Product Design through a Systemic Lens

of Ecological Economics

By

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Abstract

Products, tangible artefacts created through a process and intended for delivery to an end-user (Boundless, 2017), have been a primary method in addressing the needs and wants of people, making product designers a crucial link in envisioning and creating better futures. With increased uncertainty due to unsustainable production and consumption as well as questions of social equity, I have wondered if product designers can be instrumental in tackling these complex issues.

In this paper, I look at the role of product design as an integral part of our lives and society, and how, since the domination of capitalism, the role and goals of design have changed due to the dominant reductive economic model it presents. I also explore various problem solution methodologies commonly used within the product design process to highlight strengths and deficiencies, and develop mental models that allow for 'useful' visualizations. I believe this approach will lead to greater understandings on how externalities, material and energy throughput, socio-economic and ethical concerns can be included in future methodologies.

I conclude by presenting an initial concept for a nested, hierarchical, complex adaptive system for the product development process that is comprised of a cycle encompassing both business and product design.

Keywords: Product design, Systems Thinking, Complex Adaptive Systems. Panarchy, Ecological Economics

Foreword

This major research paper is a result of my belief that through a systemic understanding of the socio-economic processes surrounding the creation and consumption of products, product designers can be instrumental in moving societies towards a sustainable future. As I return to post-secondary teaching, I see this paper as the first step in creating the foundation for an interdisciplinary undergraduate course encompassing the three major research components of my Plan of Study: product design, environmental education, and ecological economics.

The courses and activities I under-took throughout the MES program were strategically selected to expand my horizons and learnings in environmental education (ENVS 6140: environmental education, ENVS 6141: education, sustainability and the ecological crisis, ENVS 6150: popular education for social change 1, ENVS 6151: popular education for social change 2), ecological economics (ENVS 5164: environmental economics, ENVS 6115: ecological economics) and how they related to emerging design approaches (ENVS 6117: ecology and sustainability in the Global South, ENVS 4523: systems thinking in environmental studies, ENVS 6599: Individual directed study: transitions beyond consumerism).

My learning objectives that relate to this major research paper include intensely studying emerging product design approaches that offer different solutions to existing problems (learning objective 1.1), understanding the mutual effects of the changes in the environment and sustainable practices (learning objective 2.1), and understanding economic systems that can lead to strong sustainability practices (Learning objective 3.2).

I have complemented my course material by attending the 2016 Sustainable Consumption Research Action Initiative (SCORAI) conference, as well as presented the systems thinking portion of my research at the 2017 United States Society of Ecological Economics conference.

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I would like to begin by thanking my mother, Nahid Bahavar, for always reminding me to pursue my dreams and continue my education, which I would have never been able to complete without the support and many sacrifices of my husband Andy Sun, and my daughter Mina Sun.

The journey to completing my MES began at Sheridan College with an introduction to the MES program by my colleague Todd Barsanti, and generous letters of reference from another colleague Susan Beniston, my supervisor Peter Palermo, and the FAAD Associate Dean Heather Whitton. I will never forget your generosity in taking those initial steps. I would also like to thank Dr. Leesa Fawcett who kindly met with me to answer questions of the MES program, offering me a glimpse of the generosity and kindness that personifies this faculty.

I know that so many of my accomplishments are due to the great privilege of having Dr. Justin Podur as my advisor. Time and again, he guided me through the agonizing steps in developing my Plan of Study with the perfect combination of encouragement, empathy, feedback and recommendations, and even included an amazing cookbook!

I would like to thank Eric Miller who skillfully managed to do what I had previously imagined as impossible: making economics both fascinating and engaging. I began his courses with the sole goal of understanding one particular economics book, but left with a mission to pursue ecological economics for the remainder of my days.

My studies were marked by such passionate and dedicated professors such as Dr. Felipe Montoya-Greenheck who challenged my belief system about progress and development, and Dr. Martin Bunch, who in that same semester introduced me to systems thinking, allowing me to envision new relationships and connections to supplant the ones that had been broken.

I was also privileged to take two courses on Popular Education for Social Change with the unforgettable Chris Cavanagh who embodies the commitment and humility so necessary to help

others reach their full potential. Those two courses are possibly the most important ones I have ever taken, and will forever influence how I approach learning and teaching. I am also extremely grateful to Dr. Traci Warkentin and Dr. Don Dippo for broadening my horizons regarding current issues and critical thinking in environmental education.

One of my only regrets through the program was not having the ability to attend courses taught by Dr. Mark Winfield, so it is easy to imagine my delight at the opportunity to become a teaching assistant for one of his courses (*Thanks again Dr. Podur!).* I know attending his lectures provided me with a new sense of appreciation for the history and context of Canadian environmental policy and law, and the power that engaged and informed citizens have to affect policy change.

 I end my studies with an amazing sense of accomplishment that can only be achieved by the privilege of being supervised by Dr. Ellie Perkins. Not only has she guided me with insightful comments and thought-provoking questions, but has also been an inspirational role model. Dr. Perkins embodies all aspects of a socially-engaged and compassionate person; always striving for a more just society through community projects and publications.

The path of all MES students winds through the Office of Student and Academic Services, (OSAS), where I had the good fortune of getting to know two of the most generous people at York University. I would like to thank Josephine Zeeman and Silvana Careri for not only helping me through mountains of paperwork and procedures for the past two years, but for also extending their friendship as we shared a common love of gardening.

I would also like to express my warmest gratitude to Dr. Bernhard Schindlholzer who graciously forwarded his Ph.D. thesis to me, and offered valuable insights.

No acknowledgment could ever be complete without a recognition of the continued support of Wolfgang Joensson who 28 years ago, introduced me to product design and encouraged me to study it. I value his friendship and wisdom more than I can express.

And last but not least, I have to thank my brother Parham and my sister-in-law Sena for coming to my aid at a difficult juncture. I could not have done this without them!

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List of Abbreviations

CAS   Complex Adaptive Systems

C2C   Cradle to Cradle

DT   Design Thinking

FFE   Fuzzy Front End

GDP   Gross Domestic Product

HCD   Human-centered design

IT   Information Technology

PD   Product Design

PDPSM   Product Design Problem Solutions Methodologies

SCORAI   Sustainable Consumption and Research Action Initiative

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Product Design through a Systemic Lens of Ecological Economics

Products, tangible artefacts created through a process and intended for delivery to an end user (Boundless, 2017), have been a primary method in addressing the needs and wants of people.

While for much of the existence of humanity, craftspeople spent years learning about a trade so they could use their embodied knowledge and skills to create products, the Industrial Revolution created a rift within this process. It separated creation into distinct steps that would require creativity only in the initial phase and unskilled labour through the rest of the process (Bürdek, 2005).

Bürdek (2005) believes that the separation between craft and design occurred sometime in the 18th century when one person was no longer responsible for both conception and production (Bürdek, 2005, pp.17-18). This resulted in the creation of product design as the creative section tasked with creating new artefacts. Product design has been defined by Morris (2016) as an "efficient and effective generation and development of ideas through a process that leads to new products".

In a holistic overview of the role of design in society, John Heskett (2017) has defined design as "the creator of sources of wealth by satisfaction of material needs and creation of meaning." While we need design for our material and psychological survival, we must not forget that all creations come at a price; the destruction of something else (Fry, 2009, p.72). One example of such destruction presented in the 2016 Living Planet Report (WWF, 2016) which states that since the mid-20th century, human activities are endangering environmental systems. The report claims that by 2020, the demand on nature is projected to become 75% more than what nature can renew (WWF, 2016, p.83) and that the well-being of humans, and populations of all other life-forms, is being jeopardized (WWF, 2016). According to the report, renewable

resources are being used 1.6 times faster than renewal rates. Carbon dioxide is also being

released faster than can be sequestered by nature. (WWF, 2016, p.60) (Appendix A).

Neither our economic systems nor our product design profession has had the courage to

question the cost or necessity of our current trajectory of environmental destruction. This has

led me to consider if current definitions of the roles of product designers and the problem

solution methodologies they use are sufficient to tackle the question of sustainability, or are

there elements that could be added to assist product designers in achieving this goal. My main

question has been whether suitable ecological economics principles can help product designers

redirect society to flourish sustainably.

I hope this paper offers product designers insights into how they can think systematically,

improve the product design thinking process through ecological economics concepts, and

envision new socio-economic relationships to guide them into making better choices based on

understanding long-term consequences and moving towards a society that flourishes.

Chapter 1 - Purpose and Methods of This Paper

1.1. Background

Like many evolving disciplines, product design is struggling to identify itself. There is a deep divide between product design scholars and practitioners who often don't speak the same language (Buchanan, 2001). Many documents and manifestos published in recent years, show that while both product design practitioners and researchers may be concerned with environmental issues, they feel ill-equipped and helpless to tackle them, so they often do not.

I believe that this imbalance between goodwill and inaction has been exacerbated by the lack of transparency within dominant economic systems, and the fear that businesses have of the added cost socially-just decisions may bring to their bottom line. In a system that seems to reward those who ignore the cost of their destructive processes and benefit from the camouflage of international trade laws, it's hard to persuade any one company to change its behaviour (Appendix B).

For years, many notable product design thinkers and historians such as Victor Papanek (1972), David Orr (2002), John Heskett (2005), and Tim Brown (2009) have been warning that the lack of moral and social responsibility of designers in society, is creating increasingly complex ecological and social issues. Brown (2009) points to the importance of product designers recognizing their personal responsibility in creating larger problems by failing to understand the full social implications of their product designs, including resource use and consumption (Brown, 2009, p.104).

Increased consumption is an example of the type of highly complex problems we now face in society. In these types of problems since not all variables can be identified, their high levels of uncertainty means that they are not deterministically solvable. Since traditional problem solving processes are based on known variables and the assumption of the existence of a deterministic

solution, they do not allow for the randomness encountered in today's complex problems. Product design methodologies are based on abductive reasoning, making them some of the few methods suitable for tackling problems with high levels of uncertainty.

I find inspiration in the words of Buckminster Fuller: "You never change things by fighting the existing reality. To change something, build a new model that makes the existing model obsolete."

I believe that the creation of a more inclusive, holistic model of product design considerations could enable product designers to envision how their personal responsibility can become part of the process that results in the reduction of socio-environmental impacts from products as well as creation of more equitable situations for all stakeholders. This paper proposes models and approaches that highlight the importance of socially-responsible product design.

1.2. Research Design and Methodology

I begin by recognizing that I have a pragmatic worldview, and begin this research with the intention of developing an understanding of the holistic approach which I believe needs to be taken during the product design process. As noted by Barton (1999), pragmatism may not only challenge the extent of the prevalent atomistic thinking, but also offer "a coherent philosophical basis for contemporary approaches to systems thinking (Barton, 1999, p.2).

I also recognize that product design practice does not work in isolation, and is part of the larger economic system within society, leading me to take a transdisciplinary approach, drawing from some varied disciplines such as economics, systems thinking, environmental law, ethics, business, sustainable consumption and production, design thinking, and of course product

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design itself. This choice is my personal response to the knowledge fragmentation I see dominating so many fields, specifically economics which has been elevated to such a lofty status by our growth-addicted societies that few dare to question its dominance.

Understanding the role of product design within the larger system of wealth creation is an essential part of the product design thinking process which means that the consequence of the over-emphasis on economic aspects or exclusion of ethical concerns in product design, need to be included within this process.

I begin my research with an extensive literature review to define product design and current problem solution methodologies. I will continue with a review of the economic context in which product design takes place and link it to current consumption patterns and impacts.

In chapter 5 I will identify gaps in the literature, and propose solutions that address them in chapter 6. My final output will be in the form of a model of a complex adaptive system cycle that exists with a nested and hierarchical system. I believe this can be the first step to assist product designers to think systematically to achieve ecologically and socially just outcomes.

