the system, such as the activities and actions performed by humans and artefacts within an environment, and the interactions among them (Norman, 2015). Fuller considered, and the Experts concur, that being mindful of the environment at large is central to being comprehensive.

Furthermore, Hekkert (2015) states that being comprehensive implies projecting the system into the future, for "design is by definition dealing with the world of tomorrow; the users of today might not be the users of tomorrow, and the reasons for using something today might be very different for using something tomorrow". Likewise, Fuller used the word *anticipatory* (Comprehensive Anticipatory Design Science) and argued designers have to think ahead at the same time as they think comprehensively to identify relations of cause and effect among a system's components (A. C. Edmondson, 1987, pp. 290-291). Moreover, thinking ahead is an opportunity to foresee possible

adverse effects of our design actions to the world, and hence avoid ending up equally or more troubled (Hekkert, 2015).

In fact, thinking comprehensively empowers practitioners to discover non-evident causes to the problem at hand, a quest the Experts often call *re-framing the problem*. Problems can be at the same time cause and effect of other conditions; what appears to be a problem needing a solution, might be a symptom of a different problem. The re-framing notion calls us to shift our focus from the immediate context of a problem to another we discover being its cause, which is why design thinking's outcomes often appear to be more creative, as they address the problem from unexpected perspectives (Kelley, 2015).

The Experts and the literature coincide that to be comprehensive requires teamwork involving different perspectives brought by diverse people (e.g. with diverse backgrounds, personalities, or gender), highlighting the relevance of disciplinary diversity (Kress & Shar, 2012; Liedtka, 2018, pp. 16-22).

In short, thinking comprehensively in design thinking requires teams of diverse practitioners considering the present and future state of all stakeholders and artefacts involved, their activities and interactions, and the environment.

Design Thinking is System-Oriented: *Pursue Harmony*

This study revealed a systemic view of human well-being and respect for the environment drives most of the Experts' approach to design thinking. For example, Hekkert considers we need to acknowledge the power of design to transform the world by challenging systems like hospitals to deliver an "appropriate response to the challenges we are facing in the world" (Hekkert, 2015). Steinberg desires for design to reconnect with the social realities and needs of the larger world "to create solutions that are meaningful in the long term". He argues the responsibility of design should transcend human-centeredness, towards a more planet-centred approach (Steinberg, 2015).

As designers do everything with an intention (Camacho, 2016, p. 99), they need to define their belief system or normative framework to clarify their intention (Hekkert, 2015). This study suggests a design thinker's ultimate intention is to promote a systemic, humanistic and environmental approach to design. However, the literature at large does not address the search for human and environmental well-being as a universal value of design thinking.

The use of the phrase pursue harmony in the Model is inspired by Buchanan (2015), who defines a system as a condition of harmonious interaction, and argues we do not have enough of them:

> *"…the systems we create end up causing conflict rather than conditions of harmonious interaction … most of what we see around us, are failed systems … It is an aspiration to create a condition of harmonious interaction, but it is wise and humble to recognise that we do not do it very well" (Buchanan, 2015).*

Skoe argues we need to transcend a solution-oriented approach, for there are too many solutions in the world. Instead, we need to consider the impact of our design actions and involve impact assessment knowledge in design thinking (Skoe, 2015).

Design Thinking is System-Oriented: *Design Gradually*

This study suggests it is not possible to solve an entire complex problem with one design thinking project. We can only face the complexity of a systemic problem by intervening parts of it and make gradual improvements that we can evaluate.

> *Engineers, policy makers, and others, like to try to understand the whole problem at once, all of its factors, do a big analysis and make a big recommendation. However, things never get done. Because you need political support, a huge budget, and it takes time. Lots of people will object to many parts of it; you have to meet with them, overcome their objections, and modify your schemes, and it is probably going to fail. Most of these big things fail. What you want to do is small projects (Norman, 2015)*

Nonetheless, practitioners must keep a comprehensive vision of the system while addressing a part of a problem, hence being mindful of potential adverse impacts. Furthermore, gradual interventions within a system need to follow a common overarching aspiration and focus on people and their experiences to "end up with superior global optimisation over a period of time" (Norman, 2015). Likewise, Buchanan (2015) thinks if we tackle an issue starting at a higher level we will always fail. He urges us to move from the bottom up by understanding human interactions, "what we are doing with each other and to each other, and gradually trying to discover what is

harmonious and what isn't." Notwithstanding, gradual actions in the context of a system can still yield highly innovative results.

