For the Creative Problem-Solver: An Integrated Process of Design Thinking and Strategic Sustainable Development

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Abstract:
Since the dawn of humanity design has influenced human life. Today, facing the depletion of the socio-ecological system, increasing complex problems threaten humanity’s existence. Design has been a contributor to creating such problems, yet with appropriate tools can become a source for solutions. Design Thinking (DT) was identified as a possible approach that could contribute to Strategic Sustainable Development (SSD). The purpose of this thesis is to examine potential contributors and hindrances of the DT process with regards to SSD, and create a prototype for an integrated process that could help achieve more strategic and sustainable outcomes. With the use of the Framework for Strategic Sustainable Development (FSSD) as a lens to examine the above, along with interviews, Action Research and expert feedback, an integrated process was created. Results of the interviews and FSSD analysis helped shape two prototypes that were examined through the mentioned methods. It was indicated by participants of the Action Research and by experts that the prototype could help reach a strategic and sustainable outcome, and further refinement should be pursued. The final prototype is presented as part of the discussion, suggesting additional tools and actions that if included could create a possible Sustainable DT (SDT) process.

Keywords: Framework for Strategic Sustainable Development, Design Thinking process, Human-Centred Design, creative problem-solving, collaborative innovation for sustainability, systems thinking, IDEO
Statement of Contribution

Looking back at our thesis journey, we would not be exaggerating to say each of us feels it has been a great privilege to work with one another. We have found the research of this paper a tremendous learning experience, diving into Design Thinking, and deepening our mastery of Strategic Sustainable Development. We have also learned to appreciate the beauty and value each of us has to give, to make the most of the strengths and weaknesses each member brings, to work in a team, and to manage all the above in an optimal way.

Each of us contributed to our best ability, offering great energy, invaluable insights and learnings. Our synergy is evidenced by the fact that it is almost impossible to tell which part of the paper was written by which team member, as each of us contributed to all parts. All project decisions were made together every step of the way and we held each other accountable for both the professional and personal goals we had set ourselves individually and in the group. Through great levels of trust and joint contribution, we can truly call this a collaborative effort.

The chosen topic was of common interest to all of us, sourcing both from the urge to find solutions to the ever pressing sustainability challenge, and from being intrigued with topics related to creativity, leadership and people. As none of us are trained designers, we had to each activate our ability to learn quickly within a new field, use our researching skills as well as analytical and critical thinking, which helped build on each other’s ideas to reach an outcome that pleased us all.

This statement is too short to describe the many contributions made, and yet it should be acknowledged that each of us offered unique strengths:

Ada, our supreme, native English speaker, was our ray of light when reading complex materials, speaking to interviewees and experts, and articulating so eloquently and proficiently our thoughts. Nevertheless, she always encouraged and empowered us to learn, and improve our ability to express ourselves in English. Ada knew how to connect the dots, challenge our ideas and think of new ones. She was a great interview and conversation pro, creating rapport with any person we had to talk to, listening, making sure she understood the other side clearly, responding in an appropriate way, and developing and tying the threads of the conversation. Ada was a great energizer, keeping the atmosphere up and paying careful attention to our needs and thoughts.

Meret, our youngest but most mature team member, proved more organised and to the point than any of us. With a background in event management, Meret was always on top of planning ahead, delivering tasks on time, and making content as clear and concise as possible. Meret was great at wrapping up the discussion when needed, being decisive, and thinking critically and constructively on how to move forward. Meret was our gifted visual harvester, putting things on paper and software, and articulating in great language skills. She paid attention to the situation and small details, able to research and make the most of materials and conversations. Meret was always willing to help and be helped, to give moral and social support, and to take care of all of us.
Hila, our impassioned activist, was always making sure our research was ‘human-centred’ and would have relevance to the outside world. Exhibiting wholehearted commitment to take action, it was a high priority for her that our research would include ‘doing’ something to create change in the world. She would always inspire us to zoom out to see the wider context and to dream big. Her creative ideas brought us many new insights and ways to deal with problems or questions. Hila has a tremendous spirit to take initiative, assert her opinions and sense for direction, as well as go the extra mile. She always contributed to the group with her abundant energy and open heart.

The influence that each team member had on the other will continue for many years to come. The 'squiggle' below perfectly illustrates our adventurous research experience and evolved understanding of Design Thinking. It is our hope the Sustainable Design Thinking iterations will continue and that our thesis can make a positive contribution to the fields of Design Thinking, sustainability, and beyond.

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Adela (Ada) Ketchie  Hila Shapira  Meret Nehe

Karlskrona, Sweden June 2013

The ‘squiggle’ (by Damien Newman, Central Inc.)
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Throughout our research we were fortunate to receive an overwhelming amount of advice, support and inspiration from wonderful engaged people from all over the world, and for that we are profoundly thankful.

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We were very fortunate to interview an exceptional group of people who gave us their sincere and thorough opinions, sharing their world views as designers and as people who believe there is a need to use their creative convictions for the greater good of people and planet. Many of our interviewees also contributed as part of our expert panel, giving us extra hours of their time to assess our work, encouraging us to bring our findings to the world. We are utterly thankful for all your help!

IDEO inspired us to approach the topic of Design Thinking and to see our thesis project as a 'design challenge' in itself. Thank you for sharing your knowledge so openly, thereby empowering people to design and change the world for the better!

We would also like to thank our Action Research participants who were engaged with keen minds and tremendous enthusiasm both during our workshop, and afterwards, giving constructive written and verbal feedback. Thank you for making it real!

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Thank you all for being a part of our journey, “this was [...] awesome!” (Macklemore and Lewis 2012)

To be continued...
Executive Summary

Introduction

Since the dawn of humanity design has influenced human life. The concept of design is far-reaching and appears in nearly all fields and disciplines. As the act of creation is a fundamental human need and every person possesses the skills to do so, all men can be considered designers. This basic human impulse has resulted in transforming man’s environment and mankind himself. Characteristics of design developed alongside industrialisation, democratisation of access to products and services, and the onset of consumerism, which in turn impacted human development over time.

Design’s influence through the above trends caused great improvements for humankind, yet this trajectory of development spurred increasing conflict within the socio-ecological system. The single use and disposal of resources, the development of consumerism and consumption, and a lack of awareness of the limits of the planet, created exponential growth of the use of natural resources. This behaviour has been causing changes to the planet, some of which could be irreversible.

The phenomenon of global change raises very real concerns whether Earth will be able to support human civilization, as it is now known, into the future. Systematic social and environmental impacts are degrading society and the biosphere. The more society continues in its destructive activities, the less capacity of the socio-ecological system remains to support it, manifesting in increasing social, financial, and environmental crises. These sustainability challenges are interdependent and complex, requiring careful strategic planning and action to move society safely towards a sustainable future.

Many of the problems society faces today are a result of making unwise design decisions, however, design can be leveraged as part of the solution. Design Thinking (DT) was identified as a possible approach, poised to aptly respond to current sustainability challenges. DT is seen as a mindset and process that is too important to be left to professional designers. It is characterised by many traits, a few of which are human-centredness, optimism, and collaboration. This, in addition to its emphasis on accessibility and relevance for creative, innovative, and potentially strategic problem-solving across various disciplines, makes it a subject worthy of further exploration. Yet from the authors’ review of the field it appeared DT lacks a strategic approach that could better help lead towards a sustainable future. Given the sustainability challenge, the complexity of the problems to be solved, and the importance of design within this challenge, a holistic perspective within the DT process seems required.

One approach to address the sustainability challenge and to provide such a holistic perspective is ‘Strategic Sustainable Development’ (SSD), a field of study responding to the need for a definition of sustainability. Guided by scientifically-based principles, SSD seeks to transform current unsustainable patterns of society to move strategically towards a sustainable future (Robèrt 2000).

Research Purpose and Research Questions

The purpose of this research is to explore how SSD perspectives can be embedded throughout the DT process. The authors accomplish this purpose by attempting to answer the following research questions:
Main Research Question (MRQ)

*How can Design Thinking contribute more strategically to move society towards a sustainable future?*

In order to answer this question, the following three sub-questions are posed:

SRQ1 *What characteristics of the Design Thinking process currently have the potential to strategically move society towards a sustainable future?*

SRQ2 *What currently prevents the Design Thinking process to contribute to society moving more strategically towards a sustainable future?*

SRQ3 *What could an integrated process of Design Thinking and Strategic Sustainable Development look like?*

**Research Scope and Limitations**

This research aims to inspire the field of DT to consider socio-ecological impacts in every design effort. It intends to engage not only the professional designer, but any person who wishes to implement a DT approach when solving problems creatively. The study focuses on how a strategic and sustainable perspective can be integrated into a DT process by identifying those additions of greatest importance.

**Methodology**

The methodology of this research itself was inspired by the DT approach. Its phases provided an overarching structure to the research methodology, depicted in the following diagram.
In the Discovery phase, interviews were conducted with designers to examine the DT approach’s current efforts and gaps in moving towards sustainability. In the Interpretation phase, an analysis through the lens of the ‘Framework for Strategic Sustainable Development’ (FSSD) was conducted (a framework for planning in complex systems towards SSD, consisting of five levels: Systems, Success, Strategic, Actions and, Tools), based on findings from the interviews and two analysed toolkits. In the following phases, Ideation and Experimentation, prototypes of a ‘Sustainable Design Thinking’ (SDT) process were created in several iterations. A first prototype was tested by means of Action Research in the form of a workshop, which was further examined by sub-methods. Subsequently, improvements were incorporated to develop a second prototype that was evaluated through expert feedback. The Evolution phase represents the culmination of the conducted iterations in order to present a third SDT process prototype.

**Results**

**FSSD Analysis**

Based on the interviews, as well as content reviewed from two DT toolkits, and following the five levels of the FSSD, the authors completed a structured analysis of the current DT process. The analysis portrayed potential contributors and hindrances of the existing process that could affect progress towards a sustainable future. Examining the Systems level, it was found that the main focus in the process is given to the target audience for which the design challenge pertains, and to some extent indirect stakeholders. Additionally, there is no clear reference to the ecosystem within which a human need (which builds the central focus of the DT process) is being addressed, nor is there any acknowledgement of the current sustainability challenge. Concerning the Success level, it was found that the DT process does not employ a definition for sustainability, and does not consider whether the chosen design solution could result in negative consequences to society or the biosphere. Yet at the same time, the DT process puts the human need in the centre of the design challenge, thus enhancing people’s capacity to meet their needs to some extent. In the Strategic level an implicit use of backcasting from the goal to fulfil a need was found, yet as there is no definition for sustainability the use of backcasting is not sufficient to ensure reaching a sustainable outcome. In addition, there is lack of prioritisation to make decisions strategically. In regards to the Actions level it was found that there are some actions, such as observation, that could help to reach sustainable outcomes. In regards to the Tools level there were no inherent tools found in the process for that purpose.

**Interview Results**

Interviews shed light on current barriers that are hindering the integration of sustainability into the DT process. Barriers included difficulty in dealing with the complexity and trade-offs of sustainability impacts, as well as lack of information and appropriate education. Also it was voiced that the designer’s mindset can be a hindrance if they do not think or care about sustainability and that the actual term carries negative associations, influencing the designer’s desire to embrace sustainability perspectives. In addition, some recommendations on how to incorporate sustainability into the DT process were made. Those included to create a systems perspective, add sustainability constraints as part of the design challenge, create a shared vision, improve decision-making, and supplement a tool to distinguish needs vs. desires.
Action Research

Based on findings from the FSSD analysis and interviews, a preliminary prototype was created which was later tested in a workshop. The first prototype included twelve additions (referred to as ‘add-ins’) that tried to address the gaps to reach a strategic and sustainable outcome. The workshop was held at Blekinge Institute of Technology (BTH) in Karlskrona, Sweden with students from various backgrounds. Four teams tried to address a design challenge to improve the waste management system at BTH by going through the SDT process. The results of the workshop revealed that the add-ins were considered helpful by participants to reach a sustainable outcome, yet additional time was needed to go through the process more effectively. From the workshop findings a second prototype was created with some alterations to the previous add-ins, and including additional eleven add-ins. These tried to tackle more gaps along the process.

Expert Feedback

In order to theoretically assess the potential of the second prototype to yield a sustainable outcome, seven experts were asked to give their opinion in writing on each add-in, and to give general comments and further suggestions. The SDT process and the add-ins were found to be relevant and useful for their purpose, and constructive feedback was given on possible further improvements.

Discussion

Potential Contributors and Hindrances to SSD

The research identified characteristics of the DT process that have the potential to strategically move society towards a sustainable future. Emphasis on flexibility, optimism, collaboration, diversity, and a strong belief in the basic human ability to be creative and imaginative were found favourable for supporting action towards sustainable solutions. Additionally, DT’s core intent to gain a deeper understanding of human needs with regards to a problem, and build empathy by observing and looking at issues from the human’s point of view, was found to be already at work to address facets of social sustainability. However, although the human need is poised at the centre of the DT process, no systematic differentiation between human needs, desires, or satisfiers is emphasised, which if not considered could ultimately contribute to the production of unnecessary products or services that feed societies’ current course of unsustainability.

Research findings further identified additional gaps that should be addressed to ensure that a DT process includes a SSD perspective. Primarily DT takes a partial systems perspective that while referring to some stakeholders other than the target audience, is very limited in scope and long-term thinking. Especially the environment and humans’ dependency on the environment for meeting their needs are not clearly regarded. Additionally, DT lacks a shared definition of sustainability, which could hinder the design team’s ability to ensure sustainable outcomes. In general, sustainability considerations are not an inherent part of the DT process. Additionally no further strategic prioritisation is made, besides basic voting, to evaluate which ideas will be prototyped, leaving decision-making to intuition, ‘rules of thumb’ and mostly reliance on the mindset of the designer. As none of these tactics can be considered systematic or strategic, it makes the case that if sustainability is embedded more intentionally
and methodically into the DT process, designers might be more likely to address it at least in part, regardless of their mindset.

Elements of backcasting and visioning could be identified although the terms are not explicitly referenced. In this case, no overarching vision, comprised of a core purpose and values, acts to guide the process, however finding a solution that addresses a human need while being technically feasible and financially viable, as well as challenge design constraints provide goals and principles of success to plan towards. In general, the DT process lacks strategic prioritisation towards a sustainable solution and as mentioned relies principally on the designers gut feeling. If sustainability is considered as a deciding factor, social benefits seemed to be weighted higher than environmental benefits, likely due to the high priority given to human-centredness and desirability. The process furthermore lacks a strategic manner of prioritising which aspect of the design problem to focus on. This might lead the design team to focus on a problem that is not the most impactful to be solved.

The Sustainable Design Thinking Process

Through an iterative process and rounds of feedback, a third and final prototype of a SDT process was produced, yielding a total of eighteen add-ins. It is the assumption of the authors that the facilitator of a SDT process comes with the wish to create something sustainable be they a professional designer or a novice. Accordingly, following a human-centred approach for the prototype itself, simplicity of language was given importance in order to be understandable across a wide audience and accessible to the ‘designer within each of us’. Included add-ins’ compatibility with the DT process was made evident through the Action Research as well as expert feedback, finding that when merging DT and SSD, sustainable solutions can be achieved creatively and collaboratively, encouraging people towards optimism and agency. The authors attempted to address the key points identified during the research to consider sustainability; however, the integration of several gaps will be left to further research. The integrated SDT process requires further exploration in order to develop and test the usability and practicality of the add-ins across types of design challenges and contexts. Again, experts generally affirmed that the SDT process could help reach sustainable solutions, bearing possible implications for SDT to influence the wider design field.

Conclusion

DT offers to extend the power and positive potential of design to the hands of the ‘designer within each of us’. However, this research identified the process’ lack of sustainability perspectives and thereby presented guidance for how the process could become more strategic and sustainable in the form of a prototype of an integrated process. Preliminary research findings show that such an integrated process could help reach a strategic and sustainable outcome, even though further refinement should be pursued.
List of Abbreviations

4SPs  Four Sustainability Principles
DT   Design Thinking
HCD  Human-Centred Design
FSSD Framework for Strategic Sustainable Development
MSLS Master's in Strategic Leadership towards Sustainability
SLCA Strategic Life Cycle Assessment
SDT  Sustainable Design Thinking
SSD  Strategic Sustainable Development
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1 Introduction

This paper explores the role that Design Thinking (DT) could play in responding to the pressing, global sustainability challenges humanity now faces. The authors describe some of the functions of design in society, both as a basic human impulse and as outcomes that brought about many gifts to humanity, including a positive impact on human development. The full picture however, is that design has also contributed to sustainability problems to a significant degree. It is the hope of the authors that research to analyse the DT process through the lens of the Framework for Strategic Sustainable Development (FSSD), as well as through seeking knowledge from practitioners in the field, could result in integrating strategic and sustainable perspectives in the DT process.

1.1 Design and Humanity

The act of creation is a fundamental human need, where individuals exercise their curiosity, imagination and boldness in order to conceive, invent, and construct (Max-Neef 1991). The term ‘design’ broadly describes a process to that end (also the outcome itself) and is characterized conceptually by characteristics such as problem solving, creation, addressing a need, team work and coordination as well as cultural and artistic contributions (Borja de Mozota 2003).

At a high level, design encompasses the human ability to both “prefigure what we create before the act of creation” (Fry 2009, 2) and to travel the vast spectrum “from knowing to doing” (Thorpe 2007, 15). The umbrella of design can therefore be far-reaching, and appear in nearly every field and discipline. Additionally, the ability to design is not a talent or skill only few can possess. In fact, Victor Papanek (1984, 3) contends, “all men are designers. All that we do, almost all the time, is design, for design is basic to all human activity.”

1.1.1 Design and Development

The impetus to create and design has drawn humanity to develop over time, creating infinite examples of designs throughout history (Heskett 2005). From handmade tools in the prehistoric age to democratic governance and space shuttles today, everything, except for the natural environment, was designed by humans. Arguably even nature, as evidenced through the advent of agriculture and many other subsequent manipulations, can be seen as influenced by human design. Transformation is at the heart of design. Papanek (1984, 28) highlights that, “the ultimate job of design is to transform man’s environment and tools and, by extension, man himself.”

Industrialisation, democratisation of access (to products and services), and consumerism have significantly influenced the evolution of design and in turn, design’s impact on human development. The largest transformation came with the industrial revolution about two hundred years ago (Heskett 2005) when machines replaced human hand-made production and products started to be designed for the masses, shipped to markets in faster rates and in rising quantities (Papanek 1984). Industrialisation allowed for production to grow in increasing quantities at decreasing prices which contributed to ‘democratising access’, enabling more and more people to enjoy new products and services (Vezzoli and Manzini 2008). Products such as the washing machine, car, and radio became available to many, and provided easy access to services (such as laundry, mobility, music and information), which
saved time and enhanced freedom (Manzini 2006, Vezzoli and Manzini 2008). The combination of science and technology to transform industry, along with democratising access to ever cheaper products and services, created great opportunities to improve human well-being (Vezzoli and Manzini 2008); concurrently increasing population size and economic growth contributed to a dramatic change in consumption patterns (Steffen et al. 2004).

1.1.2 Conflict of Design, Development and the Socio-ecological system

Arguably, consumerism has become the dominant theme for design and development in the twentieth and twenty-first centuries. Fuelled by rising consumption patterns, consumerism is seen as an approach to economic development, concerned with providing goods and services to the customer whilst generating profit for the manufacturer (Thorpe 2007). Thorpe argues (2007, 13), “earlier concerns about positive social change and broader social goals [within design] largely have been abandoned. The [design] emphasis is on [...] the appearance of objects themselves, the fantasy of a brand [...], and the move toward relatively generic solutions that can appeal in global markets.” Design’s influence through the above illustrated trends of industrialisation, democratising access, and rising consumerism have caused a great transition for humankind, yet this trajectory of development has spurred increasing conflict within the socio-ecological system. Seminal statements on sustainability made in the UN Report of the World Commission on Environment and Development (commonly known as the ‘Brundtland Report’) attest, “many of the products and technologies that have gone into this improvement [of living standards and quality of life] [were and] are raw material and energy-intensive and entail a substantial amount of pollution. The consequent impact on the environment is greater than ever before in human history” (WCED 1987, chapter 1.1). The methods in which humans design dictate the consequences of their creation. Human’s modern methods have been shown to result in environmental disregard and destruction, prolific waste, and considerable benefits lost to a large part of the human population (Parikh 2010).

Albeit significant, until the industrial revolution changes that were made to the planet due to human influence were still mostly dominated by nature (Papanek 1984). With the progress of technology and industry, a new era emerged - the anthropocene. The anthropocene is a global epoch characterising humankind’s activities as a “growing geological and morphological force” on par with, even rivalling nature (Steffen, Crutzen, and McNeill 2007, 615). The single use and disposal of resources (rather than cyclic patterns that are existent in nature), the development of consumerism and consumption, and a lack of awareness of the limits of the planet (Vezzoli and Manzini 2008), created exponential growth of use of natural resources causing changes to the planet, some of which might be irreversible. During the past fifty years it has gradually become clear that the planet’s natural resources are finite (Vezzoli and Manzini 2008) which in turn highlights the fundamental conflict between humanity’s present course and the limits of the planet.

Beyond the impact on the environment, the reality is that although great developments positively influence living standards all over the world, 1.2 billion people still live in extreme poverty1 and are unable to meet their basic needs (The World Bank 2013). One in eight

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1 Living on less than $1.25 per day (The World Bank 2013)
people do not get enough food to be healthy and lead an active life (Chen and Ravallion 2008). The Brundtland Report acknowledges both social and environmental shortcomings, stating, “many present development trends leave increasing numbers of people poor and vulnerable, while at the same time degrading the environment.” This begs the question, “how can such development serve next century's world consisting of twice as many people relying on the same environment?” (WCED 1987, chapter 1.1). These pertinent realisations and questions indicate that current strategies for human design on this planet are not working. The benefits of developments in design have not been equally distributed and have caused profound environmental impact. The role of design in causing the inability of the socio-ecological system to sustain itself must be addressed lest humanity keep, “pushing the Earth into planetary terra incognita” (Steffen, Crutzen, and John McNeill 2007, 614).