Chapter 2 - Product Design

The often quoted definition from Simon (1969) defines design as an activity that changes existing situations into preferred ones, though I think Buchanan (2001) offers a more cohesive definition for design as "the human power of conceiving, planning, and making products that serve human beings in the accomplishment of their individual and collective purposes" (Buchanan, 2001, p.9). These two definitions highlight design as a human activity that includes intentionality in achieving a purpose. While some other species have also shown these traits, the climate change problems we currently face have been created by humans and their actions, so that will be the focus of this paper.

These definitions also allow us to see that we are constantly surrounded by design, to the point that we are so accustomed to being surrounded by man-made, designed environments, that we often fail to recognize them for being just that: artificial. It can be argued that the first time   humans began intentionally altering things to improve their survival, they began designing. Even the "nature" we experience each day in the form of gardens, parks and wildlife, are no longer representative of the way nature has really evolved, but represent carefully conceived, planned and executed spaces that provides us with specific possibilities of interaction.

Since the dawn of time, humankind has created objects that have enhanced human life and allowed humans to flourish physically and spiritually. These objects were created as part of a regenerative relationship (Milani, 2000, loc.41) that respects nature and its processes, and also instills a sense of belonging.

With the expansion of industrialism, utilizing the ideas of part standardization and sequential manufacturing, the time and skills required to create objects was greatly reduced, making workers skilled at performing small repetitive tasks, but with no clear understanding of

the purpose or impact of their work (Tanenbaum & Holstein, 2016, para.1). Production methods also changed, going from what had previously been a regenerative cycle, to a wasteful linear process that created waste at every step of the way, from extraction of raw material and energy usage to final disposal. This impact has been further intensified with the introduction of the concept of planned obsolescence as a purposeful strategy that ensures products have a limited lifespan and lose attraction. It has resulted in the additional speeding up of this linear cycle of waste generation (Papanek & Fuller, 1972, p.230).

Sassatelli (2007) points out that through history, regardless of the type of society or economy, objects have had clear social and cultural value and closer provenance to users. "The fundamental cultural dichotomy on which social order rested was that of sacred/profane rather than of production/ consumption" (Sassatelli, 2007 p.4). Today we are faced with objects that do not possess significance by themselves unless we are told what they are

In what he refers to as the "Waste Economy", Milani (2000) points to the importance of this built environment that surrounds us in fueling consumer demand. Citing the 1949 Housing Act in the United States which essentially created a new market for consumer goods by isolating family homes in sprawling suburbs, he argues that this policy lead to the disappearance of communal spaces (town halls and public gardens) and services (communal laundry), (Milani, 2000 loc. 618-621) including public transportation (Rogers, 2010 p.359).

Looking at the fundamental structure of the product design industry, Boehnert (2014) identifies a deep-rooted structural problem in which product designers are limited in what they can do by the systemic bias of capitalism which operates on highly reductive economic feedbacks. Even when product designers want to address ecological concerns, they are trapped within a system that only sees short-term profit, and denies long-term social and ecological consequences (Boehnert, 2014).

2.1. Design Shapes Behaviours

Buchanan (1985) has noted that at a fundamental level, design is a persuasive argument on how people should live. That vision of the future and the possible ways of getting to it is one thing that sets design apart from many other activities. While many activities try to use a combination of large number of variables with the limited knowledge of today to understand the past or present, design tries to find solutions that would work in the future. This frames the question of what those futures are, and who benefits from them as an ethical one which has not been adequately answered.

Stegall (2006, p.58) believes that while modern product designers focus exclusively on "physical issues surrounding a new product or technology", the ability of the product to induce widespread behavioural changes is usually ignored. He provides an example of how good intention of product designers in saving time and energy on cleaning and storage by creating disposable products has led to a consumer trend resulting in increased material use, pollution and waste (Stegall, 2006, p.57). Nobody predicted that such an approach could be successful. It has led to the redesign of items previously only considered as durable goods such as cameras, cookware and even diapers, to make them single-use and disposable. While these disposable products are seen as a boon to the economy, their devastating effects on the environment cannot be denied.

Buwert (2015) notes that throughout history, product designers have "consistently expressed social, political, ethical concerns and aspirations" (Buwert, 2015 p.4.2). Through a series of interviews with product designers in 2013/2014, Buwert was able to illustrate the conflicted realities that plague product designers as they are faced with wanting to act ethically, but being unable to do so. Boehnert (2014) believes that "systematic priorities" and "structural

dynamics" of the design industry are responsible for the reproduction of "the conditions of deep unsustainability" that makes product designers feel so helpless (Boehnert, 2015, p. 119).

Buwert (2015) presents several examples of products in affluent societies that claim it is possible to act ethically, and at the same time address social problems in poverty-stricken areas without changing one's lifestyles or consumption. Several bottled water brands such as Thirsty Planet, Life Water and Ethos promise to provide funding or water sources to places that currently don't have access to clean water, completely bypassing the fundamental questions of the reason for the existence of the particular problem, and disregarding that drinking bottled water is huge source of waste. They offer the sensation of being "right" using a pain-free solution that does not require us to make any changes to our everyday activities (Buwert, 2015, p. 4.5).

A more current example of this approach is automaker Kia's television advertisement for its Niro model, unveiled at the 2017 Super Bowl (Kia, 2017). This ad features actress Melissa McCarthy in several short segments as she aims to protect whales, trees and rhinos, but winds up in unfortunate and painful situations each time, screaming and howling. The ad concludes by saying: "It's hard to be an eco-warrior, but it's easy to drive like one", subtly suggesting: don't bother trying, just buy a car instead.

One other pain-free solution has been presented by Braungart and McDonough through their Cradle to Cradle (C2C) philosophy which proposes a system for cycling technical nutrients (resources and materials) in the economy, similar to the way nature cycles biological nutrients (McDonough & Braungart, 2002). While initially hailed as a radical move to sustainability, the concept has been difficult to incorporate, leading McDonough to clarify in a 2009 interview that it was really a business model about rethinking the relationships between suppliers, plants and customers (Den Held, 2009). Braungart noted that while there is a misconception that the

system is an aim in either waste minimization or recycling, it should be considered as a "strategy to come up with product and process innovation" (Den Held, 2009).

C2C also has been noted as a marketing strategy allowing products to be certified by MBDC (McDonough Braungart Design Chemistry) as being C2C, though to this date, of all products that are being certified by MBDC, not even one has reached the goal of 'waste equals food' (Sacks, 2008). Many of the successes McDonough has touted such as collaboration with Nike sportswear manufacturer, Interface Carpets, or the Oberlin College buildings simply don't produce the results he claims (Sacks, 2008).

Fry has criticised the C2C philosophy saying that it fails to ask the all-important question of what is produced and why? (Fry, 2009, pp.189-190) resulting in yet another model that supports "a continual growth capitalist economy" without questioning the reason.

2.2. Designing for Change

Buwert (2015) draws on the work of Anne-Marie Willis as she examines a fundamental problem with design activism engagement, which is that "even with the best of intentions and enthusiasm, product designers are asked how to achieve change without really knowing what that preferred change should be". Willis (2013) utilizes the example of often cited definition of design by Herbert Simon (1969) which defines design as an activity that changes existing situations into preferred ones as an example of how most designers gloss over the what actual change means.

"If pressed to name the gap between the existing and the preferred, those who cite Simon would perhaps say something like – better functionality, performance, convenience, efficiency, aesthetic appeal, and so on. The parameters of change are assumed as given, as issuing from

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the client, thus they are circumscribed, delimited, not an issue" (Willis, 2013, p.1). Orr believes that the inability to distinguish what can and what should be done renders designers vulnerable to do whatever is asked without the strength to question whether it is the right course of action (Orr, 2002, p.63).

One other aspect of product design that is also often overlooked is that design is never culturally-neutral. Fry (2009) writes that design always brings more than just itself, including socio-cultural values (Fry, 2009, p.100). As the products created through a globalized economy reach into subordinated cultures, Fry believed that it creates a type of "postcolonial double bind" that breaks ties with past traditions while it undermines current socially sustainable practices.(Fry, 2009, pp.101-102).

The impact designs can have in limiting future pathways can be seen through various lock-in mechanisms prevalent in society. A lock-in occurs when, even in the face of much superior options, a flawed technology continues to persevere (Perkins, 2003, p.1). One case of lock-in that has led to massive environmental pollution and social problems is the internal combustion engine that is based on fossil fuels (Appendix C).

2.3. Design Solution Methodologies

Buchanan (2001) traces the origins of modern design research to Galileo in the early seventeenth century with his decision to study natural sciences to explain the superiority of the design of certain items in the arsenal of Venice. This idea was further enhanced by Bacon's vision to use art and human artistry to mold nature and create "artificial things." By the twentieth century, designers were seen as artisans who, through their skill and intuition, could create new items.

Martin (2009) presents a clear overview of inductive, deductive and abductive reasoning and how they relate to problem solution. Traditional knowledge generation utilizes two forms of declarative reasoning, inductive and deductive reasoning, which both aim at proving a conclusion either true or false. Deductive logic can be likened to the application of a general rule to a specific case. Inductive logic, on the other hand, is based on what is operative, using specifics to define the general (Martin, 2009, loc. 453). While both these forms of declarative logic rely on past data, several philosophers, most notably Peirce have reasoned that only the existence of a third form of logical mode that allowed "logical leaps of mind" would allow for the creation of new ideas.

Peirce believed that new ideas arose when a thinker observed data that did not fit with existing models as the thinker sought to make sense by making "inference to the best explanation". This modal form of reasoning does not aim to prove something true or false, but to posit what could be true.

While most firms are dominated by declarative logic, or deductive and inductive reasoning (the logic of what should be or is operative) they often forget that new knowledge comes about by way of abductive reasoning, the logic of what might be. Abduction "merely suggests that something may be," as opposed to deduction, which "proves that something must be," or induction, which "shows that something actually is operative" (Peirce 1974, CP 5.171). In review of Pierce's modes of pragmatic inquiry, Barton notes that Pierce "identified abduction at the heart of pragmatism" (Barton, 1999, p.4), and regards it as the only form of inference that extended knowledge through action learning.

In a comprehensive study of design thinking discourses, Johansson, Woodilla & Çetinkaya (2013) conclude that there is not a unique meaning to the phrase, so they focus on identifying the application and the meaning given in each case. They identify two distinct streams as

'designerly thinking' as "ways to describe what designers do in practice" (Johansson, Woodilla & Çetinkaya, 2013, p.123) and a management design thinking stream. While designerly thinking has been around for over 40 years (Johansson, Woodilla & Çetinkaya, 2013, p.123), the newer form of management discourse can be traced back to the early 2000s with maybe the most significant development being that IDEO, the world's largest product design company changed its marketing strategy, choosing to move away from its base of product design to market itself as 'an innovation company' (Johansson, Woodilla & Çetinkaya, 2013).

Johansson, Woodilla & Çetinkaya's research into 'designerly thinking' has noted its strong academic foundation based in contributions from product designers as well as others in related fields. The study has utilized theoretical perspectives to identify five separate streams as noted in table 2.1.

Table 2.1: *Comparison of Five Design Discourses of Design Thinking,* from Johansson, Woodilla & Çetinkaya, 2013, p.126.