Design Thinking is Human-Centred

Organisational systems tend to concentrate solely on achieving resource optimisation in detriment of operational workers: in the traditional mass production line, everyone does the same task over and over again, optimising the expense of time, though often in detriment of the individual (Norman, 2015).

In opposition, the literature presents design thinking as a human-centred approach to innovation: "the idea that design thinking is human-centred, not technological or business-centred" (IDEO.org, 2015; Norman, 2013, pp. 221-235). This study confirms human-centeredness is a core aspect of design thinking. Furthermore, it shows deeper meanings to human-centeredness than the ones commonly expressed in the literature.

Design Thinking is Human-Centred: *Genuinely empathise with all stakeholders*

The full meaning of human-centeredness is often confused with, and limited by, the term user-centeredness. This study indicates that to be human-centred we must be mindful of the systemic impact of our design actions on humanity: to think comprehensively and respect the systemic nature of design thinking, "but focusing on the individuals" (Norman, 2015). That is, including every possible stakeholder (like the operational worker) with genuine empathy, thus transcending user-centred design:

> *It is true usability plays an important role in human-centred design, but the principles that guide our work are not exhausted when we have finished our ergonomic, psychological, sociological and anthropological studies of what fits the human body and mind. Human-centred design is fundamentally an affirmation of human dignity. It is an ongoing search for what can be done to support and strengthen the dignity of human beings as they act out their lives in varied social, economic, political, and cultural circumstances (Buchanan, 2001, p. 37).*

The literature increasingly discusses considering stakeholders (and not just users) in a design thinking process (Björgvinsson, Ehn, & Hillgren, 2012, pp. 106-107; van der Bijl-Brouwer & Dorst, 2017, p. 8). However, there does not appear to be specific information on considering all possible stakeholders from a system-oriented perspective, which opens up an opportunity for further research. Meanwhile, existing methods enable us to understand stakeholders and identify their needs, as we do with users. For example, a valued approach in obtaining a broad human-centred understanding of problems considers involving stakeholders and users in the design process as part of the design team (Sanders & Stappers, 2008, pp. 7-9), an approach the Experts often call participatory design or co-design. Furthermore, the future-oriented nature of design demands considering users and stakeholders as inhabitants of the future, to envision how they might interact in the future with other people, artefacts, and the environment (Hekkert, 2015). Moreover, Hekkert argues that in design thinking we need to be aware of human nature from a psychological perspective, learning "what drives us as humans" and does not change in time.

Empathy is critical for effective human interaction among stakeholders, users, and team members. This study revealed a significant influence from humanistic psychology on design thinking's concept of empathy and the methods to achieve it. Data indicates notable psychologists Karl Rogers and Abraham Maslow among others, as well as theories of group therapy, inspired several Experts in the 60s. Likewise, a study by Stanford's CDR confirms the importance of empathy in teamwork, according to Jung's personality types (Kress & Saddler, 2014). However, further specific research on attaining empathy in design thinking is desirable, both for user research and for teamwork.

Design Thinking is Human-Centred: *Work in functional teams*

This study evidenced an influence from humanistic and social psychology on design thinking's conception of teamwork. For instance, Personal Interaction, a concept of social psychology, was vital to Skoe's shaping of his proprietary approach to social interaction in small groups, directed at facilitating effective teamwork for problem-solving (Skoe, 2015). However, the literature on human interaction in design thinking teams from a social psychology perspective is scarce. Psychology, together with protocol-based research has also played a part in understanding teamwork in design thinking, this time from a design engineering standpoint. Professor Leifer and his doctoral students at the Centre for Design Research (CDR) at Stanford University have produced extensive literature on the socio-technical nature of design, reinforcing the significance of managing communication and

emotion among team members. CDR researchers also use psychology to explore the role human personality has in design thinking teamwork. For example, they did extensive research using Jungian typology and the Myers Briggs Temperament Indicator (MBTI) in forming teams (Dym et al., 2005, pp. 107-108). A joint design thinking research program with Hasso Plattner Institute (HPI) of Potsdam University, produces extensive literature focused on discovering metrics to "predict team performance and facilitate real-time team performance management … [to] develop and evaluate innovative (analogue and digital) tools that support teams in their cooperative creative work eventually even bursting time and space boundaries" (Design thinking: Understand - improve - apply, 2011, p. xvi).