1.2 The Sustainability Challenge

The large and growing impact on the biosphere in the anthropocene era presents a major challenge for humanity moving forward. Human activities are now so pervasive and profound that they are altering the stability of the earth in ways that are threatening the very life support system upon which humans depend (Steffen et al. 2004, Chick and Micklethwaite 2011). The majority of the scientific community agree that, “warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level.” (IPCC 2007, 5). Additionally, other interdependent environmental pressure factors caused by humans are threatening crucial planetary boundaries², contributing to ocean acidification, ozone depletion, increasing global phosphorous and nitrogen cycles, aerosol loading and chemical pollution, biodiversity loss, freshwater use and land-system change (Rockström et al. 2009). The phenomenon of global change raises very real concerns whether Earth will be able to support human civilization, as it is now known, into the future. Furthermore, the pending state of environmental and social sustainability rely on each other. For example, Chick and Micklethwaite (2011, 76) emphasise that “poverty alleviation and environmental protection are intrinsically linked and one cannot be meaningfully addressed while the other ignored.”

One common approach to deal with these current socio-ecological problems is to believe economic growth and technological innovations will yield sufficient solutions (e.g. innovating more fuel-efficient engines for automobiles). However, this approach views the depletion of resources as a non-systematic problem, causing an irresponsible underestimation of the actual pressure the planet faces (Robèrt 2013). Fry (2009) contends that for the ‘excesses of the present’, humanity has created a world that limits its future possibilities. He points out that, through the act of production, humans take destructive actions on the planet, thereby ‘defuturing’ themselves. This impact can be illustrated by the metaphor of a funnel, which shows the systematic degradation of the socio-ecological system. The more society continues in its detrimental activities, the less capacity of the socio-ecological system remains to support it. The walls of the funnel illustrate the limitations of opportunities that will evolve over time. Ignoring symptoms of ailing people and planet will only contribute to more corners of society (e.g. organisations, nations, etc.) ‘hitting the walls’ of the funnel,

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² Nine scientifically identified Earth system processes which have thresholds that if crossed risk resulting in abrupt permanent environmental change. (Rockström et al. 2009)
manifesting in increasing social, financial, and environmental crises (Ny et al. 2006, Holmberg and Robèrt 2000).

![Funnel Metaphor](image)

**Figure 1.1. The Funnel Metaphor.**
*(Holmberg and Robèrt 2000; Design: Serrure, Beltrame and Rootes 2013)*

Usually examined in isolation, the relationship between many singular impacts on the socio-ecological system are too complex and non-linear to decipher, making it impossible to foresee how and when multiple repercussions on the larger scale will occur (Ny et al. 2006). Furthermore, because of the complexity of the biosphere and its relationship with human activity, phenomena occur at unpredicted occasions due to delay mechanisms (Steffen et al. 2004). For example, when the first generation of refrigerators was introduced, CFC$^3$ substances (carried by the refrigerators) were not suspected to contribute to ozone layer depletion, which only happened and was understood by humans years later (US EPA 2013). The manner in which most designs were and are created, still do not consider socio-ecological impacts or the possible connections one small sub-system has on another. Shedroff explains the role of design in contributing to global problems: “Even where our best intentions have been engaged, our outcomes have often fallen short - sometimes making matters worse - because we didn’t see the whole picture when creating what we envisioned” (Shedroff 2009, XXIII).

### 1.2.1 Role of Design within the Sustainability Challenge

As was discussed above, and as recognised by many thinkers in the design field, many of the problems society faces today are a result of making unwise design decisions (Heskett 2005, Chick and Micklethwaite 2011, Manzini 2006, Shedroff 2009). However, if the power to design has become of ill-consequence, Tim Brown, designer and CEO of international design firm IDEO, argues that design can once more be a part of creating positive change. He notes, “times of great change demand new solutions and new alternatives. [...] at the height of the industrial revolution [...] every aspect of life and society was being re-invented. Now those systems have run their course and are in fact part of the problem. Now we are in another period of great change, asking us to re-question fundamental aspects of our society” (Brown, 2010). The link between design, its opportunity to shape a sustainable future, and the threat of hitting the funnel walls is clear. Design has been evidenced as part of the problem, which is all the more reason to leverage it as part of the solution. Due to its essential strength at balancing creativity, complexity, compromise, and choice (Walsh et al. 1992) the authors

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3 Chlorofluorocarbons are primarily used as refrigerants, solvents, and in insulating foams. They destroy the ozone layer in the stratosphere and are powerful greenhouse gases (US EPA 2013).
believe that design is poised to aptly respond to current sustainability challenges. Additionally, several scholars from the field of Design Management argue that design makes an important contribution to innovation (Verganti 2003, Borja de Mozota 2003) and can serve as a strategic tool (Peters 1997, Jevnaker 1998, Turner 2000, Borja de Mozota 2003, Hargadon 2005), both vital necessities for creating new pathways and possibilities. It has been said that all designers are futurists to some degree, experimenting with and suggesting how the world might be (Borja de Mozota 2003). As such, this is a skill to be nurtured and developed across disciplines and among all people to envision a sustainable and promising future.

It is worth mentioning that numerous responses to address both environmental and social sustainability concerns have already been made within the design field. Examples include Biomimicry, Cradle to Cradle, Design for Sustainability, Ecodesign, Base of the Pyramid Protocol and several others. Design is not the only solution to all of the challenges human society faces, other measures such as policy and legislation must be included. Design however offers a thinking approach, a critical and often overlooked asset to the work of addressing sustainability challenges (Buchanan 2001).

1.3 Design Thinking

1.3.1 Defining Design Thinking

Interpretations and understanding of the term ‘Design Thinking’ (DT) vary. Descriptions range from an attitude comprised of various qualities such as curiosity and empathy (Spoelstra 2013), a way of approaching problems (Bishop 2013, Mukaze 2013, Larsson 2013), making sure one answers the right questions (Norman 2013), taking a broader systems perspective (Young 2013a, Daniel 2013a, Larsson 2013), something not defined nor clear (Newman 2013) or merely a business label or branded name (Rego 2013a, Garcia I Mateu 2013a). Academic literature finds DT as experimental and focused on early feedback and redesign (Razzouk and Shute 2012) as well as concerned with translating observations into actionable insights (Brown and Katz 2011). For the purpose of this paper, DT is characterised by the following key themes:

- **Human-Centredness:** instead of a product or service, humans, their needs, practices and preferences are placed at the centre of a design process (Young 2010).
- **Research-based:** Research is necessary to understand the humans’ needs, drivers and barriers (Young 2010).
- **Knowing the surrounding context:** it is necessary to “zoom out for context” (Suri and Howard 2006, 247) to get an overview of the surroundings of the design problem.
- **Collaboration:** DT is collaborative and multidisciplinary, requiring a design team (rather than an individual person) and the inclusion of stakeholders throughout different levels of the design process (Young 2010, IDEO 2012).
- **Optimism:** DT is based on the fundamental belief that everyone can create change—“no matter how big a problem, how little time or how small a budget [...] designing can be an enjoyable process” (IDEO 2012, 11).
- **Non-linearity and experimentation:** in research as well as in generation and evaluation of solutions including prototyping, one should think with his/her hands (Gravina 2010). This prevents the design team to stick with one solution, which might not be the optimal one at an early stage of the process, and encourages the exploration of several solutions (Young 2010).
Eloquently expressing the depth and range of DT Garcia I Mateu (2013) notes, “Design Thinking is what lays in the middle of artistic and scientific thinking.” Using a blend of inspired expression and a methodic, repeatable process, DT is “a way of shaping a reality that is beautiful and responds to truth.”

The authors acknowledge that other design concepts such as ‘User-Centred Design’, ‘Human-Centred Design’ (HCD), and ‘Service Design’ share many aspects with DT, namely; a focus on humans’ needs, desires and behaviours; iterative design processes; the aim to find new solutions to problems; and prioritising synthesis rather than analysis (Nussbaum 2007). However, for simplicity the term ‘Design Thinking’ will be used throughout this paper to describe such a conception of design (although the term HCD will be at times referred to synonymously due to its close relationship).

The ‘Three Lenses of Human-Centred Design (HCD)’, an often-used mental model in the field to define DT (Alexander 2013), offers a visual representation of DT’s core priorities. The three lenses are Desirability, Feasibility and Viability. A design challenge is first addressed through the ‘Desirability lens’ to identify the needs, dreams, and behaviours of the people that will be affected by the solution generated (IDEO 2011). Only after having examined the challenge through the Desirability lens, possible solutions are looked at through the lenses of Feasibility and Viability, asking, “what is technically and organisationally feasible?” and “what can be financially viable?” (IDEO 2011, 6). The final solution that a designer identifies during the design process lies in the area where the three lenses overlap.

![Diagram of the Three Lenses of HCD](image)

**Figure 1.2. The ‘Three Lenses of HCD’. (IDEO 2012)**

### 1.3.2 Design Thinking in Practice

Though ‘how designers think’ has been discussed as a concept in academic circles for many decades (Johansson and Woodilla 2009), a growing interest in the practical DT approach has gained traction in fields such as business, leadership, management and others, advocating the virtues of the ‘design process’ (Borja de Mozota 2003, Hargadon 2005) and ‘design attitude’ (Boland and Collopy 2004) in order to cope with increasing complexity. Conceptualised and popularised by IDEO and Stanford d.school, predominantly as a mindset and process that is too important to be left to professional designers, discourse on DT is currently becoming more multidisciplinary in nature (Johansson and Woodilla 2009, Brown 2010, IDEO 2013, d.school 2013). Vezzoli and Manzini (2008) also emphasise the opportunity for a changing role of design in today’s society by insisting that professional designers do not have the ‘monopoly’ on design anymore, rather, everyone can design anywhere. Brown (2010) concludes that by applying DT as an approach to any person in any field, design will have greater impact in the world.
The DT emphasis on accessibility and relevance for creative, innovative, and potentially strategic problem-solving across various disciplines, whether one is a professional designer or not, makes it a subject worthy of further exploration. Equally, these traits showcase its potential to serve as a part of addressing sustainability issues, which therefore appealed to the authors of this thesis to focus research efforts on DT.

1.3.3 The Design Thinking Process

For the purposes of this research, one document translating the concepts of DT into a structured process, was of great use. The ‘Design Thinking for Educators’ (DT4E) toolkit published by IDEO enables any person without a design background to “create solutions to everyday challenges” (IDEO 2012, 10). Solutions can be products, services, environments, organisations, and modes of interaction (IDEO 2011). While there are many different versions to articulate the DT process, the basic tenants remain essentially the same, and therefore the authors chose the DT4E toolkit as it is a recent and clear expression of the process. By “[putting] Design Thinking into action” (IDEO 2012, 14) the process helps navigate the design challenge through five phases, which are presented chronologically but in practice require iterations amongst them.

The Discovery Phase provides the basis of the process - in this phase, the design team understands the challenge, defines how to approach it and gathers research and inspiration through different means (observation, interviews, field visits, etc.). As the diagram below illustrates, the Discovery Phase requires the design team to diverge, whereas in the following Interpretation Phase, the team narrows (or converges) to transform the gathered information into ‘meaningful insights’ which give a direction and more clarity for what aspects of the problem the team would like to solve. In the Ideation Phase, the team approaches the problem by diverging their thinking through a brainstorm to generate as many ideas as possible. The Experimentation Phase results in a final convergence to chose one to a few ideas with which to experiment and refine. Through prototyping the idea(s) and sharing them with the relevant audience, the design team receives invaluable feedback to develop and further improve a final solution. To ensure the evolvement of the chosen idea on the long-term, the Evolution Phase directs the team to plan further steps, document them and reach out to people who will help to take it further (IDEO 2012).

![Figure 1.3. Structure of the DT process. (IDEO 2012)](image-url)
1.3.4 Design Thinking and Sustainability

Within the natural and social disturbances felt globally, an opportunity for transition and transformation exists alongside a dilemma for how organisations and individuals proceed in coping with the speed of such changes and their web of interrelated challenges. Sir Ken Robinson states, “to face these challenges we have to understand their nature; to meet them, we have to recognise that cultivating our natural powers of imagination, creativity, and innovation is not an option but an urgent necessity” (Robinson 2011, 1). To brave such complex systemic sustainability challenges, DT has an important role to play. Brown (2010) comments, “it changes the way we tackle problems. Instead of defaulting to our normal convergent approach, where we try to select the best choice out of existing alternatives, DT encourages us to diverge, to explore new alternatives and new choices that have never existed before.”

DT has many strengths. It helps people express opinions, needs or ideas they have not been able to voice or do not know how (Alexander 2013), it is grounded in real experiences (Larsson 2013), and activates and empowers others (Daniel 2013). It has been said, “Design Thinking as a frame is what sustainability needs” (Bishop 2013). However, it is also said, “you shouldn’t design without sustainability” (Rego 2013a), indicating an imperative to include this priority into all design. Looking at DT as a process today it appears there is no emphasis put on a whole-systems-perspective nor does it define future success of the design challenge in line with socio-ecological principles. Consequently solutions are not necessarily helping society to move towards a sustainable future, which society cannot afford if design is to be part of the solution and not the problem. Moreover, not taking a strategic approach towards sustainability might cause well-intended solutions created through the DT process to lead to unintended and negative consequences on the larger socio-ecological system.

Furthermore, part of the problem organisations and individuals encounter if trying to create a new ‘sustainable’ solution is the lack of a common understanding of sustainability (West 2010). For example, the term ‘sustainability’ often expressed in the design field is used to describe the financial stability of a business model or segment on the long-term (IDEO 2011). ‘Sustainability’ understood in the sense of preservation of the socio-ecological system is not referred to explicitly within the DT process. Given the sustainability challenge, the complexity of the problems to be solved, and the importance of design within this challenge, a holistic perspective in the DT process seems required.

One scientific approach to address the sustainability challenge and to provide a holistic perspective is ‘Strategic Sustainable Development’, a field of study responding to the need for a definition of sustainability. Guided by scientifically-based principles, SSD seeks to transform current unsustainable patterns of society to move strategically towards a sustainable future (Robèrt 2000).

1.4 Research Purpose and Research Questions

This study was in fact born out of the evidence that DT, as generally expressed, does not explicitly regard sustainability in the design process nor does it account for a broader range of needs beyond those of humans. Though a popular and useful tool, the absence of sustainability thinking in the DT process could lead to unanticipated impacts and to unsustainable design solutions being magnified throughout society.
The purpose of this research is therefore to explore how SSD perspectives can be embedded throughout the DT process. The ‘Framework for Strategic Sustainable Development’ (FSSD, further explained in section 2.1.1) was applied as an analytical lens to evaluate the current contributions and gaps of DT towards SSD. Based on this analysis, elements of the FSSD were integrated into the DT process resulting in a prototype of these combined perspectives, which could be called a Sustainable Design Thinking (SDT) process. The authors accomplish this purpose by attempting to answer the following research questions:

**Main Research Question (MRQ)**

*How can Design Thinking contribute more strategically to move society towards a sustainable future?*

In order to answer this question, the following three sub-questions are posed:

**SRQ1** *What characteristics of the Design Thinking process currently have the potential to strategically move society towards a sustainable future?*

**SRQ2** *What currently prevents the Design Thinking process to contribute to society moving more strategically towards a sustainable future?*

**SRQ3** *What could an integrated process of Design Thinking and Strategic Sustainable Development look like?*

### 1.5 Research Scope and Limitations

This research aims to inspire the field of DT to consider socio-ecological impacts in every design effort. It intends to engage not only the professional designer, but any person who wishes to implement a DT approach when solving problems creatively. It is outside the scope of this study to address the specificity, nuance and expertise required to apply SDT in particular professional settings (i.e. industrial product design, process/service design, architecture, or other applications), rather it was the intentional choice of the authors to work with a simple and generic example from which readers of various knowledge backgrounds could extrapolate to their own end. This research furthermore focuses on the integration of sustainability within the DT process and does not seek to identify inherent strengths and weaknesses of the DT process in general.

By virtue of the fact that this research is specifically interested in furthering the application and integration of the FSSD framework, the ‘sustainability’ factors taken into consideration are those that are central to the FSSD framework, and thus not exhaustive. This study does not seek to identify an ideal integrated process or conclusive end point. Instead it aims to spark a beginning by identifying those additions of greatest importance to prototype one version of an integrated process that would require subsequent testing and refinement. Similarly, this study looks to define the potential points of influence required to build sustainability into a DT process, however it is out of the authors’ scope to describe or test explicit instructions how to facilitate that process or speak to the full range of tools that could be employed to deliver it. Additionally this research focuses on how a strategic and sustainable perspective can be integrated into a specific DT process as expressed in IDEO’s DT4E toolkit (albeit generic in its representation of the basic DT elements). Therefore the authors acknowledge that due to the sheer diversity in DT understanding and practice, application of the results of this study will be dependent on the situation and context.
2 Methodology

This section discusses the design, methods, and range of participants used to conduct this study. It also addresses reliability and validity assumptions, biases and expected results. The research process was informed by Maxwell’s Model for Qualitative Research Design (Maxwell 2012). It was the authors’ desire to ensure an iterative and flexible approach to the evolving research, and as such, Maxwell’s interactive model was preferred, leading to reflexive refinement of the goals, conceptual framework, research questions, methods, and validity throughout. This resulted in a research structure that was more spiral than linear in nature, and that allowed for a process in which each time the learning deepened in one area of research it would refine understanding as well as gaps in another. In addition to direction from Maxwell, the authors were also guided by concepts from Design Research Methodology (Blessing and Chakrabarti 2009).

The authors designed the research structure to follow the phases of the DT process studied. This, in turn, gave the authors the opportunity to experience and better understand the investigated topic. Creating a more strategically sustainable DT process was identified as a design challenge in itself. The need to address this challenge was validated by the authors’ preliminary analysis and through exploratory interviews with experienced designers. The DT approach was adopted as a mindset and its phases provided an overarching structure to the research methodology, depicted in diagram 2.1.

As diagram 2.1 illustrates, the research process follows the five different DT phases: In the Discovery Phase, the authors sought to understand the wider design field generally, and the DT approach and its current efforts and gaps in moving towards sustainability specifically.
This was accomplished by conducting interviews with designers who have knowledge either on the DT process, sustainability, or both. This was intended to glean the stories of people considered to be experts or have on the ground project experience in the design field. In the Interpretation Phase, an analysis through the lens of the FSSD (further explained in section 3.2) was conducted, based on findings from the interviews and two documents (HCD toolkit, DT4E toolkit). Interviews and the FSSD analysis were conducted simultaneously - however for the purpose of writing in the clearest manner, the authors chose to present the FSSD findings first.

In the following phases, Ideation and Experimentation, a strong emphasis was put on creating, testing and iterating, as sufficient early-analysed information was at hand to start prototyping an integrated process. Since the authors believe that learning develops faster by tangibly trying things out, the integrated process was reflected upon and adapted with each succession. Firstly, the authors went through parts of the process themselves in a less formal way to sketch preliminary points of intervention; this became the first prototype for an integrated ‘Sustainable Design Thinking’ (SDT) process. Subsequently, it was tested in an Action Research workshop facilitated by the authors. According to feedback (measured through several sub-methods: feedback forms, concept descriptions and focus group), the first prototype was improved and evolved into a second prototype. This prototype was then examined by experts to receive their professional feedback and recommendations for further development via a written questionnaire. The Evolution Phase represents the culmination of the conducted iterations in order to present a third SDT process prototype (presented in section 4.2).

2.1 FSSD Analysis

The FSSD analysis aimed to address the first and second research questions in order to examine whether the DT process possesses a strategic approach towards sustainability, and to inform the first prototype of an integrated process. In addition to interview findings, data was collected as part of the FSSD analysis mainly from two toolkits that depict the DT process in a detailed and clear way. The ‘Human Centered Design (HCD) Toolkit’ (2011) and the DT4E toolkit (2012), both published by IDEO, have been made available online and are free to download. By complementing the interview findings with analysis of the toolkits, potential ‘reactive effect’ of respondents to provide answers they think are expected, was mitigated, ultimately increasing validity (Bryman 2008). The authors acknowledge the possible limitations of document content analysis as it is not peer-reviewed and thus could lack the level of scientific rigor and consensus that other formal research does. In addition, the toolkits have been conceived by one particular organisation which could be held to scrutiny for underlying business intentions. However, the authors believe as the toolkits are instructional rather than promotional, it is likely that their publication was not created as a means for publicity and marketing, but to make the DT process open source.

2.1.1 The Framework for Strategic Sustainable Development

In order to assess the current strengths and weaknesses of the DT process to reach a strategic and sustainable outcome, the ‘Framework for Strategic Sustainable Development’ (FSSD) was employed. The FSSD is a unifying and generic framework that offers a strategic approach to analyse, plan and make decisions within ecological and social system boundaries (Robèrt 2000). The framework was created and continuously developed through a consensus
and scientifically peer reviewed process to substantiate a shared language of sustainability by
defining the minimal requirements necessary to address the sustainability challenge. The
framework provides a holistic, systems perspective, of any given subject, with principles
which are “necessary, enough, general, concrete and non-overlapping” (Ny et al. 2006, 63) to
reach a sustainable society. The FSSD is structured in the five following interdependent
levels that should not be regarded sequentially but understood and looked at simultaneously
(Robèrt 2000; Ny et al. 2006).

**Systems Level:** refers to the need to consider the whole system when planning or making
decisions, taking into account how the relevant social and ecological systems function, are
affected by the choices made, as well as the current sustainability challenge (Robèrt 2000).