Founder	Background	Epistemology	Core Concept
Simon	Economics & political science	Rationalism	The science of the artificial
Schön	Philosophy & music	Pragmatism	Reflection in action
Buchanan	Art history	Postmodernism	Wicked problems
Lawson & Cross	Design & architecture	Practice perspective	Designerly ways of knowing
Krippendorff	Philosophy & semantics	Hermeneutics	Creating meaning

Table 2.2: *Comparison of the Three Management Discourses of Design Thinking from Johansson, Woodilla &* Çetinkaya*, 2013, p.129.*

Originator	Audience	Discourse Character	Academic Connections	Relation to Practice
IDEO design company (Kelley & Brown)	Company managers (potential customers)	IDEO success cases (written for managers)	Grounded in experience rather than research. Connections to innovation research	Kelley: How 'we' (IDEO) do design thinking. Brown: how anyone can use design thinking
Martin	Educators (academics & consultants) Company managers	Success cases from production companies used to illustrate theory development (managerial thinking)	Grounded in cognitive science & management science. Builds on planning theories ('wicked problems')	How successful production companies do design thinking. How 'any' company (manager/ individual) can engage in design thinking
Boland & Collopy	Academic researchers & educators	Short essays where established (management) scholars apply their theoretical perspective to the design area	Grounded in individual researchers' own theoretical perspectives. Inspired by Gehry's architectural practice or contact with design.	Design thinking as analogy & alternative

In their comparison of the three dominant management discourses on design thinking presented in table 2.2, Johansson, Woodilla & Çetinkaya note that without considering the embodied knowledge that is so important for product designers to tackle issues, the three design thinking methodologies reduce problem solution to a purely cognitive activity. They also conclude that the only commonality between the three streams is their lack of analytical structure (Johansson, Woodilla & Çetinkaya, 2013, p.132).

2.4. Comparative Study of Methodologies and Toolkits

Based on the previous discussions on designerly and design thinking methodologies, I have reviewed eight that represent product design problem solutions methodologies from both within design, as well as some that moved beyond product design to other disciplines. A design thinking (DT) toolkit is a collection of design management, communication and other individual tools that can be applied individually or in conjunction with others during the design thinking methodology. Among the toolkits, Schindlholzer's (2014) Ph.D. thesis stands apart as being the only one which tries to bring scientific rigour and an academic foundation to design thinking

I will now proceed with a comparative study of the following eight methodologies:

Table 2.3: *List of Product Design Methodologies Reviewed in this Paper- Sayeh Dastgheib-Beheshti, 2017*

Methodology	Resource	Summary
Koberg & Bagnall	Toolkit: The Universal Traveler: A soft system methodology	Appendix D
Cross	Book: Design Thinking	Appendix E
Kelley & Kelley	Book: Creative Confidence	Appendix F
IDEO	Toolkit: Handbook for Human-centered design	Appendix G
Stanford University	Toolkit: "Bootleg bootcamp methods cards"	Appendix H
Martin	Book: Design of Business	Appendix I
Ogilvie & Liedtka	Toolkit: Designing for Growth	Appendix J
Schindlholzer	Toolkit: Design Thinking Coaching	Appendix K

An overview of the afore-mentioned books and methodologies illustrates that each promotes a different message for a different audience.

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Table 2.4: *Comparison of 8 Methodologies/Toolkits - Sayeh Dastgheib-Beheshti, 2017*

Toolkit / methodology	Background	Core concept	Message	Audience	Examples utilized
Koberg & Bagnall	Architecture	Cybernetics: study of human control systems	Complex problems can be solved through a logical and orderly process.	Entry-level problem definition and solution	Based on an analogy of traveling
Cross	Design Research	Understanding how successful designers think	sophisticated cognitive ability that cannot be directly observed	Design research	Grounded theory based on observations and interviews
Kelley & Kelley	PD & Management	Design-driven innovation	Creativity can lead to routine innovation	Future innovators	Business case studies
IDEO	Non-profit design firm	Human-centred Design	Knowing users creates better products & services	New and experienced practitioners	Case studies Testimonials, anecdotal evidence, some empirical evidence
Stanford University	Educational institution	Use design to develop creative potential.	Make impact with design	Undergrad/ graduate students and the public.	Real-world projects
Roger Martin	Management consulting	Business model as knowledge funnel.	Costs fall as knowledge moves through funnel.	Managers	Anecdotal evidence
Ogilvie & Leidtka	Business innovation and management	Systematic approach to problem solving	Profitable business growth	Business	Case studies
Schindlholzer	Business science and innovation	Unified approach for developing new products or services especially at the "Fuzzy front end"	Innovation through coaching	Information & communication technology sector	Methods engineering and two case studies

A further comparison of the pros and cons of each methodology allows insights into the strengths and weaknesses of each to identify how design can be best utilized in creating a sustainable future.

Table 2.5: *Comparison of Pros and Cons of each Product Design Methodology - Sayeh Dastgheib-Beheshti, 2017*

Methodology	Pros	Cons
Koberg & Bagnall	• Casts a wide net to diverse fields for essence of problem solution methodologies. • Applicable in personal and professional life.	• There is often very little academic rigor to prove the efficacy or usefulness of a technique.
Cross	• Utilizes grounded theory (systematic generation of theory from systematic research). • Points to designer's willingness to embrace ambiguity and uncertainty. • Shows holistic, interconnected overview essential to successful solution. • Designers often re-framing problem to create new patterns, based on embodied knowledge. • Defines design intelligence as the concept of dualities of problem & solution developing concurrently: an emergent property larger than each component. • Ability to shift between abstract and concrete thought. • Ability to operate across different levels of scale (high-level systemic to low-level physical scales). • Innovation come from practical experience and draws from technology transfer from other fields.	• Does not show techniques on how one can apply findings. • Proficiency in generating solutions seems tied to personal passion. • There is no consideration for issues of social equity or whether they are addressed by designer but leaves the door open that these may be part of the "re-framing" that the designer can include in the evolving problem definition/solution process. • Besides a few examples, does not delve into the necessity of innovation or the designer's role in bringing about change.
Kelley & Kelley	• Creative thinkers realize several possible solutions before converging on one • Creativity can be achieved through step-by-step process, with the ability to tackle increasingly complex issues with experience. • Successful solutions are those residing in the "sweet spot" between technical feasibility, business viability and desirability by people. • Successful innovation reaches peoples motivations and core beliefs • Building empathy for users is a critical step in the success of solving it.	• No value judgment on the validity of core beliefs or worthiness of the problem to be solved. • Encouraging the view that any problem is valid and can be solved creatively. • Empathy for end-user does not extend through the supply chain and does not include others impacted by process.
IDEO	• Free, online resource designed to be used to create social impact. • Easy to understand and detailed descriptions for tools. • Many tools/methods include supplemental worksheets that simplify the process. • Uses cross-disciplinary teams where designer is a part but not driver. • High level of participatory practice research. • Builds empathy for users in all phases. • Problem remains grounded in desires of community being engaged. • Business orientation to problem solution.	• This kind of focus on the human-centered element becomes very reminiscent of the concept of human domination of nature through the ages and an anthropocentric thinking that has led to our crisis in sustainable living. • No value judgment on validity or long-term consequences of project. • Framing problems as a business opportunity often leads to a return to the reductive model of capitalism in which profit is seen as the motive.

Continued: *Table 2.5: Comparison of Pros and Cons of each Product Design Methodology - Sayeh Dastgheib-Beheshti, 2017*

Methodology	Pros	Cons
Stanford University	• Free, online resource designed for beginners. • Human-centered design process. • A variety of techniques and methods try to capture ideas and harness creativity. • Immersive process which builds empathy in all stages. • Creates specific actionable items. • Constant re-evaluation of whether problem framed correctly. • Based on the idea that every business opportunity is good.	• Empathy limited to direct users of products. • Does not account for subtle cultural differences, often unaware of the potential damage it may cause based on culturally-insensitive assumptions. • People and communities impacted by the resource extraction, production and disposal of product or service considered.
Martin	• Business model based on ability to design and redesign itself in changing environments in ever faster cycles. • Uses easy-to-understand concept of funnel, with costs falling as innovative ideas progress through funnel. • Successful businesses need to create a dynamic balance between analytical mastery and intuitive originality. • Balance of exploration and exploitation needed for successful business. • Personal knowledge system comprised of stance (worldview), tools (theories, processes, rule of thumb) and experience (allows us to develop skills and sensitivities). • Creative acts convert mysteries to heuristics (rule of thumb) through intuitive thinking, and develop algorithms (processes) to solve them. • Innovation dilemma seen as a difference and incompatibility between validity and reliability. • Validity's goal: produce outcomes that meet a desired objective and often include subjective and judgmental aspects- progresses real knowledge • Reliability's goal: produce consistent and predictable outcomes (Systems like Total Quality management, Six Sigma, streamline business and enable objective data analysis to extrapolate scientific predictions. • Removal of redundancies in systems makes them fragile. • Dominant forms of traditional scientific logic: inductive and deductive reasoning are not adequate to solve problems grounded in uncertainty and in turn, need abduction (logical leaps of mind) to make connections. • Presents a model of design thinking as "an ongoing cycle of generating ideas (abduction), predicting consequences (deduction) and generalizing (induction)".	• Touches on many important concepts like redundancies that lead to resilience, but fails to follow up by convincing readers why they should promote them as product development moves through reliability cycle. • The notion of algorithms or processes to solve the mysteries once the scope of the problems have been narrowed down through creativity, seems to assume that creativity only need to be applied to certain sections and portions and does not need to be a continuous part of the process. • The concept of utilizing creativity in business cycles with ever increasing speeds leads to the question of who benefits from this increased pace? Is this increased speed leading to an improved quality of life or just a higher throughput (rate which materials are cycled through the economy)?

Continued: Table 2.5: Comparison of Pros and Cons of each Product Design Methodology - Sayeh Dastgheib-Beheshti, 2017

Methodology	Pros	Cons
Ogilvie & Liedtka	• Can be utilized by anyone in a business setting. • A systematic process for profitable business growth since maximizing productivity and re-engineering processes are no longer working. • Simplified toolkit with clearly identified tools, instructions as well as project management aids. • Combining business thinking (rational, objective, quantifiable, precise) with design thinking (human experience, messy, qualitative, uncertainty). • Only toolkit that actually addresses the value chain. • Identifies "target customer", clarifying its intent. • Customer co-creation is seen as the means to tap into wants and needs from customers.	• Utilizing actual designers is no longer necessary since this handy toolkit will teach you all you need to know about the various steps. • There is no value judgment on the need for the product or consequences. All business opportunities are seen as valid. • Value chain is seen only in terms of upstream and downstream opportunities that add value to the business portion of the product and not as having any ethical bearing. • Real innovation within various phases seems to be possible by just following toolkit, so it is reduced in importance.
Schindlholzer	• Tools and instructions are well-written and easy to understand. • Provides academic basis that has been mostly lacking in design thinking. • Recognizes that design thinking need hands-on coaching and facilitation to yield actual results in early stages of innovation. • In order to meet scientific rigor, bases his work on method engineering principles which includes repeatability and traceability of changes, as well as strong orientation towards customer needs. • Identifies uncertainty, lack of focus, ambiguity of services as some factors that can pose challenges in the early stages of innovation. • Sees innovation as non-linear iterative process. • Recognizes complexity of design thinking and the need for coaches to meet scientific rigor standards. • Utilizes participatory action research method.	• At some point Schindlholzer cannot continue with the scientific approach and has to accept the anecdotal methods developed by other methodologies. • Does not propose any ethical judgment on validity of activity.

This comparative study reveals that none of these methodologies ever mentions ethical concerns, and only focus on business opportunities. In the following chapters we will take a closer look at why various methodologies often only focus on business concerns.