Functional teams are essential for design thinking's effectiveness. Nonetheless, the literature on methods to achieve functional teams in design thinking is scarce, as well as literature expressing that methods for effective teamwork are essential to design thinking.

Overall, human-centeredness is a core influence for the design paradigm (which is context-dependent) to be a balancing force to the science paradigm (which is context-independent) (Leifer, 2015):

> *…design thinking is a paradigm. Like the physics paradigm or the science paradigm. My claim is they are of equivalent importance, and they should balance the equation. You should not violate physics. You do not usually get away with it; you should not violate context either [people]. We do a lot in the world to violate people. (Leifer, 2015)*

Design Thinking is Creation-Based

The present study confirmed the essence of design thinking is to create: turning an existing situation into a preferred one (Simon, 1996, p. 111). Other fields of knowledge can be human-centred, and system-oriented, but to create novel things that didn't exist before, is core to design. Three associated Action Principles indicate the essence of what creating in design thinking entails:

- Create a vision, interactions and manifestations, and implement
- Prototype iteratively and confidently
- Alternate creative and analytical thinking

Design Thinking is Creation-Based: *Create a vision, interactions and manifestations, and implement*

The analysis indicates that design thinking involves creating at three levels: creating a vision of the future; creating tangible manifestations and interactions coherent with that future; and creating the strategy to implement a solution. This set of actions is what some Experts call an *intervention* (Martin, 2016).

Creating a vision and its manifestations: The future-oriented nature of design is challenging and requires specific approaches to designing for uncertainty. A few authors recur to other disciplines' methods in creating a vision of the future. Bason states there are developments at the intersection of business scenario planning and design, evidenced in 2014's theme of the Oxford Futures Forum on scenarios and design. Designers "were looking at how design practice fits into foresight or scenario planning, and one of the arguments was that design could give form and shape to what it would be like to be a human being living in a new scenario that somebody else might establish" (Camacho, 2016, p. 264).

The results of this study evidence that creating a vision of a future scenario is indeed necessary. Hekkert's ViP (Vision in Design) method focuses on designing appropriate responses for future challenges, urging designers to create a vision of a future world, expressing how people want to live their lives in it (Hekkert & van Dijk, 2011). This vision becomes the reason for existence ("raison d'être") of future *tangible manifestations*, e.g. products, communications, or buildings. The vision provides a basis for teams to shape these manifestations in ways that appeal to specific human emotions, according to aesthetic and usability considerations. Finally, traditional design professionals (e.g. industrial, communication or interior designers) become key players as shape-giving experts, creating manifestations that are coherent with the vision and allow specific interactions to happen (Hekkert, 2015).

Despite the above references, the literature on foresight as part of design thinking is scarce. Therefore, there is an opportunity for further research to connect foresight methods with design thinking.

Create Interactions: The systemic nature of design thinking and its increasing focus on systems and services indicate that when creating both the vision and the tangible manifestations, it is essential to focus on interactions:

interactions among people, between people and artefacts, and between people, artefacts and the environment. Furthermore, the design of tangible manifestations should follow, and respond to, the design of the interactions.

Create an Implementation Strategy: once we create the vision, the interactions and tangible manifestations, the findings show that the design intervention must continue until the solution is implemented and functioning. In this phase, many aspects can still impact the proposed design of a solution (e.g. the evolving manufacturing practices and the globalised context) forcing it to change. Hence, to assure the implemented solution is still consistent with the proposed vision, design thinking projects should not end before implementing solutions. Martin states that we even need to design the strategy for implementation, assuring consistency between the outcome and the vision (Martin, 2016). Skoe adds that at this stage, we should strive to test, at a small scale, the impact that our proposed solution might have on the system (Skoe, 2015). This testing would allow us to verify, to some extent, that the design outcome will not affect human well-being.

Design Thinking is Creation-Based: *Prototype iteratively and confidently*

All design thinking literature involves the term prototyping. The present study confirmed its importance, highlights its specific meaning in design thinking and brings together various concepts associated with prototyping in design thinking.