**Success Level:** includes four Sustainability Principles (SPs) as minimal requirements to
achieve a future sustainable society. Additionally, an overarching vision, including a core
purpose statement and values should be articulated to guide the organisation, initiative,
project team, or individual towards their idea of success. Finally, stated goals provide
ambitious positive aspirations that can motivate the change process. Success therefore means
working towards one’s vision and goals whilst abiding by the constraints of the four SPs,
which state, “in the sustainable society, nature is not subject to systematically increasing:
I. Concentrations of substances extracted from the Earth’s crust” (SP1 e.g. mining of
mercury)
“II. Concentrations of substances produced by society” (SP2 e.g. burning of fossil fuels)
“III. Degradation by physical means, and in that society…” (SP3 e.g. deforestation)
“IV. People are not subject to conditions that systematically undermine their capacity to meet
their needs.” (SP4 e.g. abusive working conditions) (Ny et al. 2006, 64)

**Strategic Level:** refers to a ‘backcasting from principles’ approach. According to this method,
a planning process should first start with envisioning a desired future and only then design a
strategic path towards realising it (Ny et al. 2006, Robèrt 2000). Basic principles to define
success of the desired future serve as overall constraints that the planning process should at
least comply with. Those principles should be the four SPs as well as constraints of the
specific planning process. Keeping the envisioned future goal as well as the basic principles
in mind helps to avoid becoming lost in details throughout the planning process. Therefore, it
is “an essential planning methodology when the system is complex, and when current trends,
actions and planning are part of the problem” (Robèrt at al. 2002, 201). The planner also
needs to consider three basic generic strategic guidelines when taking action towards
sustainability, further strategic guidelines can be chosen depending on the priorities and
context (Robèrt 2000): 1. Does this action proceed in the right direction with respect to the
Sustainability Principles? 2. Does this action provide a ‘stepping stone’ (flexible platform)
for future improvements? 3. Is this action likely to produce sufficient return on investment?

**Actions Level:** includes concrete chosen actions taken to strategically move towards
sustainability (Robèrt 2000, Ny et al. 2006).

**Tools Level:** includes strategic tools (which by measurement, reporting, auditing etc. identify
how and if a chosen action falls under the strategic guidelines), systems tools (which monitor
directly the damage or improvement caused by actions in the system) and capacity tools (to
provide people with capacities to learn about sustainability) that help reaching success within
the system’s boundaries (Robèrt et al. 2010).
2.2 Interviews

In order to answer all three sub-research questions, interviews were conducted with professionals and students from the design field, selected either due to their experience and knowledge of DT and/or sustainability. As referred to by Corbetta (2003, 117), “...the only way we can explore motivation, attitudes, beliefs, feelings, perceptions and expectations is by asking.” Interviews offered the opportunity to understand the design thinkers own reflections and values on the subject matter. To keep the DT mindset present within the research, interviews with designers were important for building empathy and understanding their needs with regards to creating an integrated process they might find of use. Acknowledging that these are individual perspectives, this method was triangulated with those more suited to uncover the unspoken realities of behaviour in Action Research.

Fourteen interviews were conducted over Skype, two of which were group interviews, and two additional interviews were completed in writing via email. A list of the interviewees can be found in Appendix A. Careful not to contrive questions that seek to elicit particular data, the interviews were designed in a semi-structured format, whilst allowing increased time for open dialogue. This kept the setting more natural, where spontaneous questions could be asked based on where the conversation evolved. The questions were pre-tested with a design professor and a fellow Master’s student (with an industrial design background), to ensure that the terminology was clear, the flow coherent, and the questions easily elicited relevant responses. After conducting initial interviews the authors recognised the need to make minor refinements to the research questions in order to yield the most focused and relevant data. These adaptations might have caused limitations in comparing answers across interview responses, but the nature of the semi-structured format also contributed to this lack of uniformity. All the interviews revolved around four main themes: The DT process, its strengths and weaknesses in general and with regards to sustainability, and the potential to integrate sustainability into it.

2.2.1 Interview analysis

The interviews were recorded with mobile phones and later replayed to ensure that the notes captured the essential points of the discussions, as well as to evaluate if, for example, a question was accidentally expressed in a leading manner. At least two authors were always present to counter validity threats like single-interviewer subjectivity. One author acted as the primary interviewer while the other one/two took notes and asked clarifying questions if necessary. Due to time constraints, full word-by-word transcription was not used in the analysis of interviews. Rather, a process of auditory review and comprehensive interview summaries were conducted to minimize subjectivity and potential bias. A post-defined, inductive coding approach was used to retrieve and organise the data concurrently with analysis (Blessing and Chakrabarti 2009). The coding process was conducted as follows: At first, general categories were created according to the research and interview questions to cluster common insights (e.g. ‘definition for DT’). Additional categories were created if insights that were found important had no relevant category to fall under. To ensure reliability each interview was independently reviewed by two authors, extracting insights under the relevant categories. Then, the findings of all interviews were aggregated under the categories, re-evaluating whether an insight needed to be moved to another, more relevant category. After reviewing all the insights, the authors looked for common themes under each category, naming them with codes in an iterative process (e.g. under the category ‘reasons for
2.3 Action Research

“Most results [of design research] end up in scientific publications only and rarely in practice. If the aim of design research is to improve design, this research should have some effect on practice, directly or indirectly” (Blessing and Chakrabarti 2009, 7). This quote underpins the authors’ desire to use Action Research as a means to avoid conducting only theoretical research, and include actions to start examining at an early stage if the recommended findings are feasible in practice and how they can be improved upon. The authors did not use a full Participatory Action Research method (Reason and Bradbury 2001) however Feyerabend’s (1975) argument for methodological pluralism was internalised for this research - as he points out that researchers do not have to stick to strict rules of ‘traditional’ research, but can develop and implement their own methods for every research project. The time frame for this Action Research was an evident limitation, however the authors’ determined it was better to start with something, albeit limited.

2.3.1 Intermediate Result: First Prototype

As an intermediate result from the first two methods, a preliminary prototype of a SDT process was created. Based on the FSSD analysis and insights and suggestions from the interviews, the authors developed a DT process with add-ins that aimed to ensure a strategic and sustainable outcome. In order to do so the authors reviewed the existing process (as outlined in the DT4E toolkit), and added the concepts and activities that the previously conducted research had proven necessary. Twelve add-ins were supplemented in different stages along the process, only from the Discovery through the Ideation Phase as the first three phases were considered to be most crucial in designing a sustainable solution (see Appendix B for further description).

2.3.2 Workshop to Test First Prototype

To examine the usability and effectiveness of the first prototype of the integrated process, ‘second-person Action Research’ (which examines an issue “face-to-face with others” (Reason and Bradbury 2001)) was conducted in a workshop of condensed time frame, seeking to continue answering the third research question: What could an integrated process of Design Thinking and Strategic Sustainable Development look like? Twenty-three participants from various backgrounds (design, SSD, and others) attended the workshop, which was held at Blekinge Institute of Technology (BTH) for 4.5 hours and facilitated by the authors. The design challenge addressed during the workshop was ‘improving waste management at BTH’. Four teams were formed, mixing participants with varying knowledge about sustainability and DT. A hand-out was sent beforehand to all participants to create a shared basic understanding of the characteristics of the DT process as well as preliminary conceptual adaptations made by the authors (see Appendix C for details). The goals of the workshop were to examine: if sustainability was factored along the process, how easy it was to use the additional add-ins, which parts were difficult or insufficient to use, and if the workshop participants’ different backgrounds influenced their ability to design sustainably using the integrated process. Blessing and Chakrabarti (2009, 273) illustrate that in Action Research “through cycles of action and research a better understanding is obtained, while at
the same time the organisation or programme under investigation is gradually changed.” The study presented in this paper aimed to test the preliminary research findings about the improvement of the existing DT process in practice. However, the intention was also to design the challenge addressed in the workshop in a way that it would be applied to a real problem with potential for solutions to be carried forward outside of this research and to therefore create change.

2.3.3 Action Research: Sub-Methods

Action Research aims to co-create new knowledge in a learning process together with social actors (Nielsen and Svensson 2006). Incorporating elements of cooperative inquiry (which means “researching ‘with’ rather than ‘on’ people”) (Heron 1971, 179) into sub-methods of the workshop allowed partial participation of social actors in the learning process by different means. The workshop was assessed by the following three sub-methods:

A feedback form was filled in by all participants after the workshop to collect their individual opinions on the process in a structured manner. This method aimed to survey the usefulness and effectiveness of the prototype in general, and specifically every add-in. The participants were asked to rate their knowledge about DT and sustainability (KaDT and KaS respectively) (10=I can work in the field; 5=I know the major issues and follow media coverage; 1=no knowledge), dividing the levels of knowledge by the following ratings: 7-10=high knowledge; 4-6=medium knowledge; 1-3=little knowledge. In addition, in order to assess how each specific add-in helped them to think of environmental and social impacts, a scale was presented (verbal scale: ‘helped a lot’-’helped a little’-’was neutral’-’hindered a little’-’hindered a lot’; which was then translated into a numeric scale of +2 to -2). A few open questions were asked to get general impressions on the workshop. The feedback forms were analysed using Excel and SPSS software (by gathering the information in a table, creating graphs, and conducting statistical tests of one-way-ANOVA and t-test), to see whether the level of knowledge about DT or sustainability had correlation with participants’ perceived ability to use the process, and to see if there was significant difference between the teams’ ratings that could indicate potential issues in a particular team (which would require further exploration). Although some of the results were analysed statistically, these only indicate trends, and not cause and effect relationship, as the conditions of KaS and KaDT were not randomly assigned or manipulated as occurs in a scientific experiment.

To ensure triangulation for the feedback on the workshop, the authors held a focus group interview four days after the workshop with five participants, representing three of the four design teams and both genders. The structure of the interview was carefully prepared to assure that the questions contributed to get a better understanding of the identified results through the feedback forms. Two authors asked questions to the focus group, while one took notes and observed participants’ behaviour. The focus group interview was analysed in a similar manner to the analysis of interviews. A comprehensive summary of the conversation was analysed by one author and compared with an audio recording. Afterwards, one author coded the conversation for key themes, based on the questions posed during the focus group. The authors were aware that the effects of group dynamics (e.g. differences in personality or status) might have affected the contributions of some participants (Blessing and Chakrabarti 2009).

As part of the original DT4E process every team had to fill in a concept description form during the workshop to describe their proposed idea (the authors used the original concept
description form from the DT4E toolkit). By analysing the concept descriptions the authors examined the teams’ understanding of the impacts of their proposed solutions on social and environmental aspects.

2.4 Expert Feedback

2.4.1 Intermediate Result: Second Prototype

The second prototype was an intermediate result based on the assessment of the workshop through the above-mentioned sub-methods. The authors examined the different add-ins from the first prototype and added new ones to cover the remaining phases of the process.

2.4.2 Expert Feedback to Test Second Prototype

Feedback from experts was integrated in the research to validate the second prototype and receive suggestions on improvements and additions. Six former interviewees and one additional expert agreed to comment and advise on the prototype. The second prototype was presented to the experts in a written format, including a list of add-ins with brief explanations and an illustration of the flow and changes to the process. Questions were posed per add-in, asking whether they thought an add-in could potentially help to create a more strategic and sustainable outcome. Additionally, general comments about the strengths and weaknesses of the process were asked (see Appendix D for the expert feedback form).

Some form of evaluation is key in design research, in order to assess whether the support tool devised can be used for the task in which it was created, to identify whether the expected impact has been realised, and to identify necessary improvements to the concept (Blessing and Chakrabarti 2009). Feedback from experts allowed the authors to ask questions, seek advice, and tap into the wisdom and experience of a group who have an explicit design background and a depth of experience using the DT process in practice (see Appendix A for the list of collaborators). Consulting experts was also helpful to counter the limitations inherent in the authors’ bias as creators of the prototype.

2.5 Assumptions and Biases

Each part of this research project was revised by all three authors, aiming to test and validate each other’s work and to question assumptions constantly. While the authors come from different countries and cultural contexts (Israel, Germany, U.S.A), this strength in diversity is also limited by a predominantly Western perspective. The authors also share mutual interests and values in creativity, collaboration and sustainability, perhaps fostering initial bias that both DT and SSD are useful for solving the world’s sustainability challenges. These similarities could colour the subjective process of coding interviews as well as general interpretations pertaining to the Action Research, although triangulation of methods was employed to mitigate this. As the nature of fieldwork contains ‘reflexivity’, it should be noted that authors were part of the social world they studied and therefore could not avoid either influencing or being influenced by it. It was therefore paramount to engage in self-reflection to both uncover personal purposes, assumptions, and potential biases (Maxwell 2012). In general, as has been described per method throughout the above section, different methods were selected to ensure triangulation and increase the validity of the research.
3 Results

This section describes the research findings, following the research methods described in chapter 2, beginning with the presentation of the FSSD analysis, followed by the interview results, the first prototype of an integrated process as an intermediate result, the feedback on the workshop gathered through sub-methods, the adaptations made to create a second prototype as intermediate result, and finally the expert feedback.

3.1 FSSD Analysis

Based on the answers from the interviewees, as well as content reviewed from the two IDEO toolkits (IDEO 2011, IDEO 2012) and following the five levels of the FSSD, the authors completed a structured analysis of the current DT process to answer SRQ1: What characteristics of the Design Thinking process currently have the potential to strategically move society towards a sustainable future? SRQ2: What currently prevents the Design Thinking process to contribute to society moving more strategically towards a sustainable future? Table 3.1 presents an overview of the findings from the FSSD analysis.

Table 3.1 Summary of FSSD Analysis.

<table>
<thead>
<tr>
<th>Potential Contributors</th>
<th>Hindrances</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Systems Level</strong></td>
<td>• Partial systems understanding</td>
</tr>
<tr>
<td></td>
<td>• Lack of reference to whole system on the long term</td>
</tr>
<tr>
<td></td>
<td>• No reference to the sustainability challenge or how the socio-ecological system functions</td>
</tr>
<tr>
<td><strong>Success Level</strong></td>
<td>• Addresses human needs (SP 4)</td>
</tr>
<tr>
<td></td>
<td>• Multidisciplinary and diverse teams</td>
</tr>
<tr>
<td></td>
<td>• No definition of sustainability</td>
</tr>
<tr>
<td></td>
<td>• SP 1, 2, 3 not addressed</td>
</tr>
<tr>
<td></td>
<td>• SP 4 is only partially addressed</td>
</tr>
<tr>
<td></td>
<td>• No overarching vision with core purpose and values</td>
</tr>
<tr>
<td><strong>Strategic Level</strong></td>
<td>• Implicit use of backcasting</td>
</tr>
<tr>
<td></td>
<td>• No backcasting from SPs</td>
</tr>
<tr>
<td></td>
<td>• No strategic prioritisation</td>
</tr>
<tr>
<td><strong>Actions Level</strong></td>
<td>• Actions inherent to the process (storytelling, observation and prototyping)</td>
</tr>
<tr>
<td></td>
<td>• Actions do not necessarily consider sustainability</td>
</tr>
<tr>
<td><strong>Tools Level</strong></td>
<td>• Flexibility to include additional sustainability tools</td>
</tr>
<tr>
<td></td>
<td>• No sustainability-specific tools</td>
</tr>
<tr>
<td></td>
<td>• Entails characteristics of optimism, empathy, experimentation, creativity and collaboration</td>
</tr>
</tbody>
</table>
3.1.1 Systems Level

The DT process generally stresses the need to understand the system and context around the design problem (e.g. through the use of stakeholder mapping). Aspects of the wider system are partially addressed in the DT4E toolkit by asking the design team to look at people and groups that are directly and peripherally related to the design challenge (IDEO 2012). However, there is no reference that society operates as part of the biosphere or how these interconnected systems function (IDEO 2011, IDEO 2012). In most cases the system stays in the realm of society, only referring to human stakeholders (Davis and Óncel 2013). Nevertheless, it was frequently commented by the interviewees that part of being a good designer is to have a systems perspective (Alexander and Hewens, Mukaze, Holmström Céspedes and Newman 2013).

According to Alexander and Hewens (2013) and Mukaze (2013), DT also does not take into account a solution’s societal or environmental long-term impact. Additionally, the DT process does not acknowledge the current sustainability challenge or make effort to impress upon the design team the interaction of that wider challenge with their design challenge (IDEO 2011, IDEO 2012). Though the process itself does not evidence concern for the sustainability challenge, every interview participant did.

3.1.2 Success Level

The interviews showed that every design thinker comes with his/her own definition of sustainability, and if not a definition, his/her own perception. Sustainability was understood as emphasising long-term thinking and preserving people’s ability to act in their best interest in the future, indefinitely (Alexander, Thorpe 2013, Young, Garcia i Mateu 2013a). Holmström Céspedes (2013) spoke of cycles of cause and effect, “what goes around comes around,” whilst Spoelstra (2013) referred to doing more to help than harm. Recurrent comments were made about a systems or holistic perspective that accounts for both ecological and socio-cultural welfare (Alexander, Bengtsson, Bishop, Larsson, Mukaze, Thorpe 2013). A few interviewees felt that the term was either hard to define, a buzzword, vague, overwhelming, lost its meaning or perceived as difficult for people to understand (Bishop, Mukaze, Norman, Rego 2013).

The first, second and third SPs are not strategically taken into account, as DT does not necessarily require the design team to include consideration of environmental impact (Young 2013a, IDEO 2011, IDEO 2012). Mukaze (2013) further argues that sustainability is usually not a criterion of success but an afterthought.

The fourth SP is partially addressed due to primary emphasis made towards meeting human needs (Daniel, Young 2013a). As DT currently lacks a whole systems perspective, the process does not address the needs of people that are not in direct relation to the design challenge. Additionally, needs are not being systematically analysed or prioritised during the process (Bengtsson 2013). Davis and Óncel (2013) pointed out that in order to consider human needs in a needfinding process, needs and satisfiers have to be distinguished better.

Building on Max-Neef’s theory on human needs (1991), they elaborate in their thesis that services and products are satisfiers of nine basic human needs (which are the same in all cultures across time), highlighting that “products and services can satisfy human needs in multiple ways” to more positive or negative effect (Davis, Óncel and Yang 2010).
by design teams. Rego (2013a) also expressed that no formal tools exist to help distinguish between needs and desires. Garcia i Mateu (2013a) furthermore argued that needs are perceived differently according to people’s values and the reality people choose to see in order to make sense of it. Each stakeholder comes with his/her own perception of those needs, therefore, even when the designer takes into account human needs, he/she might miss the way they are being perceived differently by people other than the target constituents.

In general, success for a DT initiative is determined by the problem or challenge that is chosen to be solved. The main goal is to find a solution that addresses a need of the constituents while being technically and financially feasible (IDEO 2011) and addressing further constraints of the design brief such as producing a solution of high quality (Anonymous 2013). The Interpretation Phase also articulates inspiring opportunities in the form of actionable “how might we...?” questions (e.g. how might we create a more sustainable DT process?) which serve as a goal to brainstorm ideas around (IDEO 2012, 47). Reviewed through a FSSD perspective, there is no overarching vision, comprised of core purpose and values, included in the DT process (IDEO 2011, IDEO 2012).

Diversity is touted as a key principle for creating a successful DT process (Rego 2013). This becomes obvious in both toolkits (IDEO 2011, IDEO 2012), as they highlight the importance of inclusiveness with regards to gender equality and the creation of design teams that contain a wide array of professional backgrounds and varied skill sets.

### 3.1.3 Strategic Level

Even though backcasting is not explicitly referred to in the DT process, when examining the HCD toolkit (2011), it could be inferred that the process does require the design team to backcast from the goal of creating a potential solution. The goal should fulfil the ‘Three Lenses of HCD’ (IDEO 2012) and other goals considered to be success criteria. This functions much like backcasting from principles since in DT, though there are criteria or design constraints set at the start of a process, one does not know what the outcome will ultimately look like (Daniel 2013). As there are no principles for sustainability explicitly defined, strategic planning towards sustainability is absent within the process, unless included by the design team’s will (IDEO 2011, IDEO 2012).

The DT process currently contains two convergences that require prioritisation. The first convergence occurs when a specific insight (serving as the goal of the challenge) is chosen to brainstorm solutions for (Interpretation Phase). The second convergence occurs when specific solutions are chosen to be further developed (Ideation Phase). In both phases of convergence there is little guidance on how to make decisions strategically; au contraire, emphasis is put on deciding according to ‘gut feeling’ or sometimes by majority voting (IDEO 2011, IDEO 2012). Additionally, responses from interviewees indicated that financial viability is the critical lens in prioritisation (Bengtsson, Alexander, Daniel 2013). Interviewees further supported notions regarding lack of strategic prioritisation in the DT process (Alexander and Hewens, Spoelstra 2013), especially highlighting that following one’s intuition is very common in DT processes (Newman, Norman 2013, Rego 2013a). According to Rego (2013a) “as a designer you start creating your own rules, your own understanding and own parameters to consider in your projects.” Additionally, it was expressed that “rules of thumb” (Young 2013a) and general guidelines (e.g. no use of PVC) (Alexander and Hewens 2013) are used to make decisions. Lastly, it was pointed out that prototyping can be one key aspect of DT that helps to prioritise (Rego 2013a).
3.1.4 Actions Level

The whole process of DT leads towards generating ideas to be put into action. These actions are intended to meet a need, however they do not necessarily consider sustainability (IDEO 2011, IDEO 2012). Daniel (2013) argued that, “DT lacks an inner conscience” and the use of actions is determined by the mindset of the design team. However some inherent actions such as observation can help to understand the system and identify local impacts (Young 2013a). As mentioned above, prototyping is also helpful to better prioritise options according to sustainability impacts (Rego 2013) and storytelling can deliver inspiration for sustainability (Norman, Bishop, Young, Anonymous, Daniel 2013).

3.1.5 Tools Level

Tools and activities within the toolkits that facilitate the process, foster characteristics which could potentially contribute to coming up with sustainable solutions. Characteristics include creating optimism, building empathy, engaging people to a collaborative process, helping people to be creative, and giving space to experiment, as well as feel more comfortable to fail and learn (IDEO 2011, IDEO 2012). These strengths are evidenced in case studies throughout the HCD and DT4E toolkits, for example by building empathy for children in rural India (finding out what was fun or scary to them), a design team was better able to create an experience that ensured more children would have access to basic eye care (IDEO 2011).

That being said, a typical DT process does not contain regular tools that support efforts to reach a sustainable society. The interviews showed that every process, its circumstances and team, is very different and that there are so many variables and permutations, not one tool could capture sustainability for all of them (Alexander and Hewens, Larsson, Newman, Bishop 2013). The majority of interviewees expressed the need to add other tools to the process to address sustainability impacts, depending on the design challenge. The toolkits themselves encourage users to adapt the process according to the design challenge and to supplement other tools if necessary. The HCD toolkit elaborates that, “using this toolkit on its own will yield great solutions. However, HCD is also very flexible and can complement or be supplemented by various other approaches” (IDEO 2011, 22).