Chapter 3 - Economics and Design

3.1. The Economic Value of Design

John Heskett (2015) believes that value, through an economic lens, effectively refers to monetization, while a design lens frames it as " a point of integrity and source of values in its own right", concluding that a value of a product cannot simply be reduced to a monetary one (Heskett, 2015, p.89). These "more-than-economic values" such as its ability to enable users, address and enhance capability, are much more important, and in a sense render economic value the most peripheral aspect of the values embodied within a product.

Heskett (2017) believes that this creation of value through design is a notion that has been difficult to incorporate into models presented by standard economic theory, since as a public goods, once design is created, it can be utilized by others at no additional cost. (Heskett, 2017, loc.1449). While patents, trademarks and other intellectual property rights have tried to make the designs of products into private goods by making them excludable in use (limiting use to only those who pay for them), design has continued to defy privatization by market forces **(figure 3.1)**. Heskett concludes that since capitalist economy only values things it can make excludable, design itself has been regarded as having little economic value (Heskett, 2017, loc.1491).

Excludability in Consumption

	Excludable (high)	Non-excludable (low)
Rivalrous (high)	**Private Goods** Food, clothing, cars, personal electronics	**Common goods (common-pool resources)** Fish stocks, timber, coal, national health service
Non-Rivalrous (low)	**Club Goods** Cinemas, private parks, satellite television	**Public Goods** Free-to-air television, air, national defense, design

Rivalry in consumption

Figure 3.1. Excludability & Rivalrous in Consumption

A rival good: type of good that may only be possessed or consumed by a single user. Using a rival good prevents its use by other possible users. Rival goods can be durable, where users may use them one at a time, or nondurable, where consumption destroys the good, allowing only one user to enjoy it.

Excludable if it is possible to prevent people (consumers) who have not paid for it from having access to it.

Economic theory assigns two forms of value to a product: use-value and exchange-value. Carl Menger clarifies the distinction as products with use-value directly satisfy a need, while those with exchange-value can be an indirect mean of obtaining use-value goods (as cited in Heskett, 2017, loc.1639). An example of use-value is food, providing nourishment with its consumption, while diamonds have high exchange value but no inherent use-value in themselves.

One last point I would like to make is the role design can have in creating healthy communities by keeping the wealth created in circulation within the community. In a 2009 Time magazine article titled: *Buying local: how it boosts the economy*, Schwartz (2009) uses examples to illustrate the importance of the flow of money within communities, creating more jobs and opportunities, allowing them to flourish (Schwartz, 2009).

3.2. Designing for the Growth of the Economy

Since its proposal by Kuznets to the US Congress in 1934, the Gross Domestic Product (GDP), the measure of all goods and services produced in a period, has gone on to become "the ultimate measure of a country's welfare" (Sgroi et al., 2017, p.10). Notable economists like Stiglitz and Sen have urged countries to move to more meaningful measurements since as Victor (2008) writes, it "is not a reliable indicator of progress" (Victor 2008, p.9). While it includes the growth of such undesirable items as healthcare costs, cleaning up pollution, repairs and even extra spending on the police, it leaves out many non-monetary aspects of economic activity like unpaid or voluntary work, disregarding their role (Victor 2008, p.9).

Ecologists and economists such as Easterlin (2001, 2010), Binswanger (2006), and Victor (2008) have noted that economic growth does not necessarily increase well-being since often

environmental externalities (un-intended consequences) and other adverse social effects of economic growth may be rising faster than personal incomes, so they outweigh the benefits of increased private consumption (Daly & Farley, 2011) (Victor, 2008).

In his 2006 paper titled: '*Why does income growth fail to make us happier?'* Binswanger refers to Easterlin who in 2001 noted that the "rising aspirations" as the major cause of the paradox of happiness. He concludes that subjective well-being varies directly with income and inversely with material aspirations. As material aspirations tend to increase proportionately to income over one's lifetime, measures of happiness or satisfaction shift inversely with material aspirations." These findings were also verified by Layard (2006) (figure 3.2), as well as another 2010 study which has shown that it holds true over the long-term - usually a period of 10 years or more - for a number of developing countries (Easterlin et al., 2010) as economic growth has not resulted in the happiness that has been promised (Sgroi et al., 2017, p.12).

Figure 3.2: *Income and Happiness in the United States, Source Layard (2006)*

Since nearly all development occurs due to economic incentives of one form or another, sustainability is intimately linked to economic world-views. Economists view development as interactions between three different forms of assets: natural capital (the planet's stocks of water, land, air, and renewable & non-renewable resources), manufactured capital (human-made

products and environments), and social capital (links, shared values and understanding in society).

The industrialized, capitalist countries have long equated sustainability with economic growth and argued that these three forms of capital are interchangeable and can be substituted one for the other in a view known as "weak sustainability". In this view, Neumayer (2003, p.1) points out that the usage of resources or creation of pollution is not important as long as manufactured goods are produced in return.

At the other end of the spectrum, the proponents of "strong sustainability" believe that natural capital is the source of all manufactured and social capital, and that it is non-substitutable with either manufactured or social capital. In their 2015 Global Sustainable Development Report Brief: *'Weak Sustainability versus Strong Sustainability',* Pelenc, Ballet and Dedeurwaerdere point to differences between natural and manufactured capital that will never allow manufactured capital to be substituted for natural capital, notably that ALL capital, including manufactured, is based on natural capital, and having a qualitative nature, natural capital destruction is rarely reversible. Since manufactured capital is the main consumer of natural capital, in order to preserve our natural capital, designers will need to revise and re-evaluate how we design, manufacture and consume products.

The early business cycles of industrialism were marked with periods of temporary crises of over-production, periods in which consumers did not have purchasing power (Milani, 2000, loc. 482). Milani (2000) attributes these to the fact that after the Great Depression of 1920s human consumption would no longer take care of itself to keep markets functioning, so the industrialists realized that consumption, just like production, would now have to be planned in order to keep the system going (Milani, 2000, loc.490). In his seminal book: *'Designing the Green Economy'*, Milani (2000) argues that modern industrial production no longer relates to the original goals of

providing use-value (Milani, 2000, loc.2150-2151), but is based on reinforcing production for production's sake (Milani, 2000, loc. 527).

3.3. Market-based Solutions and Design

Neo-classical economics is predicated on individuals being sovereign decision makers with agency that allows them to make the most rational choices. The three guiding assumptions of neo-classical economics (Boundless website, 2016) are:

1. The rationality of people in choosing the best value.
2. The basis of decisions on people's independent actions who have full and relevant information.
3. The sole goal of people being maximizing utility (the usefulness of a product).

According to Nadeau (2015) neo-classical economics is based on assumptions that market-based economic systems are by varying degrees, closed, self-correcting, self-sustaining, and capable of perpetual growth. The convenience of these assumptions becomes clear since they allow all calculations to be mathematized, with the added "bonus" of not having to make any moral judgements on how money is spent (Brown & Timmerman, 2015) or what the economy produces. The Latin mantra *'ceteris paribus'*, which means: *'other things being equal'*, is particularly a handy tool to have in this process since as Heskett (2017) points out, allows for the convenient exclusion of anything that inconveniently disturbs the many assumption needed for a mathematical calculation (Heskett, 2017, loc.1355).

Keynes (1931) has pointed to the unwillingness of modern economic theory to recognize the subjective nature of human desires as the most notable failure of modern economic theory since it accords the same status to all wants/needs, effectively resulting in an absence of any

accountability on the consequences of economic decisions. This unwillingness to make judgement can be seen across the board in the design thinking methodologies that were reviewed in previous chapters as well as within the design industry itself. "Who benefits when we do not question the rationale of the lock-in?"

In his 2014 writings, Piketty has taken a strong position, dispelling the claims that the rigorous mathematical theories used by mainstream economists are value-free, saying that they only serve to "disguise the fact that these theories sanction and perpetuate economic inequality, mitigate against equitable distribution of scarce environmental resources, and enhance the wealth, power and influence of financial elites" (Picketty as cited in Nadeau, 2015).

Faber (2008) believes that the collapse of planning systems of socialist countries in the 1980s and 1990s has shown the extent of the dependence of economic growth on organization of market economies (Faber, 2008, p.5). He concludes that while market economies have provided innovative and dynamic efficiencies, they have also brought forth environmental problems and increasingly unequal income distribution economies (Faber, 2008, p.5).

As natural and social externalities (un-intended consequences) of economic activities become larger than market internalities (features contained in the price), the markets lose their abilities to efficiently allocate resources. Mainstream economics has been very reluctant to even recognize the existence of externalities. To internalize the damage caused by inefficient resource allocation, companies like Trucost have quantified the external environmental costs of companies, and identified mechanisms like pricing carbon and impacts on natural resources and ecosystem services to highlight the true impact of externalities (Costanza, 2010).

Ehrenfeld (2008) observes that the dominant idea of a free market is based on the workings of an invisible hand that maximizes collective happiness but ignores any moral outcomes of this process. This effectively strips away any sense of personal responsibility

towards the degradation of the environment and undignified and unhealthy living conditions our consumption causes (Ehrenfeld, 2008, p.33).

Heskett (2017) notes that the static nature of products and markets is a failure of neo-classical economic theories, reducing design to a trivial activity that only deals with minor and superficial aspects of unchanging commodities. This directly contradicts what we have seen as a central aspect of design practice: concern about the future and envisioning changes not embraced by neo-classical economic models (Heskett, 2017, p.47).

In his classic: '*The Great Transformation',* Karl Polyani argues that the economic system is embedded as a component of human culture which evolves over time. He uses the term: *'coevolution'* to point to the intimate relationship of human culture with the environment, adapting to changes that are caused or naturally take place. While in the past the rate of these changes has been extremely slow, Daly & Farley point to their increased speed (Daly & Farley, 2011, p.11).

As money has moved beyond its historical role as the means to define the value embodied in the usage of products (use-value), it has now become the ends of our economic life (Milani, 2000, loc.679) to the extent that business and maybe most of society now sees money as the only manifestation of wealth, ignoring collective social wealth.

3.4. Freedom as a Choice to Consume

Utilizing a systemic approach, Ehrenfeld (2008) has presented high levels of consumption as a form of addiction resulting from our increasingly technological way of living that shifts the burden of this lifestyle over time and place. Ehrenfeld (2008) points to 'choice' in both economic and political contexts as he draws on the work of Schwartz in which consumption is seen as a

proxy for freedom and self-determination. Fry (2009) refers to this same concept as 'consumer sovereignty' (Fry, 2009, p.49) as he also sees freedom diminished to choices between competing products.

The truth according to Fry (2009) is that the global economy strives to increase the volume of goods and services consumed by people with disposable income (Fry, 2009, p.111). One example put forth by Fry (2009) is the deforestation of the Kalimantan region of Indonesia which as result of burnings to clear logging waste, contributes significantly to Indonesia's ranking as the third highest emitter of greenhouse gases in the world. The entire industry that pushes locals to log and burn their habitat exists thanks to designers who specify wood that is only grown in that particular area (Fry, 2009, p.112). This is the same economy that Orr (2002) believes, "works best when people confuse who they are with what they own" (Orr, 2002, p.108).

3.5. Introduction to Ecological Economics Principles and Applications

Ecological economics begins by recognizing bio-physical limits, something that immediately sets it apart from conventional economics. With the three inter-related goals of sustainable scale, fair distribution and efficient allocation, Costanza (2010) believes that ecological economics works towards activities that contribute to human well-being and sustainability (Costanza, 2010). Faber (2008) argues that the three defining characteristics of ecological economics is interest in nature, justice and time; three concepts that are not addressed by mainstream economics (Faber, 2008, p.2).