Prototyping in design thinking involves conceptualising, building, testing and evaluating a prototype. This study highlights we prototype to obtain non-existing data (mainly about people), evidence that cannot be obtained by other means, validating design work; it is what Martin (2016) calls "to pursue validity". This evidence, together with data obtained from research, inform subsequent prototyping iterations. Therefore, prototyping in design thinking transcends the meaning it has in traditional design, where it is the means to shape tangible manifestations. In design thinking, prototyping is a constant and simultaneous interplay between learning and creating: "The function of prototyping in design thinking is to drive real-world experimentation in service to learning rather than to display, persuade, or test" (Liedtka, 2015, p. 927). Using prototyping to understand the problem from a human-centred and a system-oriented perspective enables re-framing the problem (Leifer, 2015): "The re-framing process is closely linked to prototyping because the new frame of the problem is only verifiable and testable via a prototype. The created new framing for the problem will be manifested in a prototype and the 'included assumption' can be tested by the user" (Jobst & Meinel, 2014, p. 109).

As the progression from understanding the problem to shaping the solution unfolds, prototypes progress from being of a low to a high-resolution. Initial prototypes roughly represent ideas with paper, cardboard, tape, and other similar material. At this stage, ideas are abstract; having a tangible representation, even if it is rough, allows teams to interact with it and exchange views on it. It also allows the team to communicate a rough concept to a user for testing. Furthermore, the rough representation allows team members to feel confident about changing the prototype and therefore being more open to exploring. Leifer calls it the mutability of the prototype and considers it a key variable of team performance: "…if you have clay it is very mutable, if you have a CAD drawing it is maybe mutable, if you have hardware in front of you, maybe zero mutability. That mutability dimension will affect the performance of the team" (Leifer, 2015). For this reason, early prototypes do not need to focus on aesthetic qualities of a possible final artefact, and they do not necessarily have the purpose of communicating a design outcome to a client (Leifer, 2015).

Working efficiently with low-resolution prototypes requires designers to take risks, and to have no fear of failure (Roth, 2015). Popular literature has made the following set of words part of the design thinking lexicon: fail often, fail cheap, and fail fast to succeed sooner (Tim Brown, 2009, p. 17; Carleton & Leifer, 2009, p. 5; Godin, 2005, p. 144; IDEO.org, 2015, p. 10). This ability is acquired by repeatedly working on low-resolution prototyping challenges. Therefore, low-resolution prototyping is also a method to acquire creative confidence, "the ability to come up with new ideas and the courage to try them out" (Kelley & Kelley, 2013, p. 6). This concept is based on positive psychologist Albert Bandura's theory of self-efficacy:

> *… our belief systems affect our actions, goals, and perception. Individuals who come to believe that they can effect change are more likely to accomplish what they set out to do. Bandura calls that conviction "self-efficacy." People with self-efficacy set their sights higher, try harder, persevere longer, and show more resilience in the face of failure. (Kelley & Kelley, 2013, pp. 9-10)*

Design Thinking is Creation-Based: *Work in a shared space*

Some publications indicate the need for specific spaces to practice design thinking, a notion mentioned by a few of the Experts in this study. Likewise, some of the existing literature derives directly or indirectly from the Experts' research and practice (Doorley, 2012; Leifer & Steinert, 2011). In the Integrative Model of Design Thinking, shared spaces are a means to facilitate creative work in teams and co-creation with stakeholders. They enable a thriving shared culture, support creative confidence, prototyping and teamwork. Overall, they encourage a design thinking culture. According to Brown (2009), even though design thinking is a very abstract concept, it is in part "embodied in the physical spaces of innovation" (pp. 35).

Today, numerous design innovation practices in academia and industry offer functional spaces that include shared spaces for fun, relaxation, cooking, brainstorming, prototyping and information keeping (Hillen and Camacho, 2014, pp. 14-41; Aalto, 2015). Moreover, public organisations need inclusive spaces for co-creation with highly diverse stakeholders:

> *…what does it mean to organise a significant government transformation project with a focus on creating a more powerful citizen experience? … how does that disrupt legislation, funding, operations, processes, professional rules, everything? Such a project needs a design lab … think about the number of stakeholders we have in the room and the number of individual interests! … the visually and physically impaired … all kinds of citizen groups, trade unions, libraries … how do you deal with that kind of complexity organisationally? (Bason, 2015).*

Design Thinking is Creation-Based: *Alternate creative and analytical thinking*

Being creation-based does not imply using only creative (divergent) thinking; it also requires analytic (convergent) thinking. The diamond representing divergence and convergence in design is well recognised in the literature and by practitioners (DI Russo, 2015, pp.183, 222, 269). However, as we increasingly use design thinking to tackle problems in complex contexts, i.e. business and public organisations, understanding the interaction between creative and analytic thinking, and the specific role of the latter in design thinking becomes paramount.