The following tools are currently being added on a case-by-case basis by the interviewees in order to consider sustainability impacts at different stages within the DT process:

**Systems:** Stakeholder mapping (Garcia i Mateu 2013a), Holistic Impact Assessment (IDEO 2011), Flows analysis/ Input-Output analysis (Garcia i Mateu, Young 2013a), Systems mapping (Davis and Öncel 2013), Value network analysis (Garcia i Mateu 2013a), Activity mapping (Garcia i Mateu 2013a), Personas (Rego 2013a), Scenarios, videos, storyboards (Bishop 2013), Frameworks (matching the project) (Newman, Bishop 2013)

**Success:** Strategic Life Cycle Assessment (Mukaze 2013), Community indicators (Young 2013a).

**Strategic:** 2x2 matrix (Spoelstra, Alexander and Hewens 2013)

**General tools:** MEPSS (Rego 2013a), FSSD (Mukaze 2013), Cradle to Cradle (Mukaze 2013), Life Cycle Assessment (Spoelstra 2013), Ecodesign (Garcia i Mateu 2013a), Design for Sustainability (with expanded focus) (Garcia i Mateu 2013a), Social design (Spoelstra 2013), Lean process (Spoelstra 2013)
3.2 Interview Results

When evaluating the interviews with eighteen designers (see Appendix E for interview questions) the authors identified key themes that had emerged during the conversations by grouping the gathered information according to categories as was explained in the methods chapter. The key themes identified were grouped into both current barriers hindering the integration of sustainability into the DT process and recommendations on how sustainability can be integrated into the DT process.

3.2.1 Barriers hindering the Integration of Sustainability in the DT process

The interviews revealed five main barriers that are hindering the integration of sustainability into the DT process today.

Dealing with complexity and trade-offs: Several interviewees expressed difficulties when dealing with the complexity of sustainability impacts. Because of the interrelation and tensions between environmental, social and financial impacts, every decision involves various trade-offs (Alexander and Hewens, Bengtsson, Norman, Larsson, Anonymous 2013, Rego 2013a). One interviewee said, “it is so difficult to make the full calculation” (Anonymous 2013). A subset of interviewees also pointed out that it is difficult to see and understand the whole system around a problem as there are so many factors to be considered (Young, Alexander and Hewens, Davis, Holmström Céspedes 2013). Additionally, one interviewee mentioned the need for long term thinking to understand the system (Holmström Céspedes 2013).

Education in sustainability needed: Interviewees frequently brought up that if and how sustainability matters are dealt with comes down to how the designers are trained (Bengtsson, Holmström Céspedes, Thorpe, Mukaze 2013, Rego and Daniel 2013a). According to Alexander and Hewens (2013) there are “not many people with experience in this area” and Thorpe (2013) highlighted that there is a need to train designers in sustainability.

Inadequate Information: Lack of adequate information and knowledge to make decisions towards sustainable solutions was reported. It was mentioned that it is difficult to know and compare negative sustainability impacts of products and materials (Rego, Thorpe 2013).

Mindset: Larsson (2013) emphasised that sustainability needs to be built into the design process on a conceptual level. Closely related to that, it was the predominant view of the interviewed designers that sustainability needs to be brought into the process as a personal internal value (Daniel, Rego 2013a, Anonymous, Alexander and Hewens, Spoelstra, Mukaze 2013). Rego (2013a) illustrates this need for the internal value by stating, “you have to have a good heart inside.”

Pessimistic image of sustainability: Some interviewees discussed the pessimistic image of sustainability (Young 2013a, Newman, Bishop 2013). Bishop (2013) expressed that, "sustainability suffers from an extreme lack of optimism" and explained that, because sustainability points at what could go wrong, it makes designers uncomfortable because they are not used to the negativity.
3.2.2 Recommendations to Integrate Sustainability into the Process

In addition to the barriers they are facing, interviewees also explicitly gave recommendations for how sustainability can be integrated into the DT process. The authors grouped these suggestions into more concrete suggestions for different phases of the DT process (systems perspective, constraints, balancing needs and desires, decision-making, brainstorming) and themes that need to be present throughout the process (facilitation, communicating sustainability, leading through questions, stories and inspiration).

**Systems perspective:** The interviewed designers stressed that though the DT process starts with the human in the centre, a systems perspective is needed to understand the bigger system the human is operating in (Newman, Davis and Öncel, Holmström Céspedes 2013). Davis (2013) recommended mapping out different facets around the design challenge that need to be looked at and to identify and test relationships. It was also mentioned by one interviewee that the whole life cycle of a possible solution needs to be looked at to be truly sustainable (Spoelstra 2013). To acquire the information required to gain an understanding of the system, extensive background research can be needed, if possible involving experts and academics (Newman 2013).

**Systems perspective (on the long term):** Two interviewees also pointed out that the design challenge and its system need to be looked at on the long term (Alexander, Holmström Céspedes 2013). Alexander (2013) suggested that adding a fourth circle to the ‘Three Lenses of HCD’ would make the DT process more complete in regards to the bigger system that the challenge sits within and its temporal qualities. Holmström Céspedes (2013) emphasised that any solution needs to be seen on the long term or if scaled up.

**Systems perspective (understand context and describe situation):** Another recurring point that was made, falling under the need for a systems perspective, is the need to understand the context the design problem is situated within (Ann Thorpe, Mukaze, Newman, Larsson, Holmström Céspedes 2013). It was also recommended to explicitly describe the system surrounding the situation, including the direct and indirect stakeholders with their needs, values, activities, the built and natural environment as well as the relationships and flows between them (Garcia i Mateu 2013a).

**Systems perspective (risks and opportunities):** Thorpe and Bishop (2013) suggested that when understanding the situation and its context, it is advisable to also list risks and opportunities in the current situation, which was for example framed as “look at the assets” (Thorpe 2013).

**Constraints:** In general, it was pointed out by several interviewees that there is an opportunity to frame sustainability in the DT process by establishing constraints, because the strength of design is to deal with constraints (Spoelstra, Alexander and Hewens, Bishop 2013, Young 2013a). It “enables creativity in a designer to be at their best” (Alexander and Hewens 2013).

On the one hand, there were several comments from interviewees that it would be valuable to establish sustainability thinking or rules upfront in the DT process (Young, Daniel 2013a, Mukaze, Anonymous, Spoelstra, Alexander and Hewens 2013), and even establish the rules in the brief (Alexander 2013). In Daniel’s (2013a) words it means “sustainability has to be one of the principles in the process.”
On the other hand, Alexander and Hewens (2013) warned that putting constraints at the beginning of the brainstorm might prevent potential solutions or opportunities to emerge from unsustainable ideas that would then be excluded from the start. Alexander (2013) furthermore suggested to let constraints be ‘parked’ during the brainstorm and only then ‘unpark’ them to check whether unsustainable ideas could be improved.

**Sustainability Principles as constraints:** Having been asked about the possible integration of the four Sustainability Principles (SPs), Daniel and Thorpe (2013) found that it might be hard to combine the two mindsets (DT and the four SPs) in one process. Furthermore it was commented by several interviewees that the four SPs are too generally framed and thus difficult to operationalise (Newman, Larsson, Holmström Céspedes, 2013). Thorpe (2013) however sees the four SPs to be a “useful concept to use as a compass.”

**Create a future vision:** Davis (2013) suggested to include a high-level vision within sustainability constraints to backcast from, insisting this would not limit designer’s creativity but guide direction towards sustainability. Another respondent emphasised the need to generate a shared understanding of the situation and create a vision all stakeholders could live in (Garcia i Mateu 2013a).

**Balancing needs and desires:** In general, Daniel (2013) pointed out that emphasising the difference between needs and desires would be a good way to relate to sustainability without saying it. The phrasing of the design challenge should therefore go beyond the ‘desirability’ lens of the problem (Öncel 2013). Also, it was highlighted that considerations on needs and desires have to be balanced to design solutions that people really want. For example Holmström Céspedes (2013) illustrated the example of a manual mill that might be all people need, and more ‘sustainable’, but that they desire a motorized one.

**Decision-making:** Several interviewees suggested different ways of how decisions could be informed to better strategically move towards sustainability. Establishing criteria to check possible ideas against during the process emerged as one of the main themes in the interviews. It was pointed out that the criteria should be good for both the social and the environmental system and need to cover materials, the use (in contact with the user), and the whole cycle of the solution (Mukaze 2013). A strategic analysis of trade-offs was found to be helpful, even though “it is a fine line between over-analysis and rules of thumb” (Young 2013). Alexander (2013) pointed out that later scientifically rigorous criteria could balance early decisions made intuitively. However, the criteria should be imagined in context to check their relevance, because the design challenges can be very different and some criteria are very contextual (Holmström Céspedes, Thorpe, Newman 2013).

**Brainstorming:** The recommendations the interviewees gave regarding brainstorming in the DT process mainly revolved around the notion of asking questions. Alexander (2013) pointed out that in the brainstorm, it can happen easily that one narrows down to the brief without considering the whole system. The brainstorm could thus include provocative starter questions to help diverge away from the brief and to think in systems instead of products, e.g. “what if we threw out everything we know today?” (Alexander and Hewens 2013) or (referring to the idea of persistence) “how to design this so it will not be around in one thousand years?” (Bishop 2013).

**Facilitation:** In the interviews, it was highlighted frequently that the facilitation of the process plays an important role when integrating sustainability considerations into DT. The facilitator can act as activist or catalyst (Mukaze 2013). In general, the process aims to
empower “local people to solve their own problems” (Spoelstra 2013) and to “activate others” (Daniel 2013) by fostering teamwork, collaboration and building creative confidence amongst people. Some interview respondents stated it was crucial to not impose the designer’s own thoughts and values, but to let people create their own solutions (Spoelstra, Mukaze, Alexander and Hewens, Anonymous 2013). However, it was also expressed that the facilitator of the process can lead the group towards sustainable solutions by highlighting them (Daniel 2013) or helping to make decisions at the right moments in the process (Spoelstra 2013). Bishop (2013) highlighted though that courage is necessary to be a protagonist and point out a direction for the design team.

**Communicating sustainability:** Predominant comments from the interviewees were that they minimize the explicit use of the term ‘sustainability’ (Young, Daniel, Rego 2013a, Alexander, Spoelstra, Holmström Céspedes, Newman 2013). This is because “sustainability has a lot of baggage” (Young 2013a) and “the term [...] lost its sense of actual meaning” (Alexander and Hewens 2013). However, one interviewee said that she would not hesitate to use it in most places as there is “broad societal agreement to pursue sustainability” (Thorpe 2013).

Several interviewees (Bengtsson, Daniel, Norman, Bishop, Holmström Céspedes 2013) highlighted that, to include sustainability aspects into the process, it is advisable to speak to where the people are at and “make [a] point in a way that they consider important” (Norman 2013). Bishop (2013) recommended to “meet them where they are, [and to address] their cares and priorities,” which was also referred to as making a “silent argument” for sustainability in order to convince people that sustainability makes sense for their own lives (Holmström Céspedes 2013). One interviewee also pointed out that it can be helpful to highlight the risks of unsustainable solutions (Daniel 2013). In general, the interviewed designers emphasised that the crucial part about communicating sustainability is to logically connect it to the context.

**Stories and Inspiration:** There were recurring statements made by interviewees about the relevance of powerful examples and/or stories to tell throughout the process and inspire the design team towards sustainability (Daniel, Young 2013a, Alexander, Anonymous, Norman, Bishop 2013). On a similar note, Thorpe (2013) recommended to show case studies that operationalise different ways to incorporate the higher level concept of sustainability.

**Leading through questions:** Another suggestion for the process that came up repeatedly in interviews included asking prompting questions along the process in order to stimulate the design team to think about sustainability aspects (Bishop, Young, Davis and Öncel 2013).

### 3.3 Action Research Results

In the following section, the first prototype of the SDT process will be presented as an intermediate result, which was subsequently tested through means of Action Research. The section closes with the results of the sub-methods of the Action Research.

#### 3.3.1 Intermediate Result: First Prototype

Throughout and after analysing the information gathered through the interviews and FSSSD analysis, the authors identified twelve preliminary aspects to be added to a DT process thereby ensuring more strategic and sustainable outcomes. These key aspects (called ‘add-
ins’) were integrated in an intermediate result, a first prototype of a ‘Sustainable Design Thinking’ (SDT) process, which was based on the structure and flow of the DT4E toolkit (IDEO 2013). Every add-in is briefly presented in table 3.2 according to its nature (concept, visual model, activity, questions, guidelines or team role) and the level of the FSSD it aims to address. The extended overview, showing the add-ins along the DT process can be found in Appendix B.

Table 3.2. Add-ins First Prototype.

<table>
<thead>
<tr>
<th>Name of the 'add-in'</th>
<th>Type</th>
<th>FSSD level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nested HCD Model</td>
<td>Concept/Visual Model</td>
<td>Systems</td>
<td>Concentric circles representing the human as part of society and the biosphere (see illustration in Appendix B)</td>
</tr>
<tr>
<td>Care Instructions</td>
<td>Concept</td>
<td>Success</td>
<td>Articulation of the four SPs described in easy to understand terms</td>
</tr>
<tr>
<td>The Clover Model</td>
<td>Concept/Visual Model</td>
<td>Success/Strategic</td>
<td>Four lenses through which solutions should be examined and prioritised (Desirability, Feasibility, Viability and, Big Picture &amp; Long Term)</td>
</tr>
<tr>
<td>Systems Team Role</td>
<td>Team Role</td>
<td>Systems</td>
<td>Reminds the team to zoom out and see the bigger system</td>
</tr>
<tr>
<td>Big Picture</td>
<td>Activity</td>
<td>Systems</td>
<td>Mapping the system of relevant stakeholders and their relationships, including the environment</td>
</tr>
<tr>
<td>Questions Referring to the Big Picture</td>
<td>Questions</td>
<td>Systems</td>
<td>For example, what appears to be an area that would have large impact on the whole system?</td>
</tr>
<tr>
<td>Out-of-the-box Brainstorm Questions</td>
<td>Questions</td>
<td>Actions</td>
<td>Questions that trigger new thought angles (e.g. how is this problem solved in nature?)</td>
</tr>
<tr>
<td>Prioritisation Matrix</td>
<td>Activity</td>
<td>Strategic</td>
<td>Convergence guidance: a prioritisation process of rating possible solutions according to six questions (see questions in Appendix B)</td>
</tr>
<tr>
<td>Sketch to Think the Whole Lifecycle</td>
<td>Activity/Guidelines</td>
<td>Systems</td>
<td>Visualising of the cycle of the chosen solution (from inception to disposal)</td>
</tr>
<tr>
<td>Enhanced Reality Check</td>
<td>Questions</td>
<td>Systems/Success</td>
<td>Examining whether the solution would hold ground in reality with regards to SSD (e.g. how would your idea impact other stakeholders?)</td>
</tr>
<tr>
<td>Enhanced Concept Description</td>
<td>Activity</td>
<td>Systems</td>
<td>Describing the solution in writing and referencing sustainability considerations (e.g. would your design cause unintended consequences?)</td>
</tr>
<tr>
<td>Sustainability Storytelling</td>
<td>Activity (ongoing)</td>
<td>Actions</td>
<td>Stories and examples to inspire sustainability considerations throughout the design process</td>
</tr>
</tbody>
</table>
3.3.2 Action Research: Sub-Methods

The following results helped to evaluate the success of the workshop, examining the usability and effectiveness of the first prototype of the integrated process. This research phase consisted of three different sub-methods: the participants’ written feedback, a focus group, and an evaluation of the teams’ concept description forms.

**Feedback Forms:** The feedback forms provided both verbal and numerical data gathered via Excel and then analysed with SPSS (for further details see section 2.3.3; the feedback form can be found in Appendix F). There was diversity and balance in the total group of participants in terms of nationality, knowledge about the fields, and gender (for appropriate graphs see Appendix G).

The participants rated the add-ins in total average as “helpful” (mean of 1.2 of a range from -2 to +2). As Graph 2.1 shows, scores of 1 and lower were given to the add-ins ‘Clover Model’, ‘Sketch to Think’, ‘Enhanced Reality Check’ and ‘Enhanced Concept Description’. Scores of 1.5 and higher were given to ‘Care Instructions’, ‘Questions referring to the Big Picture’ and ‘Out-of-the-box Sustainability Brainstorm Questions’.

![Graph 2.1. Group average ratings on the add-ins](image)

When examining the group divided according to KaS (see Appendix G for Graph 2.6. Ratings of add-ins according to Knowledge about Sustainability), no one considered him/herself with little knowledge (the lowest score for KaS was 4 out of 10). An independent-samples t-test was conducted to compare the scores given to the different add-ins by participants with high and medium KaS conditions. None of the differences between high and medium scores was found significant given at the p<.05 level. When examining the group divided according to KaDT (see Appendix G for Graph 2.7. Ratings of add-ins according to Knowledge about DT), there were three levels of KaDT: high, medium and little. A one-way ANOVA was conducted to compare the scores given to the add-ins by
participants with high, medium and little KaDT. There was no significant effect of KaDT on the scores given at the p<.05 level for the three conditions for all add-ins. In order to see if teams rated the add-ins significantly different (see Appendix G for Graph 2.8. Ratings of add-ins according to Teams), a one-way ANOVA was conducted. Results showed there was no significant effect of the teams on the scores given at the p<.05 level for all add-ins (indicating that being in a particular team did not correlate with different scores). When asked whether they would use this process in the future for other possible ‘design’ challenges 22 out of 23 participants answered positively. One participant added, “it's a good way of engaging people on finding solutions for big challenges.”

Focus Group: Through inviting a focus group to a discussion, the authors could get deeper insights on the effectiveness and usability of the first prototype in general, clarify the participants’ opinions of the different add-ins in particular, and hear further considerations and suggestions. The following section summarizes the key findings from the focus group – the extended coding of the focus group discussion can be found in Appendix H.

General flow: The predominant view of the focus group was that the process helped naturally to consider social and environmental impacts, even though the time constraints of the workshop were found to be a significant limitation when evaluating the effectiveness and usability of the process.

Understanding sustainability: There was agreement that the workshop participants did not necessarily need to have an education or knowledge on sustainability prior, but that more effort is needed to explain sustainability in the process (e.g. to create a common understanding of the term amongst the design team in the beginning). According to the majority of the focus group participants, the SPs were explained well and had been part of conversations in the design teams, even though practicing and including them more would have been valuable. Likewise for the conceptual models, which participants expressed desire to have more explanation and practice. It was emphasised by one participant that the facilitator should have knowledge about sustainability, but could be presented as ‘part of the package’ that they could learn about while preparing the process.

Considering the system: The predominant view of the participants was that both the big picture exercise as well as the systems role were helpful to remind the team to look at the bigger picture, even though one participant expressed the need for a better description of the systems role. One participant expressed that introducing the role might have the effect that other team members feel less responsible for the task.

Prioritising ideas: Prioritisation of ideas according to the matrix was considered to be helpful, even though one team struggled with differing opinions about the voting. One participant expressed that there had been a need for a more thorough description of the terms in the matrix. One participant suggested restating the prioritisation questions in the concept description. Another participant expressed that he was not sure if his team had come up with the most sustainable idea, suggesting more guidance could be included earlier in the process.

Other add-ins: The predominant view of the participants was that both ‘Sketch to Think’ and the ‘Enhanced Concept Descriptions’ were not clear enough respectively and too extensive for the time frame. However, one participant also expressed that the extra questions on the concept description were most interesting to answer. ‘Storytelling’ was considered to be a powerful tool by all participants. Also the ‘Out-of-the-box Sustainability Brainstorm
Questions’ were found to be helpful, even though one participant mentioned that customising the questions more to the challenge might have been helpful.

Tools for assessment: It was expressed that, had the workshop process continued through the later phases (Experimentation and Evolution), a tool for assessing the prototype would have been needed. An SLCA (‘Strategic Life Cycle Assessment’) was suggested to “assess solutions in an easy way to let people think concretely and colourfully” (participant II).

**Concept Description:** The enhanced concept descriptions, which all teams filled in during the last phase of the workshop, were analysed to examine if the process lead the participants to think about their proposed solutions in a more strategic and sustainable way. Based on the core concepts of the FSSD, reflections on the effect of the integrated process to lead towards more sustainable solutions were considered to be successful if the respondents included logic which could help answer the following questions (based on the prioritisation questions): Do the design teams consider the scope or limitation of their problem/solution within the Big Picture? Do they consider if this concept builds for possible future opportunities? Do they consider if this idea follows the ‘Care Instructions’ (four SPs) in the short and long-term? Do they consider trade-offs? Do they consider if the concept gives a positive return on investment? Only a summary of the key aspects of the analysis is included in this section. Full results of the workshop concept descriptions’ analysis can be found in Appendix I.

Results from the concept description analysis show partial evidence of workshop participants’ cognitive leap to see their proposed idea within a larger system. One team clearly acknowledged that their solution was only a short-term solution and did not tackle the root cause. Another group spoke to the concept’s possible impact on suppliers and therefore on the environment on the long term. Building a platform for future opportunities was taken into account by two teams. The ‘Care Instructions’ were not referenced by most groups, however one team implicitly spoke to all of them. Another team commented on both the contributions to the violations of the ‘Care Instructions’ and the trade-offs. Three teams considered the positive social return on investment through mentioning several benefits for the university (including students and staff) and the local community.

### 3.4 Expert Feedback

In the following section, a second prototype, built upon the findings from the previous methods, is presented. Accordingly, expert feedback on that prototype is also presented.

#### 3.4.1 Intermediate Result: Second Prototype

Informed by the analysis of the workshop outcomes, which showed weaknesses and strengths of the first prototype, a second prototype of a SDT process was created. While the first focused on the first three phases of the DT process, in the second prototype the authors included an additional twelve add-ins to build out the final Experimentation and Evolution phases. The supplemented add-ins are briefly explained in table 3.3, as a second intermediate result. An extended description of both prototypes can be found in Appendix B.
### Table 3.3. Add-ins Second Prototype.