This lack of conceptualization of nature in mainstream economics is illustrated by the stance taken on the relationships between economic activities and planet Earth. During the

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formative years of classical economics in the eighteenth century, Adam Smith assumed that nature would simply provide the raw material for the continued growth of the economy (Faber, 2008, p.6), a mental model that has not changed much over the past 300 years. Ecological economics firmly places the economy as a subset of the planet's environment, and as an open system which takes material from the environment and returns waste to it. The economy simply cannot exist without this fundamental interaction with nature.

The Earth itself can be considered a closed system since its only interaction with the space that surrounds it in the form of energy absorption and loss. This creates a system in which the continued growth of the economy expands into the non-expanding realm of our planet, exacting increased resources and waste sinks (Daly & Farley, 2011, p.16). Ecological economics is based on the **recognition of planetary boundaries** that respect limits to resource usage, waste generation and economic activity.

The second defining feature of ecological economics is the concept of **justice**. While early classical economists narrowly defined it as the question of income distribution (Faber, 2008, p.6), ecological economics relates it with "the good life of society" (Faber, 2008, p.6). In this frame, it is a holistic concept that includes all aspects of social development (economy, politics, culture, social justice, and more), as well as a harmonious relationship with nature (Farber, 2008, p.6), not just for humans, but for all creatures (Farber, 2008, p.6).

Time is the third defining feature that sets ecological economics apart from mainstream economics. Since mainstream economics has only incorporated the concept time in the form of discounting, this has led to a static view that leaves no room for the concept of 'irreversibility', a decision that Arrow & Fisher (1974) define as "infinitely costly to reverse" (as cited in Perrings & Brock, 2009, p.221). "Irreversibility" highlights the problems of making decisions about investments without knowledge of future worth (Perrings & Brock, 2009, p.219) and

compromises the optimality of decisions made under uncertainty (Perrings & Brock, 2009, p.221). This is a direct confrontation with the founding principles of neo-classical economics that is based on the concept of people as 'rational utility maximizers'. How can they have the ability to make rational decisions if they do not have, and cannot have all the information right now?

The three topics of nature, justice and time all share inter-related connections, making the boundaries between the three concepts blur together in discussion. This links the dignity of humans with the dignity of nature and does not cast it as a separate topic (Faber, 2008, p.9) leading to discussions that are often complicated and intertwined. Another complicated topic tackled through climate justice is inter-generational justice, in which the actions or inactions of the current generation are impacting the future of subsequent generations.

Despite the evident shortcomings of neo-classical economics, for the past five decades, ecological economists have not been able to effectively make any changes in the dominant paradigm presented by neo-classical economics, something Söderbaum (1990) believes is due to discrimination from mainstream economists who are "more eager to save their theories and methods than to improve the chances of human survival on this planet" (Söderbaum, 1990, pp. 482, 491).

Chapter 4 - Current Consumption Practices

4.1. Consumption and Economic Growth

Consumption in economics has been defined as "the use of goods and services by households (Caroll, 2016). One factor that defines humans and in fact all other species on Earth is their need to consume to live. In an interview at the 2016 SCORAI conference, Rees said that consumption is a complex issue and it's unfortunate that for too long, people have been made to feel guilty about it, since every living thing has to consume to survive (SCORAI, 2016). Rees went on to add that the question that needs to be addressed is the appropriate level of consumption since we are in a world that produces a finite quantity of resources and can only absorb a finite quantity of waste.

In *The Economics of the Coming Spaceship Earth*, Kenneth Boulding speaks of Earth as a spaceship with a closed and linked input/output ecological system where the outputs of one system become inputs of others. This is in stark contrast with what he terms as the "Cowboy Economy", the idea that Earth as an open system, is an illimitable planet with unlimited ability to produce resources and absorb wastes (Boulding, 1966 p.2, 7).

Boulding frames the main difference between these two types of economies as their attitude towards consumption. In the "Cowboy Economy", consumption is celebrated as a sign of success, and increasing throughput (the input/output rate of material and energy) is seen as genuine progress (Boulding, 1966 p.8). One look at reports of increases to the GDP in the daily news offers a clear indication that we currently live in "Cowboy" economies.

The "Spaceship Economy" however, measures success as "the nature, extent, quality, and complexity of the total capital stock, including in this the state of the human bodies and minds included in the system." This economy aims to reduce both production and consumption

and instead uses non-monetary indicators to evaluate the health of systems (Boulding, 1966, p.8).

While growth and progress are both new concepts developed in the last century (Victor, 2008, pp.3,4), it is clear that nothing can continue to grow forever. In a linear vision of the economy, there is denial that such growth is having a non-linear effect in the form of social structure collapse and loss of biodiversity and irreparable damage to the planet. Orr (2002) points out that we are "caught in a pattern of deep denial that begins by confusing genuine progress, a difficult thing to appraise, with what is simply easy to measure - economic growth" (Orr, 2002, p.205).

As people gain the means to consume more, the throughput of material per person increases, making the cost of economic scale very important. As previously mentioned, the International Resource Panel (2016) has shown that the material consumption of the World's richest is ten times that of the world's poorest (IRP, 2016). It is no longer just a case of supply and demand, but a case of what that material extraction, processing and disposal does to the environment we all share (Daly & Farley, 2011, p.34).

Conventional economics uses an abstracted circular flow model based on supply, demand and leakages, without any mention of the linear processing of both materials and energy from the environment that makes it all possible (Daly & Farley, 2011, p.29). This gives the false impression that the economy can function without affecting the environment. This unidirectional and irreversible process takes raw materials and energy from the global ecosystem's sources of low entropy (mines, wells, fisheries, croplands), transforms them through the economy (throughput), and returns them back to the global ecosystem's sinks as high entropy wastes (atmosphere, oceans, dumps) (Daly & Farley, 2011, p.29). The recognition of the relationship

between throughput and the effects it has on the environment clearly shows that infinite

economic growth is impossible (Daly & Farley, 2011, p.64).

Throughout recent history, in a move to hide impacts of the enormous amounts of waste

generated from unsustainable lifestyle in affluent societies, there has been a tendency for the

most waste-generating activities to "move upstream" from household to industry. This move has

greatly helped hide the waste endemic to mass consumption societies; pacifying the

consciences of those who worry about the environmental impact of our economic activity.

For a consumer purchasing a laptop, they may never realize that it generates four

thousand times its weight in waste, and that only about 1 percent of all materials processed and

converted into products for North American markets continue to be still in use six months after

sale. Only 2 percent of the total waste stream is recycled (Hawken, Lovins & Lovins, 1999). One

simple example of linear throughput has been presented by Hawken, Lovins & Lovins as they

have pegged the throughput of each American at 1 million pounds per year (Hawken, Lovins &

Lovins, 1999, pp.51-52).

4.2. Limits to Consumption

Walker and Giard (2013) believe that up until the 16th century, humankind had no choice

but to live according to the world's carrying capacity (Walker & Giard, 2013, p.2), something that

was endured within a traditional worldview based on continuity. Milani (2000) also supports this

viewpoint and traces the roots of many of our current problems back to the last two decades of

the 19th century as industrializing countries moved from a "land-based organic ever-renewing

economy to an extractive industrial non-renewing economy" (Milani, 2000, loc.41). This shift in

technology was accompanied with a parallel shift in worldview from a traditional one to modern

one which was shallower and flatter, replacing meaning-seeking aspects of human activities with the notion of progress and scientific endeavor (Walker & Giard, 2013. p.3).

Faber (2008) has argued that for the majority of human existence, nature was seen as a "fountain of life', having a purpose in constantly developing higher life forms, allowing humans the chance for self-reflection (Faber, 2008, p.5). This attitude is seen in the works of Goethe, Wordsworth, Schelling and Thoreau (Faber, 2008, p.5).

According to Fry (2009), Thomas Hobbes, however, had a different viewpoint. As he lay the foundations for our modern political thinking, he presented the belief that nature had to be overcome and held in check, "maintaining the divide between civilized human beings and animality" (Fry, 2009, p.9). As Scientists tried to understand the laws that governed nature, Faber (2008) believes that the motivation was to control nature which was no longer viewed as the "fountain of life", but as a source for the material needs of humans (Faber, 2008, p.5). This type of thinking has dominated discourses on progress, and even relationships with other creations, resulting in the environment, resources and even other human beings regarded as resources there for the taking of the powerful.

When the Club of Rome presented 'Limits to Growth' in 1972, it used data from five contributing factors to develop scenarios, and calculate outcomes of unrestrained economic growth up to the year 2100. The five factors (population increase, agricultural production, non-renewable resource depletion, industrial output, and pollution generation) were used to see how their interactions would limit growth (Turner & Alexander, 2014). 45 years later, direct comparison of results published in 'Limits to Growth' in 1972 and data obtained from the United Nations show that the projections are matching reality.

Given all this information, why is it so difficult to begin changing our flawed systems? Ehrenfeld (2008) believes that modern technology has changed the context of responsibility for

consequences of actions through the great separation in time and location between the two, often making their linkages invisible or difficult to identify (Ehrenfeld, 2008, p.31) that make it hard to assign responsibility (Ehrenfeld, 2008, p.60). Fry refers to design as a "façade" that despite its attractive appearance, "effectively hides the sites and forms of destruction that enabled … (it) to come into being." (Fry, 2009, p.214).

I would like to conclude with the viewpoints of Orr (2002, p.109) as he points out that while all the political ideologies of the past centuries were competing views about the organization of the industrial society, they were unanimous in the concept of human domination of nature as well as the dominance of technology to achieve economic growth. The only difference between various political beliefs was the extent of private versus public control of capital.

As long as economic growth is seen as the measure of achievement, not much is going to change.

Chapter 5 - Areas of Additional Research

From the literature review presented in the previous chapters, I will now identify the topics that require further discussion and are relevant to the role product design can play in moving to a more sustainable lifestyle.

5.1. Strengths and Deficiencies in Reviewed Methodologies

The review of the eight product design problem solution methodologies in chapter 3 illustrated areas of strength as well as common several notable deficiencies which I have grouped into the 5 following categories: methodology, conceptual framework of problems, economic aspects considered, considerations regarding product lifecycle, as well as moral dilemmas designers face.

This comparison shows that while some criteria like business factors, technical feasibility and desirability by user are universally addressed, other criteria such as behavioural, environmental or societal outcomes of the designs are not deemed valid or suitable criteria for consideration by designers, and in fact, they are universally ignored. None of the methodologies recognizes the need to identify, let alone internalize the externalities contained within products. This leads to the expected consequence of the lack of recognition or consideration of issues such as social justice, environmental degradation, energy and material throughput or results on the environment, society and other beings. It is all assumed that any (perceived) problem, or impediment to generating more profit is not worthy of discussion and that the only costs incurred will be those associated with production, while the benefit will be the growth of the economy and all the good things it entails. It seems that product design problem solution methodologies are truly caught in the reductive capitalist model Boehnert (2014) mentioned in chapter 2.