In general, literature considers design to be a field based on creative thinking, and business a field based on analytic thinking. Martin (2009) proposes for the business field to integrate creative thinking into its practice, and for designers to improve their impact on business by considering the analytic side of things. Furthermore, Martin's "design of business" approach considers design thinking balances "analytical mastery and intuitive originality in a dynamic interplay" (pp.6). It is worth noting that Martin's approach has inspired the emergence of multiple associated methods in the field of business.

Skoe (2015) explains this interplay between creative and analytic thinking from the perspective of neuro-cognitive psychology: the creative (divergent) phase happens in the right brain hemisphere, while the analytic (convergent) phase happens in the left-brain hemisphere, and we can only focus consciously on one of these activities at a time. Hence, when diverging, we should isolate the left brain, to allow the right brain to "completely open up and liberally fall into the wild, crazy, right brain hemisphere that has no restraints, no judgement, and no questions." When switching to a converging activity, we should take a break, before engaging in "the rigorous work of the left-brain hemisphere … to do a well-structured analysis of the situations, answers, and ideas that you came up with" (Skoe, 2015). Skoe's problem-solving model recommends adding sub-diamonds to the process, suggesting most design thinking activities require alternating both ways of thinking (Skoe, 1997, pp.43; 1999, pp.32) (see Fig.5).

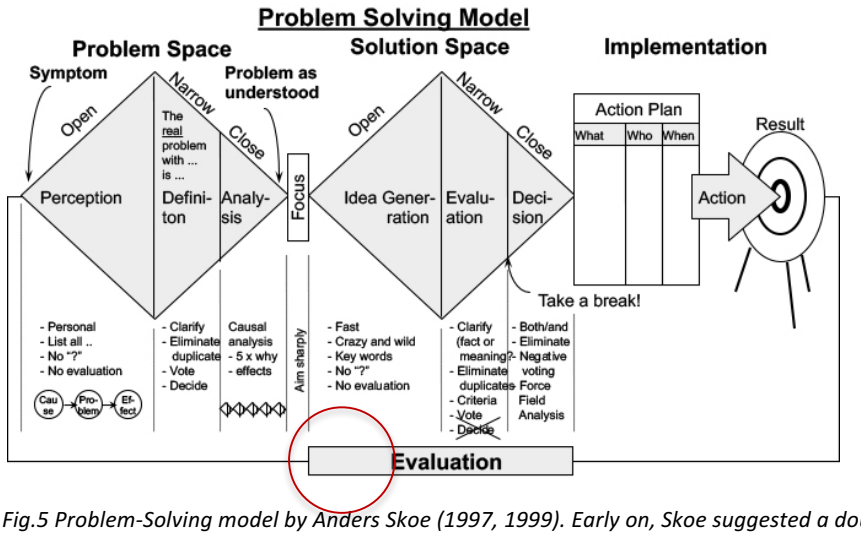

Fig.5 Problem-Solving model by Anders Skoe (1997, 1999). Early on, Skoe suggested a double diamond model, with sub-diamonds occurring at various stages, illustrating alternation between analytical and creative thinking, even in early stages seeming to be inherently analytical.

An Integrated Model of Design Thinking: Process Principles of Design Thinking

The Fundamental and Action Principles of Design Thinking discussed, provide the foundation for the proposal of five principles that describe the dynamics of design thinking processes, indicating how activities flow throughout a project. Practitioners can use these Process/Dynamics Principles as a basis to establish detailed personalised processes.