<table>
<thead>
<tr>
<th>Name of the Add-in</th>
<th>Type/Activity</th>
<th>FSSD level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Pre-Phase) ‘Common Ground’</td>
<td>Concept</td>
<td>Systems/ Success</td>
<td>Prior to the Discovery Phase: Creating a shared understanding of sustainability in the design team</td>
</tr>
<tr>
<td>Finding Leverage Points</td>
<td>Activity</td>
<td>Strategic</td>
<td>Looking at possible leverage points in order to decide strategically on which part of the problem to focus (i.e. choose an insight)</td>
</tr>
<tr>
<td>Brainstorm Improvement of Unsustainable Ideas</td>
<td>Activity</td>
<td>Actions</td>
<td>Taking obviously unsustainable but perhaps promising ideas and trying to build from them sustainable ideas / improve them (e.g. making an airplane sustainable)</td>
</tr>
<tr>
<td>Version ‘S’</td>
<td>Activity</td>
<td>Actions/ Success</td>
<td>Prototyping the proposed solution as sustainably as possible (regardless of financial or technical limits)</td>
</tr>
<tr>
<td>Creative Experimentation with Prototypes</td>
<td>Activity</td>
<td>Actions</td>
<td>Thinking about the solutions from the perspective of the non-human stakeholders (e.g. how would a river be influenced by the construction of a new railroad?)</td>
</tr>
<tr>
<td>Systems Focused Feedback</td>
<td>Activity/ Guidelines</td>
<td>Systems</td>
<td>Including as many stakeholders as possible when seeking feedback on the prototype (also from a sustainability expert if possible)</td>
</tr>
<tr>
<td>Enhanced Question Guide</td>
<td>Activity/ Guidelines</td>
<td>Systems</td>
<td>Adding questions (as part of the questionnaire for the stakeholders) to get feedback on possible socio-ecological implications of the prototype</td>
</tr>
<tr>
<td>Prioritising Feedback Questions</td>
<td>Activity/ Guidelines</td>
<td>Strategic</td>
<td>Considering how to respond to stakeholders’ suggestions on changes for the prototype when they might lead to negative socio-ecological impacts</td>
</tr>
<tr>
<td>SLCA Prototype Evaluation</td>
<td>Activity</td>
<td>Strategic/ Success</td>
<td>Assessing the prototype using Strategic Life Cycle Assessment (Ny et al. 2006)</td>
</tr>
<tr>
<td>Define Success</td>
<td>Activity/ Guidelines</td>
<td>Success</td>
<td>Setting measurements of success in regards to sustainability (e.g. 50% reduction in CO2 emissions)</td>
</tr>
</tbody>
</table>
Written feedback from seven experts was received. The feedback included detailed comments about each add-in, trying to answer the question, ‘is this add-in useful to reach a more Sustainable Solution?’ In addition, general impressions on the prototype and suggestions for improvements were also given. Some comments made by the experts concerned suggestions for specific tools. Although valuable, these suggestions were not included in the results as the exploration of the specific tools exceeds the scope of this research. In the following section, the consolidated results of the experts’ comments will be presented.

**General Feedback on the Prototype and Possible Additions**

The majority of experts found the prototype potentially helpful for reaching a more sustainable outcome, yet also suggested further refinements and testing (Davis, Spoelstra and Vastbinder 2013, Daniel, Garcia i Mateu, Young 2013b). In general, Young (2013b) concluded that, “it is a relatively comprehensive process” but that he received the impression that the process was more product-oriented and therefore limited in its application. Rego (2013b) found the prototype useful, however suggested to target the SDT process only to beginning designers. Garcia i Mateu (2013b) commented that “the language is really plain and understandable, which one can see has been an intentional effort [...] [showing also] the integration with the original DT methodology.” Davis (2013) commented that she “like[s] the way it circles back to reinforce ideas and challenge the team to dig deeper” and Young (2013b) also expressed similar strengths. Both experts also mentioned that these iterations should be explained, showing the reasoning for their importance.

In terms of general weaknesses, Young (2013b) voiced that some terms were not clear enough. Garcia i Mateu (2013b) advised that the add-ins should not be too prescriptive. Rego (2013b) suggested to make sustainability more appealing in the process and to simplify it because “people don’t like/use what they don’t understand.” A few points in the SDT prototype were less clear for the experts and they suggested to change terminology or wording (Spoelstra and Vastbinder 2013, Daniel, Garcia i Mateu, Young 2013b).

Davis (2013) referred to the possible use of Max-Neef’s model of nine human needs so as to distinguish between needs, desires and satisfiers more explicitly. Spoelstra and Vastbinder (2013) suggested to encourage building upon existing solutions instead of emphasising the need to come up with brand new ideas. Daniel (2013b) concluded that there are a few parts of the prototype where the SPs are less apparent, which makes it seem “like a ‘normal’ DT process [without add-ins] but in general this is very interesting and needs to be tested on a real project.”
Expert Feedback on the Add-ins

Understanding the system: All experts found it relevant to create a shared understanding of DT, sustainability, and their interrelation, and to use the conceptual models to support this understanding. Garcia i Mateu (2013b) commented that “assuming the participants will have different backgrounds, sustainability becomes the shared knowledge.” Daniel (2013b) remarked that speaking to “common interests [of DT process participants] could create buy-in (e.g. ‘why am I here?’).” The experts found it useful to provide a visual explanation of the system to create a systems perspective by using ‘The Nested Model’. Garcia i Mateu (2013b) referred to the model as “easy to grasp. Capital to bring to the surface.” Yet a few suggestions were made to refer to both the global and local society within which the challenge is addressed (Young 2013b), and also to ask the design team to think of the flows between different systems and describe their interrelationships (e.g. the interrelationships between the biosphere and the local society) (Daniel 2013b).

Assigning a person within the design team with a systems-thinker role was considered useful by all experts. However, Spoelstra and Vastbinder (2013) remarked that from their experience, these roles usually do not work well in practice since they are often dependent on the team members’ personal characteristics. Using a ‘Sustainability Champion’ was found useful (Davis 2013, Daniel, Garcia i Mateu and Young 2013b), but possibly could be merged with the systems thinker role. Young (2013b) warned that sustainability should not be the responsibility of one team member alone.

The activity of mapping the system was predominantly regarded as both relevant and good by the experts. Garcia i Mateu (2013b) saw it as a great opportunity that if “…done properly, sustainability will be carried out throughout the project.” He suggested to make the relations between the big picture and the challenge as explicit as possible. Furthermore Davis (2013) proposed to first conduct the activity individually and only then in a team. Young (2013b) cautioned to be mindful of the limits of the systems mapping and the level of detail needed. Also, the add-in ‘Sketch to Think the Whole Lifecycle’ was generally found necessary by the experts (Davis, Spoelstra and Vastbinder 2013). Three add-ins (‘Sketch to Think the Whole Lifecycle’, ‘Enhanced Reality Check’, and ‘Enhanced Concept Description’), aiming to depict the chosen solution as comprehensively as possible, were perceived by some of the experts as overlapping (Davis, Spoelstra and Vastbinder 2013). Spoelstra and Vastbinder (2013) mentioned that this type of overlap is apparent in the toolkits themselves.

Part of the ‘Enhanced Reality Check’ that referred to looking into the values of the users and other stakeholders received diverse responses. Garcia i Mateu (2013b) denoted it is too specific to look into the values at this stage, while Daniel (2013b) found this should be given even more attention. Supporting the latter view, Young (2013b) emphasised that, “this question on ‘how might your idea be received?’ is really important!”

Defining Success: The ‘Care Instructions’ were considered by most experts to be useful to reach a more sustainable solution. Spoelstra and Vastbinder (2013) as well as Young (2013b) commented that the ‘Care Instructions’ seem to give more weight to the ecological than to the social aspect of the sustainability challenge. Additionally, Young (2013b) found the ‘Care Instructions’ to be product centred, commenting “how does ‘reduce our destruction of nature’ play out when designing a public transportation system?” He also pointed out that the negative framing of the ‘Care Instructions’ is “limiting […] rather than aspirational” and suggested a positive framing could “get […] people to think differently.” Rego (2013b) argued that it is hard to take into account all sustainability considerations at once, saying “it
is really frustrating and not really fulfilling to finish a DT experience with something that has to cope with so many details” and would “kill a lot of good ideas.”

The ‘Clover Model’ was considered useful by experts (Davis, Spoelstra and Vastbinder 2013; Daniel, Garcia i Mateu 2013b). Young (2013b) proposed to change the model and to use the original ‘Three Lenses of HCD’ (upon which the ‘Clover Model’ was based) and “to bake sustainability into each of these lenses” in order to emphasise that sustainability needs to be considered through all three existing lenses and not become adjacent to other considerations. Young (2013b) suggested, that for example social benefits (i.e. community skills, income etc.) could be incorporated into the ‘Desirability’ lens. Doubts were also expressed about the use of the terminology “Big Picture” and “Long-Term” to describe the sustainability lens (Spoelstra and Vastbinder 2013, Young 2013b). Adding indicators for reaching the desired purpose with regards to the SPs was found important by Davis, Garcia i Mateu and Young (2013b). Davis as well as Young (2013b) commented that this add-in could be implemented in an earlier stage of the process, and refined later on (Young 2013b). Rego (2013b) did not favour the integration of measures stating, “avoid metrics - design is not objective and measurable.” Garcia i Mateu (2013b) suggested to integrate the creation of a shared vision amongst the team as part of the process. He also asked “what about a ‘s’ vision that inspires and generates creative tension in the Ideation Phase?” Young (2013b) also stressed that defining project goals in the beginning could serve as the basis for many activities. He suggested to ask “how would success look like?” and “how will we be able to tell?” in order to create aspiration for the future and build a shared vision in the design team.

Making the convergence phases strategic: With regards to the first convergence, several experts agreed that it is important to make this decision strategically (Spoelstra and Vastbinder 2013; Davis, Daniel, Young 2013b). Spoelstra and Vastbinder (2013) found this add-in relevant and mentioned that the current toolkits (HCD and DT4E) do not offer strategic decision-making at this point. Young (2013b) suggested additional questions to inquire how to simplify parts of the system, to stimulate the thinking “what could we remove if we did things differently?” For example, “passive solar design in a building can remove the need for air conditioning units, rather than just using more efficient air conditioners” (Young 2013b).

The predominant view of the experts was positive on the integration of a prioritisation process to decide on a solution (Davis 2013; Daniel, Garcia i Mateu, Young 2013b). Spoelstra and Vastbinder (2013) pointed out that there is a missed opportunity in not referring back to the ‘Clover Model’ explicitly in the ‘Prioritisation Matrix’. Young (2013b) cautioned though that it would be “likely to be very hard to answer in a workshop environment without proper analysis.” Rego (2013b) shared similar hesitation on the ability to assess whether ideas are sustainable or not. Davis (2013) suggested at this point to distinguish the difference between needs and desires as part of the prioritisation.

The ‘SLCA Prototype Evaluation’ was referred to as a useful tool by some of the experts (Davis, Spoelstra and Vastbinder 2013; Daniel, Young 2013b). Daniel (2013b) proposed to make use of it earlier in the process. Garcia i Mateu (2013b) argued that this tool “sometimes [...] become[s] useless if [it is] not based on some sort of reality” and also that it is mostly product oriented. Young (2013b) also remarked that this tool could be considered too abstract. He remarked that if using this tool, the phrasing should be in line with the ‘Care Instructions’.
Actions to reach success: Recurring opinions on ‘Out-of-the-Box Brainstorm Questions’ affirmed their potential usability (Davis 2013; Young, Daniel 2013b). Daniel (2013b) noted that the questions require sufficient attention in order to be answered well. Young (2013b) recommended the use of storytelling or prompts at this point, to inspire “solutions that people can then use to bounce off of.”

‘Improvement of Unsustainable Ideas’ was considered relevant by the experts (Davis 2013; Daniel, Garcia i Mateu, Young 2013b). Garcia i Mateu (2013b) commented, “nice non-belligerent sustainability warriors approach, by not discarding straight away the unsustainable ones; appreciative inquiry like-minded.” Davis (2013) suggested to incorporate at this point a SLCA as a means to recognise which ideas are actually unsustainable. Young (2013b) also commented that this is a good opportunity to examine trade-offs.

The use of ‘Sustainability Storytelling’ along the process was considered beneficial by the majority of experts (Spoelstra and Vastbinder 2013, Daniel, Garcia i Mateu, Young 2013b), as “it directs thinking in framing the understanding of the problem” (Garcia i Mateu 2013b). Daniel (2013b) proposed including stories as part of the pre-phase as well. Davis (2013) alerted that a story could distract or influence the design team towards a certain way of thinking, and perhaps instead of inspiring would create the opposite effect. On the other hand, Young (2013b) actually recommended finding stories that are more specific to the design challenge.

The add-in to aide prototyping (‘Version S’) was found useful by part of the experts (Davis 2013, Garcia i Mateu and Young 2013b). According to Garcia i Mateu (2013b), creating a visionary, highly sustainable prototype could be a helpful approach to create an ideal sustainable solution. He highlighted the importance of balancing the ideal case with instructions or guidelines to avoid a naive solution. Spoelstra and Vastbinder (2013) cautioned that approaching the ideal prototype with only the sustainability lens, might disregard the other lenses in the ‘Clover Model’.

‘Creative Experimentation with Prototypes’ was found relevant by some of the experts (Davis 2013; Garcia i Mateu, Young 2013b). Davis (2013) recommended that this add-in would not only question the negative impacts of the prototype, but also acknowledge the contributions it creates for society and the biosphere, in order to make it more interesting and fun. Another point made by Young (2013) questioned the competence of the design team to assess these impacts without appropriate knowledge.

To ‘Document Sustainability Progress’ was regarded as a positive addition (Davis 2013; Daniel, Young 2013b). Yet, Garcia i Mateu (2013b) commented the purpose of the add-in was not completely clear to him. Spoelstra and Vastbinder (2013) highlighted the greatest importance of the add-in was to share the knowledge with others.

Additional feedback: In regards to receiving feedback from relevant stakeholders (‘Systems Focused Feedback’, ‘Enhanced Question Guide’, ‘Prioritising Feedback Questions’), the add-ins were considered only partly helpful (Davis 2013; Young 2013b). Comments included words like “fuzzy” (Spoelstra and Vastbinder 2013), and statements such as, “I guess you are still developing them” (Garcia i Mateu 2013b) and “cannot comment due to not understanding the content/nature of this activity” (Young 2013). Spoelstra and Vastbinder (2013) commented that the three separate add-ins could be consolidated into one. Garcia i Mateu (2013b) suggested to make connections to the ‘Big Picture’ at this point of the process, in order to help better judge the weight given to the received feedback.
4 Discussion

In this section, the findings from the research will be discussed, starting by answering the first and second research questions on the current potential and hindrances in the DT process to move towards a sustainable future. This will be followed by a discussion of the third research question to answer how an integrated process could look like. Finally, the validity and limitations of the research will be reflected upon and areas for potential further research will be presented.

4.1 First and Second Research Question

SRQ1 What characteristics of the Design Thinking process currently have the potential to strategically move society towards a sustainable future?

SRQ2 What currently prevents the Design Thinking process to contribute to society moving more strategically towards a sustainable future?

The DT process builds on the premise that every human being commands skills for creativity and imagination. It seeks to harness an open mind, as well as to channel creativity for a specific cause. Being accessible to anyone (in the form of various toolkits), the DT process also offers an opportunity for any individual or organisation to develop creative solutions to problems. At the same time, the sustainability challenge humanity faces requires creativity and imagination to make rapid changes on different levels in all fields. The authors therefore found that with intentional enhancements leading the DT process in a more sustainable direction, it provides the potential for anyone to be part of building a sustainable future and potentially become a leverage point for engagement and transformation.

Additionally, the interviews showed that the sustainability challenge is often considered overwhelming and discouraging. Its pessimistic connotation can result in a less appealing and engaging character, whereas the DT process offers excitement and optimism. The DT process could bridge the lack of optimism that restricts sustainability, and provide people with the hope that the possibility to change the world for the better is within their hands. However, as was mentioned, the journey is not one a person need make alone. The DT process encourages people to design solutions collaboratively and puts a strong emphasis on diversity being a crucial aspect of the process. Interview findings show that complexity and trade-offs, or inadequate information pertaining to sustainability, present barriers for DT to be part of the progress towards a sustainable future. Yet, to the authors’ understanding, the strength of DT to emphasise the importance of involving people from diverse fields of expertise and to cross-pollinate knowledge and inspiration, could actually offer part of the solution to these barriers. This core trait of diverse collaboration suits movement towards SSD by encouraging problem-solving across disciplines, and acknowledges that getting lost in silos stifles strategic thinking. Since the sustainability challenge entails many complex problems, it requires the synthesis of disciplines rather than specialisation in only one field. As such, the interdisciplinary DT approach could act as a platform to create the necessary bird’s eye view of many interlocking fields and therefore move towards effective and impactful solutions.

Actions that are crucial for the DT process (like prototyping and asking for feedback) require reflection and development of ideas and solutions at several points in the process instead of choosing one solution early on. Emphasising this flexibility throughout the process assures that the solution is actually proceeding in the right direction of addressing the goals of the
challenge and potentially enables the design thinker to better choose the right measures towards a sustainable future (if sustainability is included in the challenge’s goals, which the authors recommend should be included in every design challenge). DT’s comfort for trial and error enables faster learning and potentially mitigates possible unintended consequences that can develop from untested ideas.

While DT has a lot of existing potential to contribute to moving society towards a sustainable future, research findings also revealed numerous hindrances that should be addressed to ensure that a DT process includes a SSD perspective. Firstly the expert interviews, as well as the FSSD analysis, showed that the DT process through observations, building empathy, and iterations of feedback takes a partial systems perspective that refers to some stakeholders other than the target audience, but is very limited in scope and long-term thinking. Especially the environment and humans’ dependency on the environment for meeting their needs are not clearly regarded while looking at the bigger system around the design challenge. This understanding of the socio-ecological system is a fundamental requirement of a SSD perspective. Including a full systems view can potentially ameliorate adequately addressing the barriers mentioned, such as system complexity and trade-offs. This helps to increase understanding of the points of interaction and possible causes and effects which can then be considered during the design process. However, it is acknowledged that taking a systems view, while increasing awareness, does not necessarily guarantee a reduction in difficulties dealing with complexity.

In general, sustainability considerations are not an inherent part of the DT process. Currently, interview respondents claimed the integration of sustainability mainly depends on the design thinker’s wish to incorporate it. Although individual designers might include sustainability considerations into the process on their own accord, the authors believe this leaves much more to chance and is much less strategic. Thus, if sustainability is embedded more intentionally and methodically into the DT process, design thinkers might be guided to address it at least in part, regardless of their mindset. Additionally, even if design thinkers decide to incorporate a sustainability perspective into the process, DT lacks a shared definition of sustainability. This plays a part in the difficulties to ensure sustainable outcomes of the process. Presently it is commonplace that the field of DT relies on the use of intuition or ‘rules of thumb’ to consider impacts on the social and environmental system, but this approach cannot be considered systematic or strategic.

One key aspect of DT is the positioning of the human at the centre of the design challenge, which aims to gain a deeper understanding of the human need with regards to a problem by observing and looking at issues from the human’s point of view. The interviewees highlighted DT’s ability to help reach solutions that had not been thought of before to meet those needs. This trait of the DT process contributes to people not being subject to conditions that systematically undermine their capacity to meet their needs. As the created solutions address a need, the authors presume it is more likely that these will be adopted and last, decreasing environmental impacts that undesired solutions could evoke. However, although the human need is poised at the centre of the DT process, no systematic differentiation between human needs and desires is emphasised. The terminology of the toolkits mainly refers to ‘desires’ and ‘desirability’ which can lead the solution to evolve as a satisfier of a desire but neglect the underlying need, ultimately contributing to the production of unnecessary products or services that feed societies’ current course of unsustainability.

Some key SSD concepts occur to a certain extent within the DT process. For example, elements of backcasting and visioning could be identified although the terms are not
explicitly referenced. The success of a design challenge means finding a solution that addresses a human need while being technically feasible and financially viable. The process does not focus on current solutions but stimulates to expand the thinking towards new innovative solutions. Finding this unknown outcome (at the centre of the Three Lenses of HCD), and asking “how might we...?” could be considered as a vision of success, however this model is only referenced twice in the HCD toolkit and not at all in the DT4E toolkit (‘how might we’ questions are emphasised in both). Design constraints set by the design team can also be considered principles to achieve success, and these can even be related to social and environmental impacts as some of the interview respondents attested to. However, there are no principles included within the process itself to guide the project towards sustainability (i.e. ensuring wider socio-ecological ‘success’ over the long-term). Lastly, though a type of vision can be inferred from different goals, constraints or imagined ‘what if...?’ statements, no overarching vision acts to guide the whole process or potentially the various stakeholders involved to interact with the design challenge. A typical SSD vision, consisting of shared purpose and values, is not created through the DT process and would have to already exist and be called upon to influence and shape the DT process.

In general, the DT process lacks strategic prioritisation towards a sustainable solution. The FSSD analysis and interviews showed that reliance on the design thinker’s gut feeling is emphasised in the process. Moreover, financial viability is many times the deciding reason. Even if sustainability is considered as a deciding factor, social benefits seemed to be weighted higher than environmental benefits, likely due to the high priority given to human centredness and desirability. More specifically, as the problem to be solved in the DT process is not determined beforehand, the design team needs to decide which aspect of the problem to address in the Interpretation Phase. Currently, this choice is being made by looking at the most exciting/impactful problem that can be targeted as the goal of the initiative. Lacking a strategic manner of prioritising, this decision might bring the practitioner to focus on a problem that is not the most impactful or important to solve. Additionally no further strategic prioritisation is made, besides basic voting, to evaluate which ideas from the Ideation Phase will be prototyped.

Finally, with the exception of the ‘Holistic Impact Assessment’, the toolkits do not include tools explicitly that aim to help design more sustainably. The interviews showed that tools exist that can help the design thinker to address sustainability, but that those have to be adapted and chosen according to every design challenge and are not an inherent part of the process.

Overall, characteristics such as creativity, imagination, optimism and flexibility, as well as the main goal of the process to address human needs, offer potential to create design solutions in line with SSD. At the same time, the process lacks a whole systems view, a definition of sustainability, and in general an emphasis of sustainability considerations throughout. Additionally, strategic methods to prioritise decision-making are not included. An integrated process can build on existing strengths, and contribute to overcome the hindrances currently preventing the DT process to move society more strategically towards a sustainable future.
4.2 Third Research Question

SRQ3 What could an integrated process of Design Thinking and Strategic Sustainable Development look like?