Table 6.1: *Identification of gaps within 8 design solution methodologies* – Sayeh Dastgheib-Beheshti, 2017

Legend: ● Always   ○ Sometimes   (blank) Never/ Not applicable

	Methodology	Koberg & Bagnall	Cross	Kelley & Kelley	IDEO	Stanford University	Martin	Ogilvie & Liedtka	Schindlholzer
Methodology	1. Includes flexible tools & methods	●	○	●	●	●	○	●	●
	2. Offers clear process	●	●	●	●	●	○	●	●
	3. Places importance on personal experience / embodied knowledge	●	●	●	●	●	●	○	●
	4. Provides a multi-disciplinary approach	●			●	●		○	●
	5. Uses participatory action research method (includes stakeholders)				●	●			●
	6. Team-based (collaborative) method		○		●	●			●
	7. Evidence provided through rigorous academic study	○	●						●
	8. Evidence provided through anecdotal evidence	○		●	●	●	●	●	
	9. Multi-level approaches (large systemic and smaller details)	○	●		●	●	●	○	○
	10. Fosters critical thinking	○	●	●	●	●	●	●	●
Conceptual Framework	11. Grounded in needs defined by community				●	●		●	●
	12. Desirability of product important	○	●	●	●	●	●	●	●
	13. Technical feasibility important	○	●	●	●	●	●	●	●
	14. Business factors (production and distribution should be feasible)		●	●	●	●	●	●	●
	15. Fosters empathy for users	○	○	○	●	●	●	●	●
	16. Constant re-framing (making personal) of evolving problem /solution	●	●	○	●	●	○	●	●
	17. Establishes provenance of product creator to user	○							○
	18. Looking at wider context of problem (structural reasons)	○	○		○	○	○	○	○
Economic Aspect	19. Sees problem as business opportunity	○	○	●	●	●	●	●	●
	20. Promotes need for innovation to speed up business cycle		○	●	●	●	●	●	●
	21. Creativity is applied throughout process	○	●	○	○	○	○	○	○
	22. Product keeps money circulating in the community								
	23. Product internalizes all externalities								
Lifecycle	24. Takes a broad systemic approach to process	○	●	○	●	●	○	○	○
	25. Considers throughput of new product								
	26. Considers sustainability of product					○	○		
	27. Considers environmental impacts in value chain								
Moral Dilemmas	28. Ethical judgement about whether there is a need for innovation								
	29. Ethical judgment over possible cultural impact					○	○		
	30. Consideration: Long-term consequences (precautionary principle)		○			○	○		
	31. Consideration: Will it change behavior in society					○	○		
	32. Consideration: Will it result in promote flourishing within society?								
	33. Consideration: Will it result in human dignity for user?			●	●	●	○	○	○
	34. Consideration: Will it result in human dignity (manufacturing labor)?								
	35. Consideration: Will it result in human dignity (resource acquisition)?								
	36. Considers environmental impact from product lifecycle								

Strengths:

- Clarity of process and flexibility of tools & methods.

- Identification of the importance of personal experience and embodied knowledge.

- Utilization of a multi-disciplinary, team-based approach based on participatory action research.

- Utilization of multi-level approaches to address large systemic and small detailed

- Fostering of empathy for users

- Constant reframing (making personal) of problem and solution as they evolve.

Areas of potential issues:

- Lack of consistency in considering the wider context of the problem.

- Lack of consistency in applying creativity through the entire product development process which often resembles the 'throwing over the wall' project management method in which creativity is no longer deemed necessary to complete the product specifications.

Deficiencies:

- Establishing a provenance linking the producer to the user(s) has historically been one of the main ways in which artefacts have created shared meaning.

- Lack of consideration for throughput, product life-cycle issues and ethical judgment regarding the role and impact of the product.

5.2. Understanding the Changing Role of Design

Historically, design has been part of a larger system that created both wealth and meaning, often through the personal links established between creator and user, allowing the

user to flourish both physically and spiritually. When artifacts were created, they were meant for long-term usage, often being passed down through generations. These objects were valued for the skill and embodied knowledge of the craftspeople who had spent years learning their craft, and contained decorations and features that carried significant meaning. Often styles and objects evolved slowly over hundreds of years, resulting in distinct styles and features that are now associated with particular historical periods.

In contemporary culture, styles and fashion seems to be based on seasons, with everyone rushing to embrace the next new thing. Often the only constant feature is change. Sassatelli (2007) has observed that today we face objects that do not possess any significance unless we are told what they are, offering no way to understand their function, usefulness and social worth. In some ways, loyalty to brands of products has taken over the significance of social provenance resulting in people choosing and staying with brands that represents an idea or concept beyond the value of the actual product.

Many of these changes can be traced back to the Industrial Revolution and the separation of creativity from the production process, resulting in the removal of the need for embodied knowledge during production. This resulted in a fragmentation of the production process and recast the design of products as a service industry at the beck and call of manufacturers. With the separation of deep social values from artefacts, product design has become a superficial and trivial activity that only engages with superficial aspects of a product.

5.3 Defining Desired Futures

The inability to distinguish between what we can and should do, has led to a focus on tangible, short-term results. It is easy to make links between cause and effect in the short term, and it provides a sense of accomplishment.

Long-term goals, however, are a different story, as the linkages become complex and obscure, and results may not be evident often meaning that individuals may not be take credit for accomplishments. The reverse side of the coin was aptly described by Ehrenfield (2008) as he pointed to the great separation in time and space between actions and effects for those who engage in destructive practices. They benefit from the inability to connect their actions to effects that are observed, making it difficult to assign blame and demand remedy.

People are affected by a designed object in all phases of its life cycle. The materials that are specified, create demands for specific resource extraction, refinement and production methods, energy, labour and production processes as well as distribution, consumption and finally disposal. While these processes can all be improved and optimized to reduce impact and pollution, past readings have led me to question how the underlying design of a product affects the people who encounter and use it. As the tentacles of a globalized economy reach even the remotest populations, the one aspect of design that is also often overlooked is that it is never culturally-neutral.

Fry (2009) writes that design always brings more than just itself; it also introduces new socio-cultural values (Fry, 2009, p.100). As these products reach into subordinated cultures, Fry believes that it creates a type of "postcolonial double bind" that breaks ties with past traditions while undermining current socially sustainable practices.(Fry, 2009, pp.101-102), forcing these cultures into a future that has no precedence for them.

5.4. Turning Moral Dilemmas into Sources of Action

Our everyday life is filled with value judgments on what we should do, so it may come as a surprise that the field of economics is free from those judgments. While modern economics is

presented as an objective science, the failure to recognize the important role of what Keynes (1931) refers to as "the subjective nature of human desires" has been one of its most notable shortcomings. In this economic system in which all wants and needs are accorded the same status, there is no accountability or sense of personal responsibility regarding the consequences of economic decisions. There are no value judgments about the validity of activities as long as they lead to economic growth regardless degradation caused in the environment, or the undignified and unhealthy living conditions our consumption causes (Ehrenfeld, 2008, p.33).

There is no argument that generating profits provides incentives to work hard and innovate, but the methods by which those profits are generated are the real issues we need to evaluate. With current problems of unsustainability and environmental degradation that are putting the very existence of humanity and all other beings on Earth at risk, it becomes very important to consider the effect of the prosperity of some on the survival of all.

Even the most progressive design thinking methodologies often fail to move beyond the notion of the domination of nature by humans. Whether the practice is classified as user-centered or human-centered, the results seem to be the same with the slight difference that the focus on empathy in human-centered designers making the designer feel better about their work. IDEO.org, a key promoter of human-centered design (HCD) states that HCD aims to arrive at solutions that are desirable by humans, viable for business and technically feasible (IDEO, 2015, p.14). Using the hopes, fears and needs of humans as a starting point, HCD works to create solutions that address needs within the target community (IDEO, 2015, p.14) and developing understanding and empathy for the people it is designing for. (IDEO, 2015, p.22). This presents a very anthropocentric viewpoint on the supremacy of human needs and wants and seems to be a continuation of the nature dominance theory discussed in previous sections.

How can designers reclaim their moral and social responsibility that Papanek & Fuller (1972), Orr (2002), Heskett (2005), and Brown (2009) have identified as leading to the creation of increasingly complex ecological and social issues? One step in the right direction could be efforts to understand the full ecological impact of the design of a product as well as short, medium, and long-term implications the design creates. Since any design will change the pathways that are available in the future, how are our current actions going to shape the lives of future generations?

Framing personal responsibility as ethical and inter-generational justice can allow designers to relate to long-term consequences since the current generation has been forced to deal with problems of pollution and environmental degradation created by previous generations.

5.6. Conclusions

The arguments put forth in this chapter point to the following areas that have not been adequately defined:

The role of the product design industry has been to promote the usage of reductive problem solution methodologies that limit the subjective engagement of designers to empathy for users and superficial aspects of products. Any additional considerations beyond this level of engagement has been seen as unnecessary encroachment into the business side of product creation and one which is best left to the analytical workings of business.

Given that historically products have been created for the creation of both wealth and meaning, I believe that designers need to embrace the opportunity to create meaningful products that empower not just users, but all stakeholders within the value chain with the ability

to live "a good life", one that Ehrenfeld (2008) defines as the ability to live "one's life according to one's values, free from domination" (Ehrenfeld, 2008, p.51).

The creation of a more inclusive, holistic model of design considerations could enable designers to consider their personal responsibility of leading the way to the reduction of socio-environmental impacts of products through reduced throughput, and the creation of more equitable conditions for all stakeholders.

In the next chapter, I will offer new ways of visualizing the product creation process based on complex adaptive systems (CAS) with the goal of highlighting opportunities for change.

Chapter 6 - Design as a System

In the previous chapter I identified the two main gaps in current literature as:

1. Shortcomings in the design practice are based on reductive capitalist models which exclude any considerations about externalities, throughput and the long-term effect of products on society, culture and the environment.
2. There is a lack of moral judgment or ethical concerns regarding economic activities.

I also need to point to the many positive aspects in the eight methodologies that provide promising potential for tackling complex problems:

- There is a recognition that multi-disciplinary teams can create more complete solutions, especially if they are coached and trained in the process.
- Further integration of product design problem solution methodologies into diverse fields in the form of 'design thinking' is training a new generation of problem-solvers and providing them with a wider range of options.

I believe a holistic systematic approach that models the problem solution methodology will allow the illustration of shortcomings in the product design practice in addition to highlighting the role of ethical concerns regarding economic systems. This will also provide an opportunity to compare the historical and contemporary role of design in society and how they fit within the political narrative.

I will be modelling the product design process as a complex adaptive cycle, nested within other social systems and ultimately the environment. With the full understanding that such a model is not reality, but as Box (Parrish, 2017) would say: "useful", I will create a simplified representation that allows us to visualize and understand this particular predicament.

In this chapter I begin by reviewing the basic concepts needed for thinking in system before proposing and exploring different models.

6.1. Mental Models and Perception of Reality

Meadows refers to "mental models" as our perception of the way the world works (Meadows & Wright, 2008, p.86) (Sternman, 2000, p.16) that is simplified or abstracted from the complications of the real world. British Statistician George Box has pointed to humanity's desire to categorize and organize the world by famously saying: "All models are wrong, (but)……. some are useful" (Parrish, 2017). This is a very important concept since it serves as a reminder that the simplified models are only serve to foster understanding (Parrish, 2017).

Maani and Cavana (2007) believe that mental models are the "root causes" of systemic, complex social problems **(Figure 6.1)**, which can only be solved by applying systems thinking to all four levels of the problem (as cited in WWF, 2016, p.90). They identify actual events as the tip of the iceberg, while patterns and systemic structures lead us to the underlying root cause which is a flawed mental models. (Maani & Cavana, 2007, as cited in WWF, 2016, p.90).
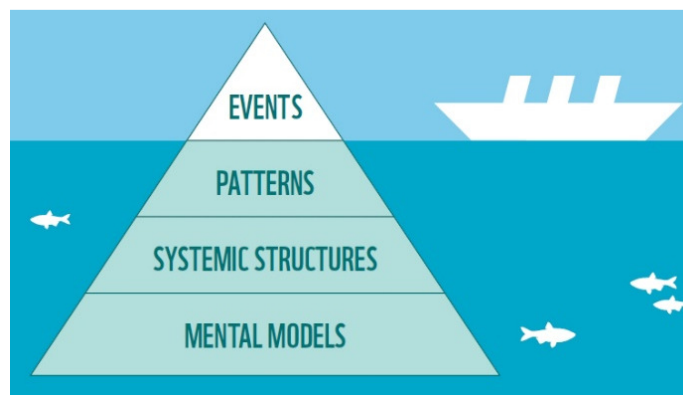

Figure 6.1: The "Four Levels of Thinking" model showing that events or symptoms are only the tip of the iceberg in the overall dynamics of a system. Meanwhile the underlying determinants of the system's behaviour are less apparent. The deeper we go below the surface events, the closer we get toward "root causes". Adapted from Maani and Cavana (2007), (from WWF, 2016, p. 90)

Meadows & Wright and Sternman all point out that the reason we continue to be surprised by events that unfold around us is that we often think of relationships as linear, with clear action and response (Meadows & Wright, 2008 p.91), instead of as dynamic patterns of behaviour over time (Sternman, 2000, p.16). These non-linear relationships, where the response is not proportional to the action, often catch us by surprise, confounding our expectations.