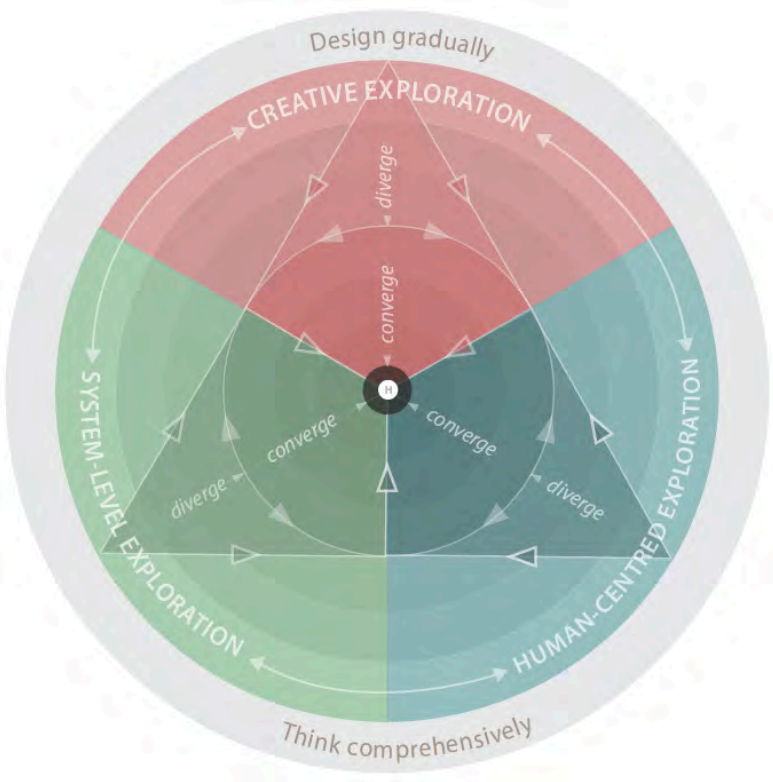

Fig. 6 This figure shows the proposed Integrative Model of Design Thinking, highlighting its Process/Dynamics Principles. The concentric circles and circulating arrows represent the principles of Iteration and Graduality. The representation of

Divergence/Convergence, coupled with the circles indicate a flow towards the centre, symbolising a synthesis towards a harmonious solution. The circular flow also represents a constant consideration of the fundamental principles.

The following are the five Process/Dynamics Principles proposed in the Model:

1. Comprehensiveness: widen the vision of the given context, consider unexpected systemic relations and the potential impact of potential solutions, throughout the design thinking process.

2. Simultaneity: continually focus on system, human and creation activities simultaneously; develop an understanding of the problem at the same time as developing a solution.

3. Iteration: perform design thinking activities repeatedly throughout the process (e.g. research, analysis, prototyping, evaluation).

4. Graduality: through iteration, gradually augment the understanding of the problem, and increase the resolution and detail of the solution. Also, select a reasonable portion of a systemic problem to make a design thinking intervention and learn from it, hence gradually improving an overall situation.

5. Divergence/convergence: use creative thinking when exploring and opening up to possibilities, and analytic thinking to synthesise and make decisions. Alternate between divergent and convergent thinking throughout the process, emphasising divergence at early stages, and convergence at later stages.

Conclusion

This paper aims to contribute to the establishment of a common field of knowledge of design thinking to effectively face today's complex problems. The study performed synthesised diverse approaches into a common one, focusing on integrating higher-level principles to guide design thinking methods and tools for practice. Furthermore, this study responds to the urge to investigate design thinking as a whole, as "today most disciplines study design from a partial point of view, restricted to the facets that do not reflect the whole picture" (Papalambros, 2015, p. 6).

The twelve global Experts interviewed provided their complementary and non-contradictory understanding of design thinking, resulting in an invaluable source of analysis, constituting the foundation of the proposed Integrative Model of Design Thinking.

The Model proposes three fundamental principles of design thinking:

- Design thinking is system-oriented
- Design thinking is human-centred
- Design thinking is creation-based

While the study provides an overarching view of design thinking, it also evidences an opportunity for further research on the specific principles formulated, their associated methods and the relationship among them.

Overall, the analysis hereby discussed, uncovered a conviction that design thinking has the potential to pursue long-term human and environmental well-being. Experts aspire design thinking to "balance the science paradigm", by elevating the level of respect we give to people (Leifer, 2015). Buchanan (2015) thinks the establishment of principles allows contrasting design actions against them and hence evaluating our creations' level of respect for people.

The purpose of the proposed Integrative Model of Design Thinking can be summarised with Fuller´s affirmation that a "balanced combination of the intuitive and the rational, the heart and the mind, of art and science, is ultimately essential for excellence in design" (Ben-Eli, 2007, p. 22).

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