Through an iterative process and rounds of feedback, the authors arrived at a third prototype. This suggested ‘Sustainable Design Thinking’ (SDT) process does not claim to be complete, but is rather an encouraging beginning to give some facet of structure and guidance in completing a DT challenge as sustainably and strategically as possible. As the only opportunity to test dimensions of this prototype occurred in a compressed workshop environment, all suggestions to the process will require real-world application and refinement before concretely establishing how effectively it aids in creating sustainable solutions. However the Action Research conducted for the purpose of this paper supports the finding that, when merging DT and SSD, sustainable solutions can be achieved creatively and collaboratively, encouraging people towards optimism and agency. The experts, while sharing suggestions for clarifications and improvement, generally affirming that this process could help reach sustainable solutions. The overall findings brought the authors to believe that this prototype could be a promising start towards development of an integrated process, and hold possible implications for SDT to influence the wider design field.

4.2.1 Who is this process for?

The SDT process is designed to reach as many people as possible that are interested in DT, be they professional designers or novices. The process is intended for use by someone who would choose to facilitate it. The authors see this as an important role to target as the interviews evidenced the facilitator as key to lead and empower action towards sustainability. Still, the current prototype is not a facilitators guide and does not include overt explanations nor instructions for working in varied contexts (e.g. suburban India vs. rural Sweden) or towards different types of solutions (e.g. building a car-sharing platform vs. an assembly line product vs. a community festival). More tools and processes could be helpful or even required to respond to such differences, however anticipating alternatives in application was outside the remit of the research. The add-in ‘SLCA’ is informed by the Method for Sustainable Product Development (MSPD) and delivers support especially for product-development contexts – the MSPD itself and Templates for Sustainable Product Development (TSPD) can give further guidance to incorporate sustainability in such contexts (Byggeth et al. 2006, Ny et al. 2008).

An attempt was made to craft most of the add-ins of the prototype as simply as possible in order to demonstrate that sustainability can be considered through simple principles and guidelines. Following a human-centred approach for the prototype itself, simplicity of language was given importance in order to be understandable across a wide audience and accessible to the ‘designer within each of us’. While the integrated process itself cannot fully address the lack of adequate information needed to make informed decisions about sustainability considerations (as was identified through the interviews as one of the barriers to address sustainability), it nonetheless aims to help overcome barriers referring to complexity by providing a simple and clear structure.

While all add-ins could be considered like an idea-box to pick and choose from, as is the case with the toolkits themselves, the authors presume that by completing all the steps laid out in
the SDT prototype, in addition to the regular flow of DT activities, it will most likely ensure the outcome is more sustainable. Some steps of the SDT process might be more crucial to come to such an outcome, especially the ones added in the early phases of the process as they prime the thinking of the design team. Even then, further evidence is needed to corroborate these assertions.

In order to speak to the flexibility and non-prescriptive nature of DT, the SDT prototype was intended as an overarching process guide that could be scaled up or down depending on the timeframe and resources available for the design challenge (although it would need more rigorous testing on the expansion). In general the prototype is not a stand-alone process and should be followed alongside the existing DT process to reach its full potential. The process follows the phases as expressed in the DT4E toolkit, nevertheless the authors believe that the add-ins could be integrated into any DT process. In fact it was a challenge for the authors to find a balance between speaking to a general idea (e.g. having a systems role within the design team) and not getting stuck on specific examples (e.g. the ‘astronaut’ as a team role) as was the same for specific questions offered. This is mostly due to the fact that it is a process which if put into action, requires a level of detail that can at times appear prescriptive. Additionally, without having the chance to test specific questions within the add-ins, it is difficult to assess which are fundamental to SDT and which can be used as inspiration to be expanded upon. It is of course within the facilitators remit to test new questions and creative ideas for fulfilling different add-in ideas along the process.

**Required Knowledge in Sustainability and Design Thinking:** The authors acknowledge there is an interplay to be considered between the need for the facilitators of the process to come with a desire to strive towards sustainable solutions through using the SDT process and his/her actual sustainability knowledge. Perhaps all those who are persuaded that sustainability is important already have enough knowledge in order to understand the sustainability add-ins without further explanation. Workshop focus group responses indicated similar notions regarding the need for prior education of the design team in sustainability. However, the authors could not examine this aspect through tests of the prototype since there were no workshop participants or experts with little knowledge in sustainability.

Workshop participants indicated that more practice would be needed for the design team to cultivate fluency in utilising the ‘Care Instructions’ or aptly using systems thinking in activities such as the ‘Big Picture’. Should time be ample enough, learning and receiving knowledge about sustainability within the process could be possible for the design team, much like DT is taught via the toolkits at present.

Participants with little knowledge about DT rated the add-ins helpful on average, and the majority of participants saw a potential to use the process in the future, indicating that formal knowledge of DT is not necessarily required to successfully engage with SDT. This point however needs to be regarded along with the great time limitations of the workshop that both the authors and the participants saw as a hindrance to understanding the full potential of the process. Additionally, the small sample of participants might make it difficult to induce generalisations from.

Nevertheless, the authors, who had no prior experience in DT, were able to facilitate the integrated DT process with relative ease. This suggests that it could be possible for anyone, regardless of background, to use or deliver the process, even though the authors find that the more one is practiced, the greater depth of understanding of the process one can achieve.
4.2.2 Assumptions

It is the assumption of the authors that the facilitator of a SDT process comes with the wish to create something sustainable. Sustainability should be of interest for the design team, but especially prioritised by the facilitator. The need to ‘convince’ people of the importance of sustainability could not be addressed in this research and no effort was made to gauge/engage participant motivations for sustainability towards this goal, except for building of common interest in the ‘Pre-phase’. Even though most interviewees suggested to avoid using the term sustainability explicitly, the authors chose to use it, because the audience is assumed to be people who are already convinced. Depending on the design team, the facilitator might decide to change the language to speak less about sustainability. Elements in the process that lead more implicitly towards sustainability (storytelling, asking questions) could be helpful in this case. Of course someone can still decide that he/she is not interested in a sustainable outcome, however following the SDT process should nonetheless facilitate consideration and prioritisation of such sustainability factors. Ultimately however, as interviews findings impressed, sustainable solutions are dependent on a person’s values and intention.

4.2.3 Opt-outs of the SDT process

As outlined below, the steps of the SDT process aim to address gaps and barriers identified in the research that limit the DT process in its ability to strategically move towards a sustainable future. While the SDT process speaks to the bridging of most of those gaps, some of them could not (fully) be addressed within the scope of this research. The reasoning will be outlined in the following section.

The SDT process does not include a step that explicitly speaks to the recognition or explanation of the sustainability challenge that society is facing, as it was considered to be less coherent with the optimistic mindset of DT. It was also determined that the ‘Pre-Phase’, by including an understanding that the human is nested within the society and biosphere, introducing sustainability as another lens of the ‘Three Lenses of HCD’, and providing ‘Care Instructions’, integrates aspects of the sustainability challenge sufficiently.

Interviewees as well as the experts mentioned that differentiation between needs and desires could be emphasised more in the DT process. The SDT process briefly touches upon that notion, nevertheless the authors acknowledge that this aspect of the process could be explored, and its possible integration into the SDT process developed in more detail.

Neither the DT nor the SDT process includes an explicit phase defining a shared vision. However, two experts emphasised that there is potential to create a vision as an encouraging basis for the design team to work towards. Due to the complexity of a process to create a shared vision and because of its dependency on the context the DT process is conducted within (e.g. a vision might already exist in a multi stakeholder-setting, an organisation or community), the authors suggest that the integration of this aspect needs exploration in future research.

With visioning not being a further elaborated step in the SDT process, the authors also found it less relevant to address backcasting in more detail, even though the authors found through the FSSD analysis that the process does entail congruent notions. Also, the integrated process already includes several new notions and concepts that the design team needs to familiarise itself with, therefore adding an explanation of backcasting was consciously not addressed at
this time. Both visioning and backcasting are thus suggested to be examined in further research and subsequent prototypes.

4.2.4 The Integrated Sustainable Design Thinking Process

In the following section the integrated SDT process will be presented. Firstly, figure 4.1 illustrates where the add-ins are situated in the existing DT4E process, secondly, every add-in is described and discussed in further detail. An overview of the add-ins of this final prototype can be found in Appendix J.

**Common Ground (Pre-Phase):** Findings from the research show that a Pre-Phase is necessary to develop a shared understanding amongst the participants of the design team prior to starting the challenge. The add-ins, ‘Nested HCD Model’ and the ‘Propelling HCD model’ are conceptual models that should be presented to the design team at the start of the design process (further explanation will follow below). The models aim to add understanding of the

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**Figure 4.1. The Integrated Sustainable Design Thinking Process. (Inspired by IDEO 2012)**

Common Ground (Pre-Phase): Findings from the research show that a Pre-Phase is necessary to develop a shared understanding amongst the participants of the design team prior to starting the challenge. The add-ins, ‘Nested HCD Model’ and the ‘Propelling HCD model’ are conceptual models that should be presented to the design team at the start of the design process (further explanation will follow below). The models aim to add understanding of the
bigger system and its boundaries in which a design challenge exists. By introducing Sustainability Principles (SPs) in the Pre-Phase, it is also assured to create a common understanding and definition of sustainability. They serve as creative constraints to shape the design process. Additionally, feedback indicates this phase is significant for building ‘common interests’ around sustainability by meeting people where they are at, through their own perspective, and providing the platform for expressing their personal views on the importance of sustainability. This has the potential to create participant buy in, and engage them more fully with the integrated process. Examples of questions might include ‘why am I here?’, ‘why do they need me?’, ‘why do I need them?’, ‘what’s the cost of not doing this process?’, and ‘what kind of future could we create together?’ to build team rapport and commitment for engaging with the SDT process.

*Nested HCD Model:* As shown in figure 4.1, the ‘Nested HCD Model’ acknowledges that the human, who is centre to a design challenge, is situated within a bigger system that should always be taken into account. It shows that the human is part of the global society, which is part of the biosphere and operating within the boundaries of the planet. Dependencies between these circles are indicated by dashed lines representing a permeable distinction between the spheres of self, society and the environment. The importance of considering local community and societal concerns with global needs is also emphasised in order to help take into account these connections. As was noted by one of the experts, this might not be obvious for an untrained ‘systems thinker’. Findings show this model to be essential for maintaining the strengths of DT’s primary concern for human well-being, while also heeding interview recommendations to take a systems perspective.

![Figure 4.1. The Nested HCD Model.](image)

*Sustainability Principles as constraints:* Creative constraints through SPs are introduced as a frame for the design brief so as to avoid systematically undermining either the ecological or social system. They function as a definition of sustainability and a requirement for success. It is suggested that the facilitator of a SDT process would present the SPs in easier terms, such as ‘Care Instructions’ (to make sure all members of the design team, no matter what their knowledge is, understand the constraints). The instructions could be articulated as follows (The Natural Step 2010):

In a sustainable society, we need to
1) reduce our dependence on fossil fuels and heavy metals
2) reduce our dependence on synthetic chemicals that persist in nature
3) reduce our destruction of nature
4) and we are not stopping people globally from meeting their needs.
Interviewees pointed out that the strength of design is to deal with constraints, making this add-in appear a logical fit in the eyes of the authors, to promote sustainability within DT. However some experts conveyed dissonance with the ‘negative’ framing of the SPs, pointing back to the ‘pessimistic baggage of sustainability’ and a lack of optimism which conflicts with the DT approach. The authors argue the SPs merely offer minimal requirements that allow rather than constrict creativity and freedom. The SPs are therefore not prescriptive and should work well with the flexibility DT advocates. Research findings also show that despite rephrasing into ‘Care Instructions’ the SPs might still be too abstract, or even too product/ecology based with a lack of social emphasis. The authors wish to emphasise that these principles are chosen for this process as they are scientifically based, ‘necessary, enough, general, concrete and non-overlapping’ to reach a sustainable society. At the same time research is currently being conducted on the FSSD to advance the understanding of social SPs (Missimer 2013), and to change the imbalance in weight between the ecological and social SPs that some experts addressed. These concerns cannot be addressed in the DT process without further trial and research.

Propelling HCD model: The ‘Three Lenses of HCD’ were combined with a ‘propeller-shaped’ illustration aiming to represent the SPs as part of reaching a successful outcome. The intersection between the lenses and propeller ideally address a need that is relevant financially and technically, and is sustainable. The propeller illustrates the ongoing progress of possible solutions towards a sustainable future, maintaining the active optimism the DT approach possesses. The way the diagram is presented allows all possible intersections to occur (e.g. a solution could be feasible and viable but not sustainable and so on). In the intermediate results the diagram was described differently, putting Big Picture and Long Term perspectives as a fourth circle (called the ‘Clover Model’). Yet it was changed in order to avoid creating an impression that sustainability is an adjunct consideration to the design challenge, as was noted by one expert. The authors agree that this lens is integral for looking at a design challenge and needs to be considered within the existing lenses of desirability, feasibility and viability.

Figure 4.2. The Propelling HCD Model.
Discovery Phase

**Big Picture**: The different research methods showed that, in order to have a broader and more thorough systems perspective, mapping the bigger picture around the design challenge is an essential add-in to the SDT process. The map of the bigger picture should include both people and groups that are directly involved and or influenced by the topic as well as those that are peripherally relevant. Additionally, non-human parts (places, things) need to be included. As a note, the ‘Nested Model’ could be a helpful reference at this point to make sure all relevant systems are being considered. The expert feedback showed that highlighting the connections between people and non-human parts with the topic, as well as occurring social and environmental impacts, is important. One expert proposed that it could be useful to have team members first draw the big picture individually before discussing it together in the design team, as each person would come up with a different description of the system. The authors found this idea useful as the diverse mappings could synergistically create a more complete systems view. At the same time, another expert noted that one needs to be cautious on the scope of the big picture, as reaching too far might make it lose clarity.

Interpretation Phase

**Finding Leverage Points**: In the Interpretation Phase within the existing DT process, the design team is encouraged to intuitively choose which insight to focus on. For example, in the Action Research of this study, when the workshop participants decided on a problem from ‘gut-feeling’, one team chose to focus on the question “how might we create better waste receptacles?”, however in hindsight, one focus group participant reflected back his uncertainty if they had made the most ‘sustainable’ choice. He considered an alternate question, “how might we help people consume less?” to have potentially been the more impactful opportunity. This realisation helped the authors identify this convergence point in the process as a key opportunity to decide strategically rather than intuitively. Thus, within the SDT process the authors include a strategic guideline to focus priority on the part of the problem that will deliver the most benefits if solved. These benefits are determined by the human need in the centre of the challenge, the challenge’s constraints and the four SPs. The following questions are possible questions to be presented the design team:

- Look at the big picture - which insights point to possible leverage points (meaning, where will a small change potentially create a larger change in the system’s behaviour)?
- What insights are most actionable within the challenge’s constraints? (e.g. the design team might identify an insight that if solved would create the largest impact on the problem, however it requires resources that are beyond their grasp, then the team might choose another insight which they have more influence on. That being said, it should be cautioned not to rule out insights that could be creatively solved, thus able to abide by the constraints.)

The expert feedback generally supported the idea of identifying leverage points, however there is still room to question whether this is the most strategic guideline to converge with and if the questions suggested above are the most effective method to do so (or if a more sophisticated analysis needs to be integrated). The authors did not recognise how the FSSD can inform a prioritisation process of this sort as the FSSD addresses guidelines for choosing actions and not guidelines for choosing a goal. In the FSSD the goal/purpose is usually determined beforehand, serving as the foundation for the planning process. The authors
determine that the question of how to converge strategically when choosing a purpose is an important strategic part of the SDT that could be further investigated in future research.

**Ideation Phase**

*Out-of-the-box sustainability brainstorm questions:* Supported by the research findings, the use of various out-of-the-box questions and prompts prior to the brainstorm in the Ideation Phase helps to trigger creative thinking and to approach the challenge from different angles. The questions provide an opportunity to inspire thinking imaginatively with regards to sustainability. A few preliminary examples for such questions are included here but more could be generated as well as tailored according to the specific challenge: ‘How is this problem solved in nature? How could you design your solution so that it is never thrown away? How could you design this solution so it will not be around in landfill in one hundred years’ time? How could you design this so it will be in use in one hundred years’ time? What if the solution is not a product?’ One expert suggested that this could be a good step to include examples and stories that could inspire the design team, and act as a starting point to further build on. However, as another expert noted it could also narrow creative thinking by giving too concrete of examples (which the questions do not) and possibly deflate the design team’s morale (a caution posed to the add-in ‘Sustainability Stories/Case Studies’ in this process).

*Brainstorm improvement of unsustainable ideas:* The interviews demonstrated that good ideas can evolve from unsustainable ones. Therefore, in the SDT process, after brainstorming without any constraints, the ‘Care Instructions’ are reintroduced in order to see whether good/exciting ideas that exhibit unsustainable characteristics emerged. Because these ideas might contain valuable inspiration for a relevant solution, the additional brainstorm was added to re-examine if those ideas could become more sustainable. Experts supported the relevance of this activity affirming that it is a positive, appreciative approach for making the most of the ideas, which the authors find falls in line with the optimistic approach of DT. One expert suggested to create an informed prioritisation process to assess the level of ‘unsustainability’ per idea before choosing which ones to improve, however the authors decided to leave the add-in more free in nature as this activity should still fall into divergence and speak to what the design team is most excited by, rather than strategically assess ideas.

*Prioritisation Matrix:* To ensure strategic decision-making when converging from the brainstormed ideas to one or a few solutions, a prioritisation matrix is integrated into the SDT process. Findings from the FSSD analysis, comments from the focus group, as well as expert feedback revealed the need for this structured and systematic approach of prioritising. Therefore, the matrix rates the ideas on a numerical scale based on the following questions: ‘Does the solution meet a real need for the audience? Does this idea follow the ‘Care Instructions’ on the short and long term? Is something going to cause an unintended consequence or rebound effect elsewhere? Is this idea technically feasible? Is this idea financially viable? Does it give a positive return on investment (economic, social, political, etc.)? Does this idea build for possible future opportunities?’ Expert feedback highlighted that the level of depth with which the ideas can be prioritised strongly depends on the resources and length of time available to the design challenge. When facilitating, one should also be aware of the potential danger for group bias in this add-in. As emphasised in the expert feedback, a weakness of the current add-in is the lack of further exploration of the difference between addressing human needs or desires. Exceeding the scope of this study, this aspect will be left to further research.
Enhanced Concept Description: Within the concept description, capturing sustainability related thoughts and ideas on the chosen idea is considered to be crucial. In this step, the design team records what considerations informed their decisions in the prioritisation matrix. The team also imagines what the whole lifecycle of the chosen solution (including raw materials, production, use, and disposal) would look like in reality and identifies how the idea will impact other stakeholders within the big picture (including the environment), what part of the problem it tries to solve, and which part it leaves unresolved. This add-in was originally divided into three separate add-ins (‘Sketch to Think the Whole Lifecycle’, ‘Enhanced Reality Check’ and ‘Enhanced Concept Description’), each building on an existing activity in the original DT4E toolkit process. The participants’ feedback forms from the workshop showed that these add-ins received the lowest scores (albeit still in the high end of ‘helpful’ of the scale given in the forms). From the focus group the authors extrapolated that these activities, due to time constraints, did not get enough explanation in the workshop. Therefore, for the second prototype the activities were still considered relevant and useful. Finally, the expert feedback re-emphasised the repetition of activities. Hence the SDT process merges the three add-ins into one. The expert feedback also highlighted that it is especially important to refer at this point to how the design might cause unintended consequence or rebound effect elsewhere. Some experts elaborated that one should ask how the idea might be received (speaking to values, opinions or beliefs of the audience/other stakeholders that could be affected by the solution). However, one should be careful to not go too much into detail on this aspect.

Experimentation Phase

Version ‘S’: This add-in encourages the design team to first prototype the proposed concept as sustainably as possible (without thinking about financial or technical limitations). Subsequently the team builds new versions that realistically incorporate aspects of the ‘S’ prototype in relation to the project’s constraints and to further develop the idea. One expert commented that only focusing on sustainability at this point contradicts the notion of taking also ‘desirability’, ‘feasibility’ and ‘viability’ lenses into mind. The authors still found this add-in relevant, as one other expert argued, this could serve as an ideal case to work towards, emphasising the optimism of DT and encouraging the design team to ‘dream big’. On another note the authors caution, as one expert recommended, that the instructions or guidelines should also guide the design team to avoid imagination of unrealistic ideas.

Creative Experimentation with Prototypes: In the SDT process, various types of prototyping methods (e.g. role play, storyboard, mock-up and so on) are suggested to be creatively elaborated on to ensure sustainability is taken into account. For example in a ‘role play’, a non-human stakeholder (such as a river) could be in conversation with those using the prototype to try and draw out questions of concern (e.g. regarding a prototype for a new cosmetic product, the river could ask, ‘How could the chemicals in your product affect the pH of my water?’) Even though experts expressed the precaution that it might be difficult to do, this add-in was considered valuable. Based on the expert feedback, it is advised to go beyond the risks and weak points by speaking to the positive impacts of the prototype.

Strategic Choice and Evaluation of Feedback: As the usual process advises to get feedback on the prototypes from potential users, in the SDT process the design team is also advised to include as many stakeholders as possible when choosing feedback participants. This add-in was created to maintain the systems perspective towards the end of the process. If possible, it is particularly suggested to seek an expert in sustainability or systems thinking to give feedback. Also, additional questions to evaluate possible environmental and social
implications of the prototype in its context are suggested to create a more robust question guide for feedback participants.

When evaluating how the feedback influences improvements made to the prototype, the SDT process also cautions to take the sustainability perspective into mind. The expert feedback indicated that this step could help the design team to be more critical about the feedback and avoid making changes to the prototype that have unintended negative impacts on the bigger system. A possible question could be, ‘could any feedback or suggestions made by participants have an adverse effect on the big picture and/or over the long term?’

It should be noted that originally this add-in was comprised of three add-ins (‘Systems Focused Feedback’, ‘Enhanced Question Guide’, ‘Prioritising Feedback Questions’), following the DT4E toolkit, and due to the expert feedback was redesigned into one. From the responses given to the original add-ins it could have been concluded that they were not written in a clear way to give feedback on whether they are useful or not. The authors re-articulated the instructions for this combined add-in yet it should be further tested with more scrutiny.