Most of us do not appreciate how common yet invisible mental models are in our daily perceptions of the world as we naively believe that our senses reveal the world "as it is". This is very important to understand this point as mental models help formulate problems by defining important elements and relationships and expected outcomes. They provide shortcuts that eliminate the need for us to process vast amounts of information for each event, allowing us to reach conclusions quickly.

The current mental model held about the role of product designers in society relegates them to the position of providing products to satisfy needs of society while creating wealth for manufacturer. What are the different elements that act within this mental model and how do the relationships between them affect the outcome? More importantly, how close is this mental model to allowing us to live equitably within the Earth's planetary boundaries? To answer this, we will need to gain a better understanding of systems.

6. 2. Design as a Complex System in Our Lives

While nobody has the ability to predict the future, according to Meadows & Wright and other systems thinkers, dynamic systems studies aim to" explore what would happen if a number of driving factors unfold in a range of different ways" (Meadows & Wright, 2008, p.46), a concept that as a product designer who strives to envision possible futures, resonates with me.

Meadows defines a system as an interconnected set of things that, through their interactions over time, produce their own pattern of behaviour (Meadows & Wright, 2008, p. 2,11) and "must consists of elements, interconnections and a function or purpose" (Meadows & Wright, 2008, p.11).

The traditional scientific method of reductionism begins research by understanding the parts and works its way up to the whole, a methodology that Jackson (2003) notes, often fails to capture that the whole that emerges is greater than the sum of its parts. The holistic approach begins with the emergent whole and proceeds to understand the parts and networks which have given rise and continue to sustain the system (Jackson, 2003, p.4).

Jackson (2003) defines a system as "a complex whole, the functioning of which depends on its parts and the interaction between those parts" (Jackson, 2003, p.3). Dekkers (2015) expands on this definition by stating that complexity can be imposed either internally by the complex inter-related relationships of a large number of agents (elements), or externally as an expression of emergence of new behaviour due to external forces in the environment (Dekkers, 2015, p.170) (Meadows & Wright, 2008, p.12). While individual elements are the easiest to detect, changing them often has the least effect on a system (Meadows & Wright, 2008, p.16) while interconnections, which are harder to detect, may lead to fundamental changes in the system behaviour (Meadows & Wright, 2008, p.17). For a society that is taught to reduce real-world problems into small and understandable pieces with direct paths between cause and effect, the realization that rational analysis cannot solve problems based in complex systems is unsettling (Meadows & Wright, 2008, p.3).

We can begin forming a preliminary causal loop diagram of the idealized product development process often cited by designers **(Figure 6.2.)**. There is no actual representation of the designer in this model since it is based on actions and their effects. A positive (+)

indicates a change in the same direction while a negative (-) signifies an inverse change. In the following diagram is we look at the relationship between costs and profits, clearly marked as a negative relationship, which means that as costs rise, profits fall. Empathy for user needs is an example of a postitive effect, meaning with the increase of empathy, more user needs are percieved.

Figure 6.2. Causal loop diagram:
Ideal product design process
Sayeh Dastgheib-Beheshti, 19/07/2017
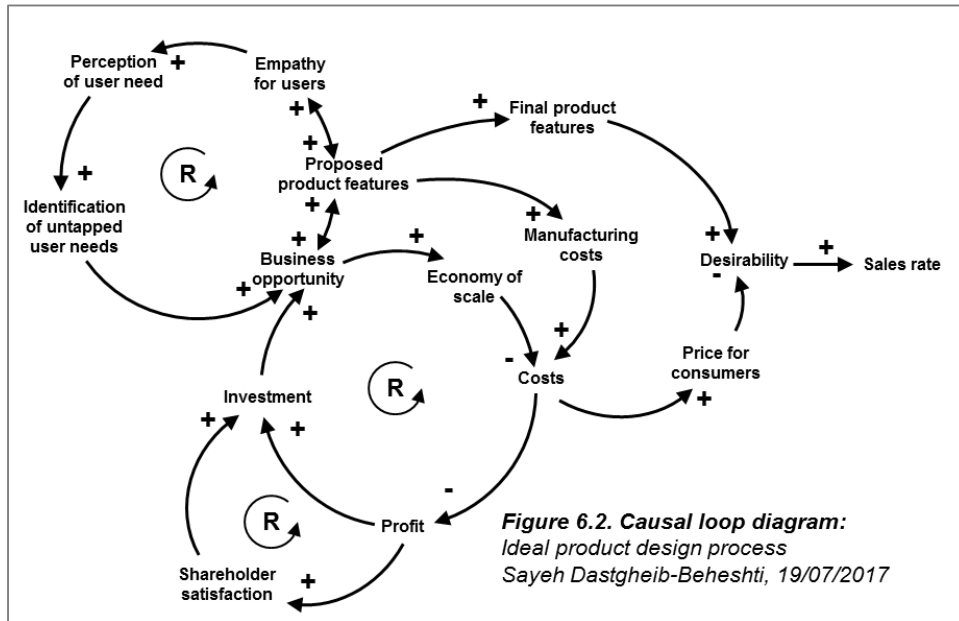
This model paints a rosy picture of the design profession, noting that if there are any additional issues or problems, they are beyond the concerns of the designers themselves. Are designers concerned about where the resources come from, how and under what conditions the labour is provided, and what kind of changes the use of the products creates in society, as well as how the products are disposed? What about the role of throughput in changing low entropy material from mines and fossil fuels to high entropy wastes? There seems to be no concerns regarding irreversible consequences or the lock-in of inferior technologies, one of the many nagging questions regarding how design shapes future pathways.

From these questions it becomes clear that I believe that this model of the role of product designers is incomplete and ignores any input or influence product designers can have to shape

our future, an important feature of any system; its function. The function or purpose of a system is often one of the hardest things to detect, but Meadows & Wright believe that by observing behaviour over time, it can be deduced (Meadows & Wright, 2008, p.17) and notes that "An important function of almost every system is to ensure its own perpetuation" (Meadows & Wright, 2008, p.13). So, what are the elements, relationships and purpose of our current design practice, who benefits, and how is that purpose being perpetuated?

In the case of design, as humans have continued to consume more and more, one would think that they are now happy with their needs being met. On the contrary, their increased consumption has fueled even more demand, resulting in a feedback loop of increased resource use, a mechanism that is seen through consistent behaviours that persist over time (Meadows & Wright, 2008, p.25)(WWF, 2016, p.75). There are two types of feedback mechanisms that can occur: reinforcing and balancing. Reinforcing or positive feedbacks are self-reinforcing, amplifying or self-multiplying and lead to a mutual reinforcement and escalation of both cause and effect (Meadows & Wright, 2008, p.30) (Sternman, 2000 p.14). Balancing or negative feedbacks, work in exactly the opposite way as self-correcting, goal-seeking or stability-seeking actions (Meadows & Wright, 2008, p.28) (Sternman, 2000 p.14). It is important to note that not all feedback loops have the same impact on behaviour, and a concept known as "dominance", the behaviour of one loop, could influence other competing loops.

Based on previous discussion, we have noted that the purpose of design as it is currently practiced seems to be the generation of profit for capitalism. This allows us to draw a new causal loop diagram for design **(Figure 6.3.)**. While this figure uses **Figure 6.2.** as a starting point, the addition of several new elements and relationships illustrates some interesting concepts. The Inclusion of throughput and socialization of externalities creates effects on manufacturing costs, price and the profit that is generated.

Figure 6.3. Causal loop diagram: socializing externalities during the product design process
Sayeh Dastgheib-Beheshti, 19/07/2017

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Figure 6.4. Causal loop diagram: _Balancing_ feedback when externalities are internalized during the product design process
Sayeh Dastgheib-Beheshti, 19/07/2017
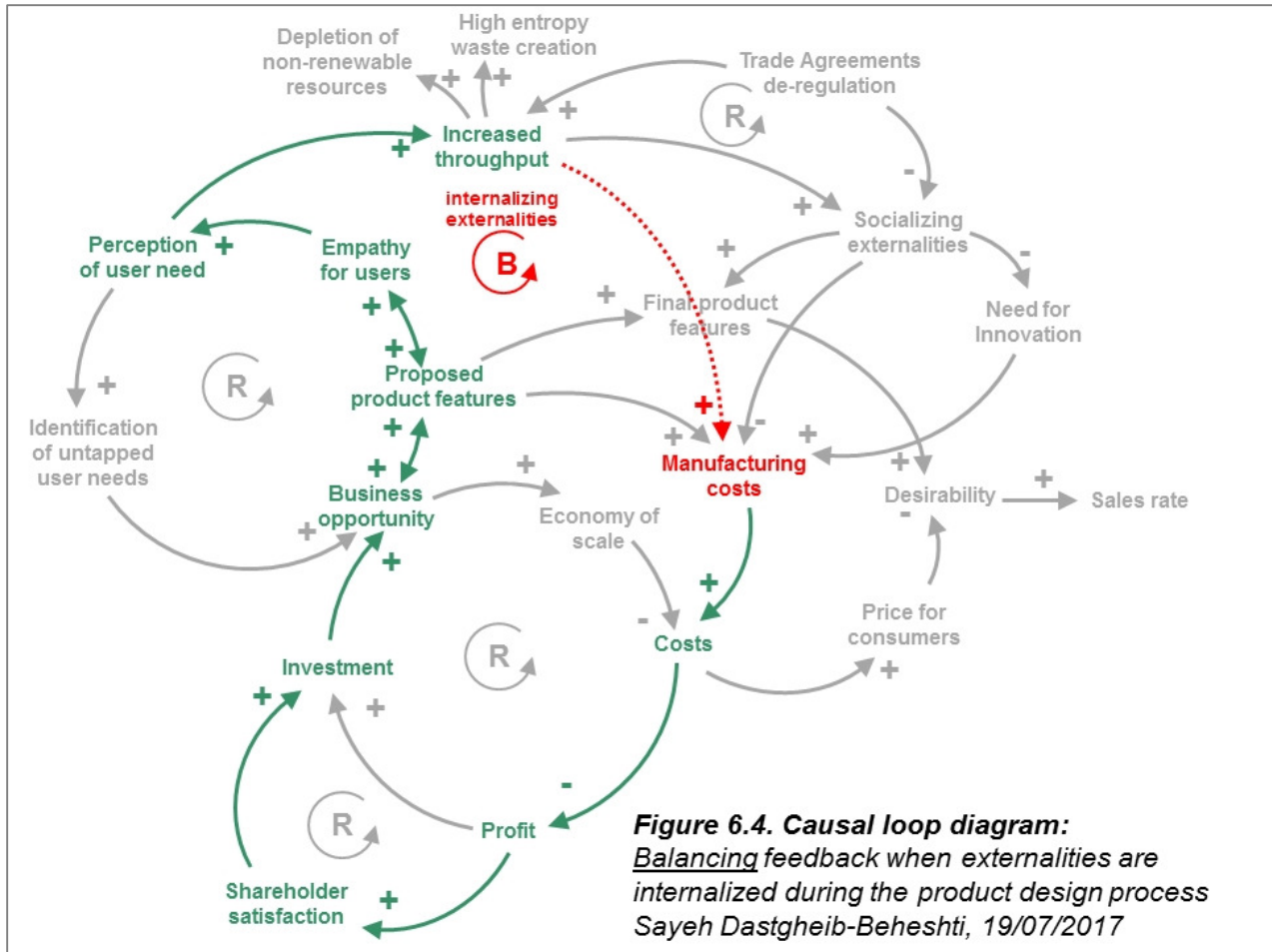
This causal loop diagram actually offers two different ways for increases in throughput to affect manufacturing costs. In the **Figure 6.4.** I have highlighted one path in which throughput has a direct effect. As increases in throughput raise manufacturing costs, this leads to a reduction in profit, and causes the entire loop to have a balancing effect and a stabilization of throughput. This is the result of a single inverse effect of added costs on reducing profits that are generated by the product development, resulting in the entire loop to become balancing.