SLCA Prototype Evaluation: To end the prototyping phase, a Strategic Life Cycle Analysis (SLCA) is added to check the prototype’s environmental and social impact, be it a product or a service. According to most expert and focus group comments, the SLCA serves as a good assessment tool to strategically analyse the concept’s major impacts through the whole lifecycle in relation to the SPs/‘Care Instructions’ without going into detail, but to analyse the impacts from a high level overview. Different colours indicate the alignments or misalignments with the SPs to provide a clear overview for the design team. However, as one of the experts highlighted, it might be problematic to make use of an SLCA in this phase as the solution cannot yet be looked at in reality.

Evolution Phase

Define Measurements: To measure the impact of the solution, as the original process suggests, a set of criteria for measurement are to be defined to help evaluate the concept’s ongoing development. These criteria can be informed by findings from the earlier conducted SLCA (especially to address the misalignments as identified in the Experimentation Phase) but should be specific to and dependent on the idea. Expert feedback affirmed that this step is needed, yet suggested that the measurements could also be defined earlier in the process and refined later. The authors kept the add-in at this part of the process in order to follow the process as suggested by the DT4E toolkit, but leave it to the judgement of the facilitator to decide if this add-in should be integrated earlier.

Document Sustainability Progress: The existing DT process advises to track the signs of change and noticed effects created by the design, and to share stories and celebrate accomplishments (with each other, the public, relevant stakeholders etc.). The SDT process advises to do the same with regards to sustainability. The purpose of this add-in is to encourage the design team to remind themselves of how the solution positively impacted the big picture (e.g. how it created more sustainable behaviours or avoided harmful effects). It could also help to encourage further improvements of the solution to make it even more sustainable by maintaining awareness on the long term. Mostly positive feedback from experts indicated that it is useful to incorporate this add-in.
Add-ins throughout all phases

Sustainability Stories/Case Studies: In general, the Action Research as well as expert feedback revealed that inspiration from existing cases can help to consider sustainability throughout the design process. Therefore, sustainability stories and case studies (e.g. telling real-world creative methods to substitute materials in a product) are included within the SDT process from the Pre-Phase throughout the whole process. Opposing feedback was received on how much the story needs to relate to the particular challenge and how specific examples limit or broaden the Ideation Phase. The stories should thus not suggest a specific way to create solutions for the challenge at hand, rather prime the design team’s minds to consider what is possible beyond existing assumptions.

Sustainability Team Roles: Often within a DT process, a design team includes assigned roles. In the SDT process, based on positive feedback from different research methods, two sustainability team roles are added. To ensure systems thinking, a role like an ‘astronaut’ is added with the purpose to remind the team to zoom out, see the big picture and look at the challenge from other points of view. A role called the ‘Sustainability Champion’ also ensures that one person is responsible to take unresolved questions about the solution’s sustainability impact further, and to cross check the sustainability improvements with the established criteria of success. Feedback showed that the roles might be less effective because their success depends highly on the individual and their character, and could also diminish other design team members’ commitment to hold a systems thinking approach themselves. In spite of this feedback, the authors consider the add-in to be useful, as it builds on an existing activity, and could serve as an opportunity to leverage a systems thinking perspective yet again in the process.

4.3 Validity

Literature review/interviews: Due to the study’s time constraints, as well as the desire to focus research energies on prototyping an integrated process, the reviews of the literature were not exhaustive. Additionally, academic literature on DT, especially it in combination with sustainability, was limited and therefore some reputable web content was utilised.

For the interviews, the authors made use of the most interested interview candidates, possibly indicating sample bias could have been a factor. Similarly, due to the relative newness of a possible integration between DT and sustainability, some of the interviewees’ suggestions were theoretical and not yet proven to be effective. The authors attempted to ameliorate such validity threats by seeking candidates who work or are from a diverse array of eleven different countries. The interviewees also come from diverse backgrounds in design and so yielded many different perspectives and suggestions. Whilst interview questions were devised in a more open, enquiring manner to avoid leading participants to certain conclusions, the very nature of the topic of sustainability and the values associated might lead interviewees to alter their responses to appear more socially favourable. Also due to time constraints, the authors had to limit the research to interviews with professional designers even though it might have bolstered validity to consult lay people who attempt to use DT, as they are included in the research’s audience.

With Action Research comes a strong potential for bias not only for the researchers but also the participants as they chose to attend the workshop voluntarily, indicating a certain level of interest in the discussion topics. Also, having set the improvement of waste management as
the design problem of the workshop, this might have influenced the perceived effectiveness of the process, as the topic can be seen as closely related to sustainability matters. Nevertheless, as the topic was relevant to many people, it attracted workshop participants from different backgrounds. Thus, the diversity of the group and the shared interest for the topic was assured. As all workshop participants possessed a certain degree of knowledge on sustainability matters, examining the usefulness and effectiveness of the process with participants without sustainability knowledge was not possible. Workshop participants also represented a wide array of geographical areas and professional backgrounds. These contextual factors might have influenced either how respondents interpreted questions or gave constructive feedback.

In general, the Action Research performed in this study was short and intensive and perhaps distorted some of the possibilities of the integrated process to perform as it would with a longer time span. Nevertheless, the use of three different sub-methods for the Action Research assured cross-validation of the findings.

The high level of optimism and enthusiasm that the authors brought into the workshop might have caused the participants to evaluate the integrated process and the sustainability add-ins in the feedback form more successfully than they actually were. Also, the participants of the focus group did not know each other very well and the degree of honesty with which they could speak to one another about the process, along with a natural tendency towards social desirability, might have skewed their ability to comment constructively. Limitations to evaluate the success of the process through the concept descriptions occurred due to lack of time as well as insufficient questions on the form to illicit sustainability considerations.

Based on the learnings about the first prototype from the Action Research, the second prototype was evolved. At this point, the new add-ins were only theoretically tested, albeit with the help of experts who were chosen due to their substantial background in design and sustainability. Concurrently six experts were also interview participants, a fact that might have influenced their feedback as they knew the authors’ research and that some of their contributions from the interviews could be incorporated into the SDT process.

Lastly, the final prototype presented by the authors could not be validated by external assessment. Minor changes were made, however they were based on recommendations made by the experts. Testing the third prototype should be conducted in the future to validate the effectiveness of the changes made.

4.4 Further Steps and Potential Future Research

As outlined above, sufficient material has been gathered and developed through this research to evolve the prototype into something more tangible. Creating a guidebook as a supplement to the existing toolkits seems to be a likely next step. An open-source guidebook as supplement to the existing DT toolkits could provide direct facilitation guidance and specify the instructions on several add-ins. In general, further experimentation and efforts to evolve the SDT process in different settings (ideally by groups of individuals, in communities, or organisations) is encouraged to test and improve its effectiveness and applicability in different contexts. As described in detail throughout this paper, questions and ideas arose over the course of the research that were considered outside the scope of the research. The following aspects are therefore proposed for future research:
• The differentiation of needs and desires could be highlighted much more in a SDT process to assure that the created solutions are actually fulfilling a human need instead of only a desire or 'satisfier'.

• Defining a shared vision to work towards would be a significant modification to the original process, and therefore needs further work to be integrated. Also, the vision could in many cases be combined with an overarching vision that already exists in communities or organisations. Enhancing the vision might also correspond with the need to build more explicitly a backcasting approach into the SDT process.

• It could be further researched and tested how and by which means the design team can strategically converge to the specific aspect of the problem that will be addressed in the SDT process.

• As mentioned earlier, research is currently conducted on the enhancement of the Sustainability Principles with regards to social considerations (Missmer 2013). The outcomes of that research should be integrated throughout the SDT process to ensure that social sustainability is addressed sufficiently.

• While exploring existing research on DT, the authors were familiarised with an endeavour to enhance the existing HCD toolkit with entrepreneurship perspectives, using the Business Model Canvas and Service Design as compliments (Am I a Designer 2013). As the authors value both paths of integrating sustainability and entrepreneurship with DT, future research could explore the combination of those in tandem.

• This paper investigated how DT can be enhanced with concepts from SSD. The authors estimate that SSD could also potentially learn from DT’s optimistic and collaborative mindset and its means to solve problems creatively.
5 Conclusion

_How Can Design Thinking better help society to move towards a sustainable future?_

In light of the mounting sustainability related challenges humanity faces globally, the need to develop an unprecedented range of solutions is imperative. Nathan Shedroff’s book (2009) titled _Design is the Problem: The Future of Design Must be Sustainable_ makes the point clear: while the field of design is and has been a great contributor to creating many problems, it also needs to be a part of creating the solutions - sustainable solutions.

In essence, this research builds on the assumption that design and sustainability need each other. From within the wider field of design, Design Thinking (DT) offers to extend the power and positive potential of design to the hands of the ‘designer within each of us’. DT offers a process and attitude that harnesses creative problem solving by focusing on the discovery of root causes and needs, collaborating across disciplines, cultivating optimism, and experimenting with solutions in order to learn and adapt more quickly. The authors found these traits necessary to appropriately approach sustainability challenges, involving as many people as possible.

While DT’s sense of openness and reliance on intuition provides a great strength to create empathetic, relevant and flexible solutions, it can also be a weakness in regards to ensuring sustainability by neglecting to look at the bigger socio-ecological picture and plan with it in mind. Guidance can make the process more strategic and sustainable. This research analysed the DT process by using the Framework for Strategic Sustainable Development (FSSD) to assess and incorporate these aspects. Rather than completely transform or create, yet again, another new process or tool, the authors found it important to build upon an already reputable, and even popular, topic. The result was to produce a prototype of an integrated process in which FSSD considerations were included throughout as add-ins a facilitator can use in concert with the existing process. Main findings included the necessity for some level of systematic prioritisation as well as broadening the DT perspective from being primarily human-centred to include a wider, long-term systems perspective.

Although the integrated process merges two different mindsets, results show that there is not only potential to do so, but a need for it. In particular, their compatibility was made evident through the expressed interest and encouraging feedback from both workshop participants, who experienced the SDT process in action, and experts, who hold a deeper understanding of using DT and the nuances required to implement it. Still, the integrated SDT process requires further exploration in order to develop and test many of the add-ins. Their usability and practicality across types of design challenges and contexts, as well as their effectiveness at ensuring that solutions are constructed within the planet’s social and ecological constraints, considering complexity and systemic impact throughout, must be examined and advanced.

The authors hope that the integrated SDT process is adopted and used by enthusiastic problem-solvers. Preliminary research findings show that such an integrated process is desirable (there needs to be sustainability in DT), feasible (the integrated process was perceived as unified and natural in the workshop and received general positive regard from experts), viable (it costs little besides some extra time and a shift in mindset) and sustainable (in theory could yield more sustainable outcomes, but this requires testing and ongoing evaluation). It could be concluded that SDT therefore lands in the sweet spot of the four lenses with the potential to ‘propel’ DT and society towards a sustainable future.
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## Appendix A: List of Collaborators

<table>
<thead>
<tr>
<th>#</th>
<th>Name of Interviewee/Expert</th>
<th>Country</th>
<th>Background</th>
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<tr>
<td>1</td>
<td>Adrià Garcia i Mateu*</td>
<td>Denmark / Catalonia</td>
<td>Researcher at PROTEUS Innovation Consortium, DTU and Teacher of Sustainable Service Design course at IED Barcelona M.Sc. in Strategic Leadership towards Sustainability (MSLS)</td>
</tr>
<tr>
<td>2</td>
<td>Jeroen Spoelstra*</td>
<td>The Netherlands</td>
<td>Former industrial product designer, current designer of social solutions, human-centred design teacher at the Amsterdam University of Applied Sciences and researcher &amp; consultant within the Am I a Designer project (<a href="http://www.amiadesigner.com">www.amiadesigner.com</a>)</td>
</tr>
<tr>
<td>3</td>
<td>Boukje Vastbinder</td>
<td>The Netherlands</td>
<td>Former industrial product designer, current social entrepreneurship teacher at the Delft University of Technology and researcher &amp; consultant within the Am I a Designer project (<a href="http://www.amiadesigner.com">www.amiadesigner.com</a>) and entrepreneur within Enyini.</td>
</tr>
<tr>
<td>4</td>
<td>Ronny Daniel*</td>
<td>Israel</td>
<td>Co-founder at The Natural Step Israel and Whiteboard (service design), Architect and M.Sc. in Strategic Leadership towards Sustainability (MSLS)</td>
</tr>
<tr>
<td>5</td>
<td>Grant Young*</td>
<td>Australia</td>
<td>Director, Innovation Strategy at Zumio</td>
</tr>
<tr>
<td>6</td>
<td>Mauro Rego*</td>
<td>Germany / Brazil</td>
<td>UX Designer at the Design &amp; Co-Innovation Centre at SAP; M.A. Integrated Design - Köln International School of Design</td>
</tr>
<tr>
<td>7</td>
<td>Kara Davis*</td>
<td>U.S.A.</td>
<td>Loop Strategies; uses her background in user-centred design to tackle sustainability challenges in Washington, DC, USA</td>
</tr>
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*Experts highlighted with a star (*) were both interviewees in the first phase and gave feedback on the prototype in the experimentation phase.*
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<thead>
<tr>
<th>Interviewees</th>
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<th>Position and Affiliation</th>
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<tr>
<td>1 Danny Alexander</td>
<td>U.S.A.</td>
<td>Designer and Social Entrepreneur at IDEO.org</td>
</tr>
<tr>
<td>2 Sean Hewens (group interview with D. Alexander)</td>
<td>U.S.A.</td>
<td>Knowledge Manager and In-House Counsel at IDEO.org</td>
</tr>
<tr>
<td>3 Donald Norman</td>
<td>U.S.A.</td>
<td>Academic in the field of cognitive science, design and usability engineering; co-founder and consultant at the Nielsen Norman Group.</td>
</tr>
<tr>
<td>4 Damien Newman</td>
<td>U.S.A.</td>
<td>CEO at Central (transformation consulting firm); former design strategist at IDEO and director of strategy at frog design</td>
</tr>
<tr>
<td>5 Joana Holmström Céspedes</td>
<td>Sweden</td>
<td>MA Student in Industrial Design, Lund University</td>
</tr>
<tr>
<td>6 Johanna Bengtsson</td>
<td>Sweden</td>
<td>Industrial Designer</td>
</tr>
<tr>
<td>7 Pinar Öncel (group interview with K. Davis)</td>
<td>Turkey</td>
<td>Design and Innovation Initiative for Sustainability</td>
</tr>
<tr>
<td>8 Ann Thorpe</td>
<td>England / USA</td>
<td>Strategist and Head of London office for Luum.com. Author on design and sustainability, PhD at the Design and Innovation Group of the Open University, in the United Kingdom</td>
</tr>
<tr>
<td>9 Anonymous</td>
<td>Denmark</td>
<td>Industrial Designer</td>
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<tr>
<td>10 Sabine Mukaze</td>
<td>Canada / Rwanda</td>
<td>Bachelor in Industrial Design; M.Sc. in Sustainable Product-Service System Innovation</td>
</tr>
<tr>
<td>11 Steve Bishop</td>
<td>U.S.A.</td>
<td>Global Lead of Environmental Impact at IDEO</td>
</tr>
<tr>
<td>12 Andreas Larsson</td>
<td>Sweden</td>
<td>Associate Professor and Head of Subject Innovation Engineering at the Department of Design Sciences at Lund University, Faculty of Engineering (LTH)</td>
</tr>
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</table>
Appendix B: SDT Process Prototypes 1 and 2

The following document shows the intermediate results (prototypes 1 and 2) that the final prototype of a ‘Sustainable Design Thinking’ (SDT) process is built upon. This prototype is based on the process flow of the Design Thinking for Educators (DT4E) toolkit. Changes from the first to the second prototype are indicated with green colour. The headline of an activity highlighted in green means that the whole add-in has been added for the second prototype, parts of an activity highlighted in green means that aspects had been added to an add-in from the first to the second prototype.

(Pre-Phase) ‘Common Ground’
A pre-phase was found to be needed to develop a shared understanding amongst the participants of the design team prior to starting the challenge. The next two add-ins (‘Nested HCD Model’, ‘Clover Model’) are conceptual models that should be presented to the design team right in the beginning of the design process. The models aim to add understanding to the bigger system and its boundaries in which a design challenge exists. By introducing ‘Care Instructions’ in the pre-phase, it was also assured to create a common understanding of sustainability and establish creative constraints that should shape the design process.

Nested HCD Model
As shown in Figure 1, the ‘Nested HCD Model’ acknowledges that the human, who is centre to a design challenge, is situated within a bigger system of which should always be taken into account. It shows that the human is part of the global society which is part of the biosphere and operating within the boundaries of the planet.

Figure 1. The Nested Human-Centred Design Model
**Clover Model**

Adding onto the original model of the ‘Three Lenses of Human Centred Design’ (as outlined in the HCD toolkit, see Figure 2), a fourth circle was added to emphasise that a design challenge should take into consideration sustainability. The ‘Clover Model’ (Figure 3) illustrates the interrelation of the design challenge in the wider system (‘Big Picture’) and the need to view the long term impact (inspired by Danny Alexander from IDEO.org).

![Figure 2. The original ‘Three Lenses of HCD’. (IDEO 2012)](image)

![Figure 3. The ‘Clover Model’](image)
Care Instructions / Sustainability Principles as constraints

Creative constraints in the form of Sustainability Principles (SPs) (as part of the Success Level of the Framework for Strategic Sustainable Development) were added to create a frame for the design brief so as to avoid systematically undermining either the ecological or social system. It is suggested that the facilitator of a SDT process would present the SPs in easier terms, such as ‘Care Instructions’ (to make sure everybody, no matter what their knowledge is, understands the constraints).

The instructions could be articulated as follows (The Natural Step 2010):

In a sustainable society, we need to
1) reduce our dependence on fossil fuels and heavy metals
2) reduce our dependence on synthetic chemicals that persist in nature
3) reduce our destruction of nature
4) and we are not stopping people globally from meeting their needs.

Discovery Phase

Sustainability Storytelling

Stories were added between and within the different Design Thinking (DT) phases to inspire sustainability considerations throughout the design process.

For example, in the beginning of the Interpretation Phase, to show insights from analogous settings in nature, the story of Velcro demonstrating the Bio-mimicry concept could be told. Thinking about new possibilities for ideation could be emphasised by sharing the story of ‘Greensulate’ (which combines old soybeans and rice hulls to innovate a substitute for polystyrene).

These types of stories do not suggest a specific way to create solutions rather prime the design team’s minds to consider beyond existing assumptions of what is possible.

Systems Team Role

There are often team roles assigned within a typical DT process. Within the DT4E toolkit for example, roles such as ‘coordinator’ and ‘enthusiast’ are suggested to keep the team on track (IDEO 2012, 23). To ensure systems thinking in the SDT a role such as an ‘astronaut’ could be added. The purpose of the role is to remind the team to zoom out, see the big picture and look at the challenge from other points of view.
**Big Picture**
An exercise of drawing the “big picture” was added in order to have a broader and more thorough systems perspective. A map of the system with the design challenge in the middle should be illustrated along with the following instructions (to be filled in with the existing knowledge, as best and as exhaustively as possible):

- Collect and write down the people or groups that are directly involved in or reached by your topic (IDEO 2012)
- Add people or groups who are peripherally relevant, or are associated with your direct audience. (IDEO 2012)
- Include non-human parts of the picture (places, things)
- Note the connections these people [and places, and things, etc.] have with your topic, as well as the social and environmental impacts occurring.

The last two bullet points were directly added to existing instructions from the ‘Define your Audience’ section of the DT4E toolkit.

[The following excluded activities were integrated into other points of the process:
Excluded: Questions reconnecting to the big picture (now part of ‘Big Picture’ add-in]
When defining the insights (in the Interpretation Phase), questions were added to refer back to the Big Picture. Adding to the usual questions of the DT process which mainly ask about the most surprising and inspiring insights, questions ‘such as what is the connection to the challenge?’, ‘what appears to be an area that would have large impact on the whole system?’ were added.

**Interpretation Phase**

**Finding Leverage Points**
When defining insights (in the Interpretation Phase), and deciding on which insight the design team should focus on, it was found that this convergence needs to be more strategic to ensure the most impactful part of the problem is approached. Therefore the following questions should be asked:

- Look at the big picture you have created - which insights point to possible leverage points (meaning, where will a small change potentially create a larger change in the system’s behaviour)?

Try to rate the most impactful insights.

- What insights are most actionable within the challenge’s constraints?

**Ideation Phase**

**Out-of-the-box sustainability brainstorm questions**
Before the brainstorm, the following questions were posed in order to trigger various ideas that tackle the challenge from different angles:
Brainstorm improvement of unsustainable ideas
After brainstorming without any constraints whatsoever, the Care Instructions were reintroduced in order to see whether there were good/exciting ideas that exhibit unsustainable characteristics. Because these ideas might contain valuable inspiration for a relevant solution, an additional brainstorm was added to re-examine if those ideas could become more sustainable.

Prioritisation Matrix
To ensure strategic decision-making when converging from the brainstormed ideas to the solution, a prioritisation matrix was integrated into the process. The matrix is aimed to rate the ideas on a scale from 1 to 5 by means of the following questions:

- Does the solution meet a real need for the audience?
- Does this idea follow the Care Instructions in the short and long term? (trade-offs?)
  [Does it use or rely on fossil fuels or heavy metals?  
  Does it use or rely on synthetic chemicals?  
  Does bringing this about destroy nature?  
  Does it hinder other people to meet their needs?]
- Is this idea technically feasible?
- Is this idea financially viable?
- Does it give a positive return on investment (economic, social, political, etc.)?
- Does this idea build for possible future opportunities?

Sketch to think the whole cycle
The existing exercise ‘sketch to think’ (IDEO 2012) was adapted to regard the whole life cycle of the chosen solution, including raw materials, production, use, and disposal. The teams were asked to discuss the solution, brainstorm new solutions or evolve the idea if necessary to reduce adverse impact along the solutions life cycle.
Enhanced reality check
Adding to the existing questions from the toolkit to refine the idea (‘what is the real need the idea is addressing?’, ‘what is the idea really about?’) the following questions were added:

- Imagine the idea in reality, how will it impact other stakeholders within the big picture (including the environment)?
- What values, tastes, opinions or beliefs of your audience/other stakeholders could affect your solution?

Enhanced concept description
Adding onto the regular concept description, the following questions were added to make explicit the team’s awareness of sustainability considerations:

- How does your concept impact the big picture? What part of the problem does it try to solve? What part does it leave unresolved? How does it influence other stakeholders?
- Capture your logic for the decisions made for each prioritisation question (refer to the prioritisation matrix).
- Is something in your design going to cause an unintended consequence or rebound effect elsewhere?

Experimentation Phase

Version ‘S’
Version ‘S’ was added as an exercise to first prototype the proposed concept as sustainably as possible (without thinking about financial or technical limitations). The team subsequently builds new versions that realistically incorporate aspects of the ‘S’ prototype in relation to the project’s constraints.

Creative Experimentation with Prototypes
Various types of prototyping methods could be creatively elaborated on to ensure sustainability is taken into account. For example in a ‘role play’, a non-human stakeholder (such as a river) could be in conversation with those using the prototype to try and draw out questions of concern. (e.g. regarding a prototype for a new cosmetic product, the river could ask, ‘How could the chemicals in your product affect the pH of my water?’ Additionally future generations could also add to the conversation (‘Does your product rely on palm oil because we are concerned that orangutans will go extinct and we won’t be able to see them’)).

Systems Focused Feedback
To ensure a systems perspective, the design team was recommended to include as many stakeholders as possible when choosing feedback participants. Particular recommendation was made to seek an expert in sustainability or systems thinking.
**Enhanced Question Guide**
Additional questions were encouraged to create a more robust question guide for feedback participants. Questions to evaluate possible environmental and social implications of the prototype in its context should be included as well as opportunity to express suggestions, opinions, concerns, etc.

**Prioritising Feedback Questions**
When considering what feedback to respond to, questions could be added to prompt the design team to think about relevance of feedback through a sustainability lens. An example might be:
- Could any feedback or suggestions made by participants have an adverse effect on the big picture and/or over the long term?

**SLCA Prototype Evaluation**
To end the prototyping phase, a Strategic Life Cycle Analysis (SLCA) was added to check the prototype’s environmental and social impact. The SLCA serves as an assessment tool to strategically analyse the concept’s major impacts through the whole lifecycle in relation to the Sustainability Principles/Care Instructions on a high level. Different colours indicate the alignments or mis-alignments with the Sustainability Principles to provide a clear overview for the design team.

**Evolution Phase**

**Define Success**
To measure the impact of the solution, as well as to evaluate the concept’s ongoing development, a set of criteria for success needs to be defined to help. These criteria can be informed by findings from the earlier conducted SLCA (especially to address the misalignments as identified in the Experimentation Phase) but should be more specific to the idea.
Examples of criteria could be the percentage of reduction of electricity consumption or CO2 emissions per year. The ‘Design 4 Sustainability Rules of Thumb’ can provide orientation to create these criteria.

**Document Sustainability Progress**
As expressed in the DT4E toolkit “once an idea has been implemented and became a part of everyday life, it is easy to lose sight of its impact” (IDEO 2012, 68). Therefore the design team needs to be encouraged to remind themselves how the solution positively impacted the big picture (e.g. the user’s behaviour changed or harmful impacts were avoided). Spreading these stories and powerful examples as well as celebrating
achievements (with each other, the public, relevant stakeholders, etc.) could help to encourage further improvements of the solution, and to make it even more sustainable.

*Sustainability Champion*
Another way to ensure ongoing consideration of sustainability impacts was to add a ‘Sustainability Champion’. The purpose of this role is to have a person responsible to take unresolved questions about the solution’s sustainability impact further, and to cross check the sustainability improvements with the established criteria of success.
Appendix C: Workshop Handout

What is Design Thinking?\(^1\)

It’s Human-Centred. Design Thinking begins from deep empathy and understanding of needs and motivations of people involved.

It’s Experimental. Design Thinking gives you permission to fail and to learn from your mistakes, because you come up with new ideas, get feedback on them, then iterate. Given the range of needs people have, your work will never be finished or ‘solved’. It is always in progress.

It’s Collaborative. Several great minds are always stronger when solving a challenge than just one. Design Thinking benefits greatly from the views of multiple perspectives, and others’ creativity bolstering your own.

It’s Optimistic. Design Thinking is the fundamental belief that we all can create change – no matter how big a problem, how little time or how small the budget. No matter what constraints exist around you, designing can be an enjoyable process.

You can use Design Thinking to approach any challenge.

Sustainable Design Thinking

(according to our research and adding on to the regular Design Thinking attributes)

It’s Big Picture. Sustainable Design Thinking acknowledges that every design challenge is nested within a bigger system, including the society and ecosphere. Looking at the big picture helps to reduce negative impacts on the wider system.

It’s Long Term. Every design has implications on the wider system. Sustainable Design Thinking benefits from looking at the big picture on the long term.

Design Thinking is a mindset. Design Thinking is about believing we can make a difference and having an intentional process in order to get to new, relevant solutions that create positive impact. Design Thinking gives you faith in your creative abilities and a process for transforming difficult challenges into opportunities for design.


The design process is what puts Design Thinking into action. It’s a structured approach to generating and evolving ideas. It has five phases that navigate the development from identifying a design challenge to finding and building a solution.

[See process on the next page]

\(^1\) Source: Design Thinking for Educators toolkit (IDEO 2012)
Handout Page 2:

Flow of the DT process

Source: Design Thinking for Educators toolkit (IDEO 2012)
# Appendix D: Expert Feedback Form

*Table 1. Expert Feedback Form on Add-Ins.*

<table>
<thead>
<tr>
<th>The ‘Add-in’ Name</th>
<th>Is this useful to reach a more Sustainable Solution (Yes/No)</th>
<th>Comments or clarifications</th>
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<td>(0) (Pre-Phase) “Common Ground”</td>
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<td>(1) Nested HCD Model</td>
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<td>(2) Clover Model</td>
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<td></td>
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<tr>
<td>(3) Care Instructions</td>
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**Discovery**

| | | |
| (4*) Sustainability Storytelling | *ongoing throughout the process | |
| (5) Systems Team Role | | |
| (6) Big Picture | | |

**Interpretation**

| | | |
| (7) Finding Leverage Points | | |

**Ideation**

| | | |
| (8) Out-of-the-box sustainability brainstorm questions | | |
| (9) Brainstorm Improvement of Unsustainable Ideas | | |
| (10) Prioritisation Matrix | | |
| (11) Sketch to Think the Whole Cycle | | |
| (12) Enhanced Reality Check | | |
| (13) Enhanced Concept Cescription | | |

**Experimentation Phase**

<p>| | | |
| | | |
| (14) Version ‘S’ | | |
| (15) Creative Experimentation with Prototypes | | |</p>
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<td>(16) Systems Focused Feedback</td>
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<td>(17) Enhanced Question Guide</td>
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<td>(18) Prioritizing Feedback Questions</td>
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<td>(19) SLCA Prototype Evaluation</td>
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<td><strong>Evolution Phase</strong></td>
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<td>(20) Define Success</td>
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<td>(21) Document Sustainability Progress</td>
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<tr>
<td>(22) Sustainability Champion</td>
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</table>
Appendix E: Interview Questions

1. What is your understanding of Design Thinking?
Briefly describe any strengths or limitations you experience while using this process.

2. a) As it stands now, what do you see are the main strengths and challenges with addressing sustainability in the Design Thinking process?
b) Do you think it could be improved? How? Do you use specific tools?
c) How do you understand sustainability?

3. Do you find other more successful processes to achieve sustainable design?

4. Are you familiar with the ‘Natural Step’ framework for sustainable development?
Do you find it a useful framework that can inform sustainable design?
Have you ever used it in a design process?

5. The ‘s’ word - How do you communicate about sustainability?
Do you use the term when speaking to your clients?

6. Do you think a sustainable design requires the designer to have the internal will to work this way?
Or do you think it’s possible to incorporate sustainability practices into the DT process, making it an inherent outcome for every designer regardless of their personal views?
Appendix F: Workshop Feedback Form

Team number:
Nationality:
Education (which programme) or occupation:

1. Have you received formal education on matters related to environmental and/or social sustainability? If so, what kind of education?
   Yes  No

2. How knowledgeable do you consider yourself on matters related to sustainability on a scale from 1-10 (10=I can work in the field; 5=I know the major issues and follow media coverage; 1=no knowledge)?
   10  9  8  7  6  5  4  3  2  1

3. Have you received formal education on design thinking or human-centred design? If so, what kind of education?
   Yes  No

4. How knowledgeable do you consider yourself on design thinking or human-centred design on a scale from 1-10 (10=I can work in the field; 5=I know the general design thinking process and have experienced it; 1=no knowledge)?
   10  9  8  7  6  5  4  3  2  1

5. What aspect of the process was most surprising with regards to ensuring sustainability? Why?

6. Would you consider to use this process in the future for other challenges? Why yes or why not?
7. How did the activities during the workshop help you think of environmental and social impacts?

<table>
<thead>
<tr>
<th>The activity...</th>
<th>helped a lot</th>
<th>helped a little</th>
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<td>Nested HCD Model</td>
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<td>The Astronaut Role</td>
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<td>Build the Big Picture</td>
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<td>Stories &amp; Examples</td>
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<td>Questions Referring to the Big Picture</td>
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<td>Out-of-the-box Brainstorm Questions</td>
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<td>Prioritisation Matrix</td>
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</table>

Anything else you would like to share with us?

Thank you SO much for your participation and feedback!
Appendix G: Feedback Form Extra Results

Graph 1. Gender Distribution.

Graph 2. Nationality.

---

23 participants attended the workshop.
Graph 3. Knowledge about sustainability.

Graph 4. Knowledge about Design Thinking.
Graph 5. Ratings of add-ins according to Knowledge about Sustainability.

Graph 6. Ratings of add-ins according to knowledge about Design Thinking.
Graph 7. Ratings of add-ins according to teams.
Appendix H: Focus Group Analysis

Integration of sustainability: The focus group expressed that the process in general helped naturally and logically to consider social and environmental impacts. It was said that DT and sustainability merged well. Participant V emphasised that he considered the outcome of the process a real sustainable product. He emphasised that the sustainability constraints of the challenge could even help possible participants without initial interest in sustainability to create the link between the challenge and sustainability. Nevertheless, it was observed by participant II that the sustainability aspect was not as strong in the interpretation phase as in the other phases.

Pre-Education / Knowledge: Participant II expressed that the workshop design required people that are trained in systems thinking. In his opinion, without that knowledge, it would have been easy to fall back into the obvious. All focus group participants agreed that the workshop participants not necessarily need to have an education or knowledge on sustainability, but four of them pointed out that more time needs to be spent on explaining and understanding sustainability. Two of them (II; IV) also mentioned that the more knowledge people have on sustainability, the better the result/solution will be.

Participant I emphasised that the facilitator should have knowledge about sustainability. But this knowledge could be presented as ‘part of the package’ in a process that a facilitator naturally can learn while preparing the process.

Understanding of terms: Two participants criticised (I; II) the lack of common understanding of terms. Because sustainability is a vague and not clearly defined concept, it would have been needed to make sure that all the workshop participants come to a common understanding of important terms (such as ‘sustainability’).

Time: All participants shared the opinion that the time constraints of the workshop were a significant limitation to reach a fully sustainable solution (because decisions had to be taken very quickly) and to later judge the effectiveness of the process. The proportions of the timing were found to be good.

Add-in SPs / Care Instructions: The participants gave the feedback that the SPs (or ‘Care Instructions’) were explained in an understandable way and ‘came in and out of the conversation’. Nevertheless, more time would have been needed to exercise them to ensure full understanding if people are not familiar with them (especially SP4). Participant II (familiar with the FSSD) also expressed his concern that the simplified phrasing of the SPs might reduce their meaning too much (especially SP2). Participant VI also expressed that the SPs could have been integrated more.

Add-in Clover Model / Nested Model: Participant II (with knowledge of the FSSD) expressed that he liked the nested model because “it makes people aware that every human is part of the society and the environment in an easy-to-understand-way”. Other participants would have liked both models to be more apparent and practiced during the process.

Add-in Big Picture: The big picture was considered to be helpful to consider the wider system (participant III; V; VI).
**Add-in Astronaut Role:** The opinions about the role of the astronaut were diverse. On the one hand, two participants (IV; VI; from one team) found the astronaut to be a very important role during the process to assess the relevance of the solutions. On the other hand, a participant from another team (II) said he would have liked a more detailed description of the roles and a person with knowledge about the SPs as an extra role. In general, participant V found that assigning roles makes other team members draw back from responsibilities and another one (III) suggested to assign roles beforehand to make sure people enjoy and embody their role more.

**Add-in Storytelling:** The stories leading through the process helped the participants to think big. It was furthermore said that leading through the process with stories can be enough to assure that people without previous education in sustainability understand the implications on the bigger system. Participant VI mentioned that it would have been helpful to add more examples of the solutions that one can reach it terms of sustainability.

**Add-in Provocative questions:** The intention behind the ‘provocative questions’ (e.g. how is this done in nature?) that had been integrated at several points during the process were found to be good. Two participants (II; V) pointed out that the questions were asked in a broad way and reshaping them in a way more related and specific to the problem would help to understand and use them better.

**Add-in Prioritisation Matrix:** Participant IV (without FSSD knowledge) said his team did not have any problem with the matrix. He acknowledged that the voting on the ideas would be more difficult in ‘real life’. His team member (participant III) mentioned disagreements amongst the team members on the numbers. Participant V expressed that the terminologies might have different meanings for people (e.g. return on investment) and needed more specific explanation. It would have furthermore been helpful if the prioritisation questions would have been restated for the concept description (participant I).

**Add-in Sketch to think the whole cycle:** Participant IV criticised that the instructions for this exercise were not very clear.

**Add-in Extra Question on concept description:** Most participants mentioned that the extra questions on the concept description were too much for the proposed time frame. Participant V said that he found especially those questions the most interesting.

**Further considerations and suggestions:** Participant I and II suggested to include an SLCA as a mean of prioritisation to let design teams “assess solutions in an easy way to let people think concretely and colourfully” (participant II). If the solution is a service, the system has to be even bigger to be assessed by an SLCA, but according to participant I, it helps to expand the participants thinking of sustainability impacts. The workshop only lasted until the concept presentation, but participant I and II agreed that a tool for assessing ent the concept or prototype needs to be added. Participant II warned that the activity ‘seeking for inspiration’ can be a “sword with a double edge”: in the case of this workshop, by handing out a bag with garbage to the design teams, the facilitators unintentionally stimulated to scope down to one specific aspect of the problem.

Participant V mentioned that he thought his group might not have come up with the most sustainable choice of solution. He proposed the question “why did we not end with the other, more sustainable, solution?” and guessed that the key lies in some intermediate exercise to select ideas in one of the earlier stages of the process.
Appendix I: Concept Description Analysis

The concept descriptions filled in by all four workshop teams were analysed by the following five predetermined questions:

**Did the teams consider the scope or limitation of their problem/solution within the Big Picture?**

- Team 4 acknowledged their solution only deals with “existing trash cans” and as such is a “short term solution!” They stated clearly, ‘We don’t solve the cause of the consumption.’

- Team 2 mentioned “if BTH gets more aware, [it] can impact their suppliers” and emphasising that “people will use less products/materials/packages if they become aware [it will] have an impact [on the] environment”, the team referred to the big picture on the long term.

**Did the teams consider if this concept builds for possible future opportunities?**

- Team 2 acknowledged that “if BTH gets more aware, [it] can impact their suppliers” which speaks to future opportunities of the solution.

- Team 1 mentioned that a next step for the concept could be to expand to other universities.

- Team 3 built for future opportunities by “creat[ing] a common vision” from which they will “find and develop innovative ideas” for “creating a proper waste management system that engages all the different stakeholders”. The vision attempted to lay foundations for cooperation and future action by “involv[ing] them” (stakeholders) in the process.

**Did the teams consider if this idea follows the Care Instructions (4 SP’s) in the short and long-term?**

- Team 1 referred to the 4 SP’s as follows:

  SP1-3: It was mentioned that the concept ”may bring some waste including energy waste etc.“ but also this illustrated that ”it can be improved by minimizing the waste”.
  
  SP3: Team 1 mentioned that the concept gets people to clean up their trash.
  
  SP4: The team emphasised that the concept addresses people’s needs for ”socialisation, participation, awareness, social cohesion, team work, sense of belonging, leadership, and ownership”. 
**Did the teams consider trade-offs?**

- Team 2 explained that their developed concept ”works well within the constraints” and “[doesn’t] need much materials”. They acknowledged that ”you might need materials that contribute to violations of SPs, but will save a lot of material when it works”. They furthermore stated that the concept could be improved ”if we can reuse materials or use recycled materials”.

**Did the teams consider if the concept gives a positive return on investment**

- Team 4 sought there would be more student ”ownership through [the] competition”, and ”good PR” for the school. Also, the team articulated this solution could be used to ‘educate Karlskrona Kommun’

- Team 2 mentioned several benefits of the concept for society: the concept ”rais[es] awareness”, ”engage[s] staff and students to make better recycling signs” and it is also emphasised that while the group creates the signs in the game or workshop, they ”learn about sustainability”. It is also implied that ”students will get more aware and bring it to their families and friends”. Regarding economic return on investment, the team illustrated that the concept can ”increase [the] brand value of BTH”.

- Team 3 considered the social ROI of ”raising awareness” as well as social/political ROI through ”creat[ing] ambassadors” and ”creating a brand of being a “Sustainability Driven Uni[versity]””
## Table 2. Add-Ins Final Prototype.

<table>
<thead>
<tr>
<th>Name of the Phase/Add-in</th>
<th>Type</th>
<th>FSSD level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Pre-Phase) ‘Common Ground’</td>
<td>Concept</td>
<td>Systems/Success</td>
<td>Prior to the Discovery Phase: Creating a shared understanding of sustainability in the design team</td>
</tr>
<tr>
<td>Nested HCD Model</td>
<td>Concept/Visual Model</td>
<td>Systems</td>
<td>Concentric circles representing the human as part of society and the biosphere (see illustration in section 4.2.4.)</td>
</tr>
<tr>
<td>Care Instructions (Sustainability Principles)</td>
<td>Concept</td>
<td>Success</td>
<td>Creative constraints framing the design brief so as to define the minimal requirements to reach a sustainable solution</td>
</tr>
<tr>
<td>Propelling HCD model</td>
<td>Concept/Visual Model</td>
<td>Success/Strategic</td>
<td>The centre of the intersecting lenses and propeller image ideally address a need that is financially and technically feasible, and at the same time sustainable (see illustration in section 4.2.4.)</td>
</tr>
</tbody>
</table>

### Discovery Phase

| Big Picture | Activity | Systems | Mapping the system of relevant stakeholders and their relationships, including the environment |

### Interpretation Phase

| Finding Leverage Points | Activity | Strategic | Looking at possible leverage points in order to decide strategically which part of the problem to focus on (i.e. choose an insight by asking which change can create a large effect on the systems behaviour) |

### Ideation Phase

<p>| Out-of-the-box Brainstorm Questions | Questions | Actions | Questions that trigger new thought angles (e.g. how is this problem solved in nature?) |
| Brainstorm Improvement of Unsustainable Ideas | Activity | Actions | Taking obviously unsustainable but perhaps promising ideas and trying to build from them sustainable ideas / improve them (e.g. making an airplane sustainable) |
| Prioritisation Matrix | Activity | Strategic | Convergence guidance: a prioritisation process of rating possible solutions according to six questions (see detailed questions in section 4.2.4.) |
| Enhanced Concept Description | Activity/Guidelines/Questions | Systems | Describing the solution in writing, recording the thought behind the prioritisation matrix, drawing the life cycle of the solution (from inception to disposal), imagining how the idea would work in reality and impact other stakeholders |</p>
<table>
<thead>
<tr>
<th>Experimentation Phase</th>
<th>Activity</th>
<th>Actions/Success</th>
<th>Prototyping the proposed solution as sustainably as possible (regardless of financial or technical limits)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creative Experimentation with Prototypes</td>
<td>Activity</td>
<td>Actions</td>
<td>Thinking about the solutions from the perspective of the non-human stakeholders (e.g. how would a river be influenced by a solution of a new cosmetic product?)</td>
</tr>
<tr>
<td>Strategic Choice and Evaluation of Feedback</td>
<td>Activity/ Guidelines</td>
<td>Systems/ Strategic</td>
<td>Including as many stakeholders as possible when seeking feedback on the prototype (also from a sustainability expert if possible), while considering that consequent changes to the prototype should be in line with the Sustainability Principles. Feedback questions regarding possible socio-ecological implications of the prototype should also be sought</td>
</tr>
<tr>
<td>SLCA Prototype Evaluation</td>
<td>Activity</td>
<td>Strategic/ Success</td>
<td>Assessing the prototype using Strategic Life Cycle Assessment (Ny et al. 2006)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Evolution Phase</th>
<th>Activity/ Guidelines</th>
<th>Success</th>
<th>Setting measurements of success in regards to sustainability (e.g. 50% reduction in CO2 emissions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Define Measurements</td>
<td>Activity/ Guidelines</td>
<td>Actions</td>
<td>Documenting and monitoring the evolution of the solution with regards to reaching the goals, acknowledging achievements, and sharing success with others (e.g. public)</td>
</tr>
<tr>
<td>Document Sustainability Progress</td>
<td>Activity/ Guidelines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prioritising Feedback Questions</td>
<td>Activity/ Guidelines</td>
<td>Strategic</td>
<td>Considering how to respond to stakeholders’ suggestions on changes for the prototype when they might lead to negative socio-ecological impacts</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Add-ins throughout all phases</th>
<th>Activity (ongoing)</th>
<th>Actions</th>
<th>Stories and examples to inspire sustainability considerations throughout the design process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustainability Storytelling</td>
<td>Team Role</td>
<td>Systems</td>
<td>Reminds the team to zoom out and see the bigger system</td>
</tr>
<tr>
<td>Systems Team Role</td>
<td>Team Role</td>
<td>Systems/ Success</td>
<td>Taking care of unresolved questions about the solution’s socio-ecological impacts</td>
</tr>
<tr>
<td>Sustainability Champion</td>
<td>Team Role</td>
<td>Systems/ Success</td>
<td></td>
</tr>
</tbody>
</table>

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