There is however one other way for throughput to effect this system. **Figure 6.5.** illustrates a second route available for throughput and that is by socializing the externalities. In this case, with increased throughput, as industry passes the costs onto society, the result is a reduction of manufacturing costs. The inverse effect from this action cancels out the inverse effects of costs

on profit, resulting in an overall reinforcing effect. Simply, the more industry passes the costs of externalities such as pollution, waste and dirty energy onto society, the more incentive it has to continue the practice.

Figure 6.5. Causal loop diagram:
Reinforcing feedback when externalities are socialized during the product design process
Sayeh Dastgheib-Beheshti, 19/07/2017
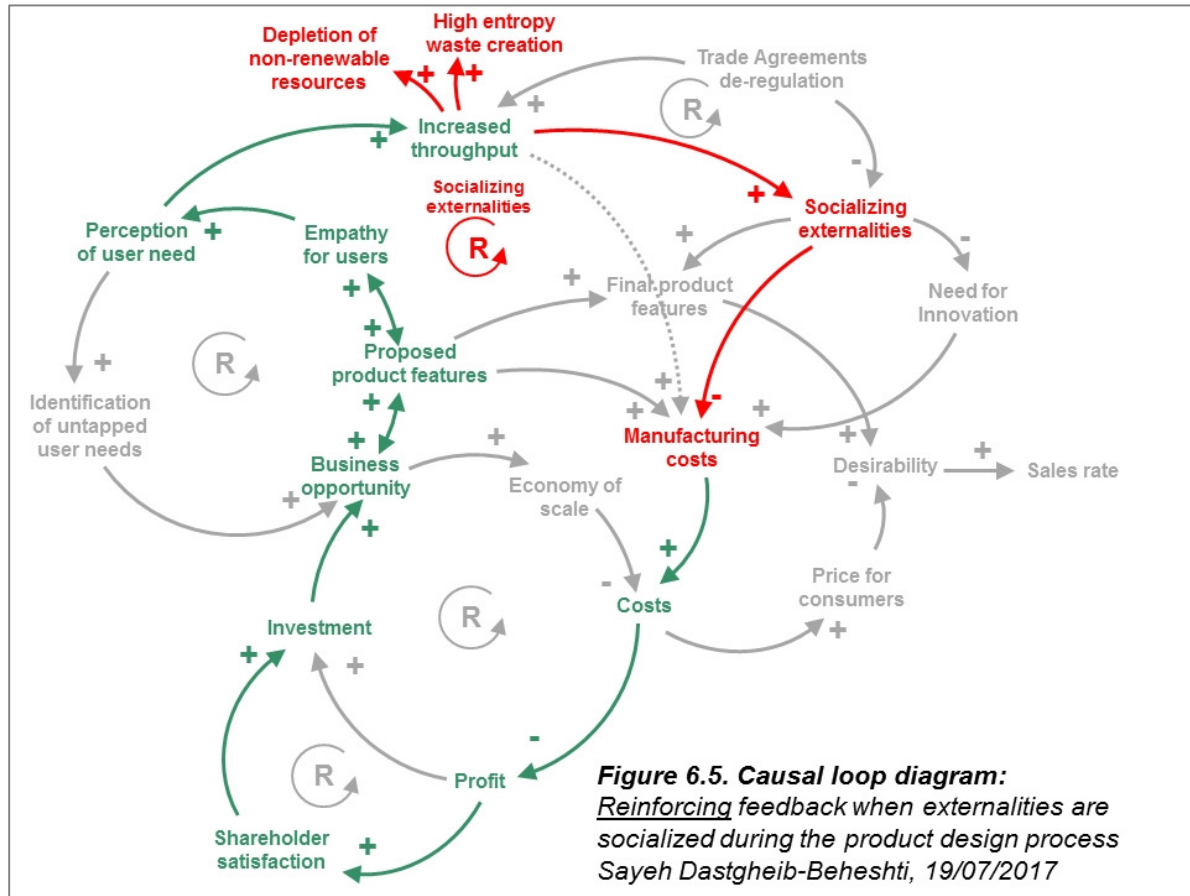
While this explains some things that occur during the design of products in a system where designers are not involved or even aware of the full scope of the consequences of their actions, how does this relate to the role of design in society?

In the next section I will introduce the concepts of complex adaptive systems as well as panarchy, a model that presents a model of the world as a series of nested systems with hierarchical relationships.

6.3. Panarchy: Nested Complex Adaptive Systems

Holland (2006) has defined complex adaptive systems (CAS) as complex systems (those having a large numbers of components that interact) but with the added ability to adapt or learn. The adaption and learning of the system is an emergent property that is not seen in the individual components. Holling & Gunderson (2002) have updated the theory of CAS by adding an element of evolution and naming it panarchy. Their model includes a hierarchy of nested adaptive cycles operating at discrete scales across time and space which can lead to larger systems stabilizing smaller nested ones (Holling & Gunderson, 2002, p.20).

At this point, it is important to remember that the model of panarchy, like all other models, is not a representation of reality but a simplification to foster better understanding. This is a point stressed by Holling & Gunderson several times as they review case studies and experiments, reminding readers that "the adaptive cycle is one part of a heuristic theory of change" (Holling & Gunderson, 2002, pp. 49, 52, 103) in which limits still need to be identified (Holling & Gunderson, 2002, p.51).
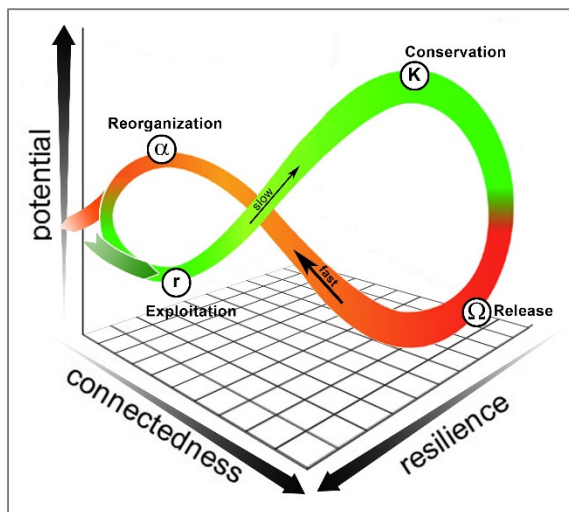
Figure 6.6: *Simplified panarchy loop, based on Figure 2.2 from Holling & Gunderson, 2002, p.41, Redrawn by Sayeh Dastgheib-Beheshti, 2017.*
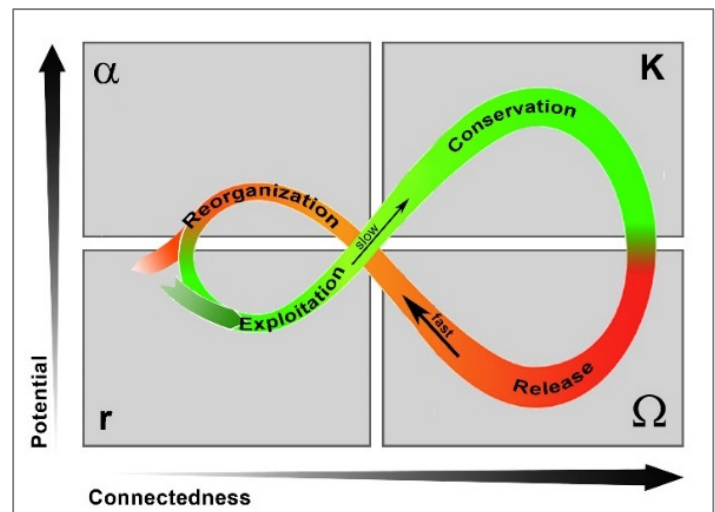
Figure 6.7: *Cycle of Adaptive Change from Holling & Gunderson, 2002, p.34, Redrawn by Sayeh Dastgheib-Beheshti, 2017.*

This model is visualized as a loop in a cube constructed with the three axes **(Figure 6.6.)**: 1. Potential for change, 2. Connectedness of internal processes, 3. Strength and resilience as the ability of a system to experience disturbance but still continue its processes (Holling & Gunderson, 2002, p.34).

The loop itself contains four distinct stages of adaptation within a metaphorical cycle **(figure 6.7.)**: growth or exploitation (r), conservation (k), release (omega), and reorganization (alpha).
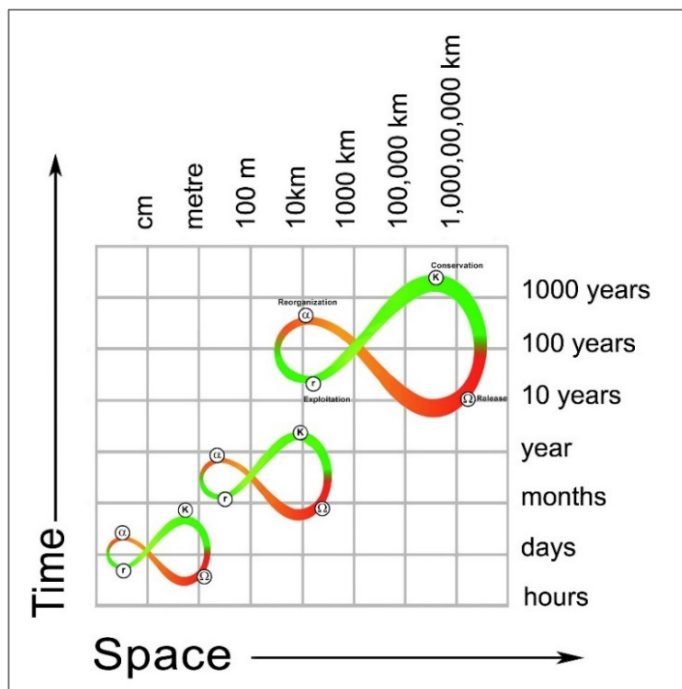
Figure 6.8: A stylized panarchy. A panarchy is a cross-scale, nested set of adaptive cycles, indicating the dynamic nature of structures depicted in the previous plots from Holling & Gunderson, 2002, p.74, Redrawn by Sayeh Dastgheib-Beheshti, 2017

What is the most interesting aspect of panarchy is how it explains the simultaneous existence of different systems of different size and speed **(Figure 6.8.)**. As smaller systems that have faster cycles are nested within larger systems, the stability and resilience provided by larger systems allows the entire nested system the ability to withstand external and internal disturbances **(Figure 6.9)**.

Holling & Gunderson conclude that the minimal complexity needed to understand a panarchy and its adaptive cycles requires 3-5 interacting components in three qualitatively different speeds with a nonlinear causation (Holling & Gunderson, 2002, p.102).
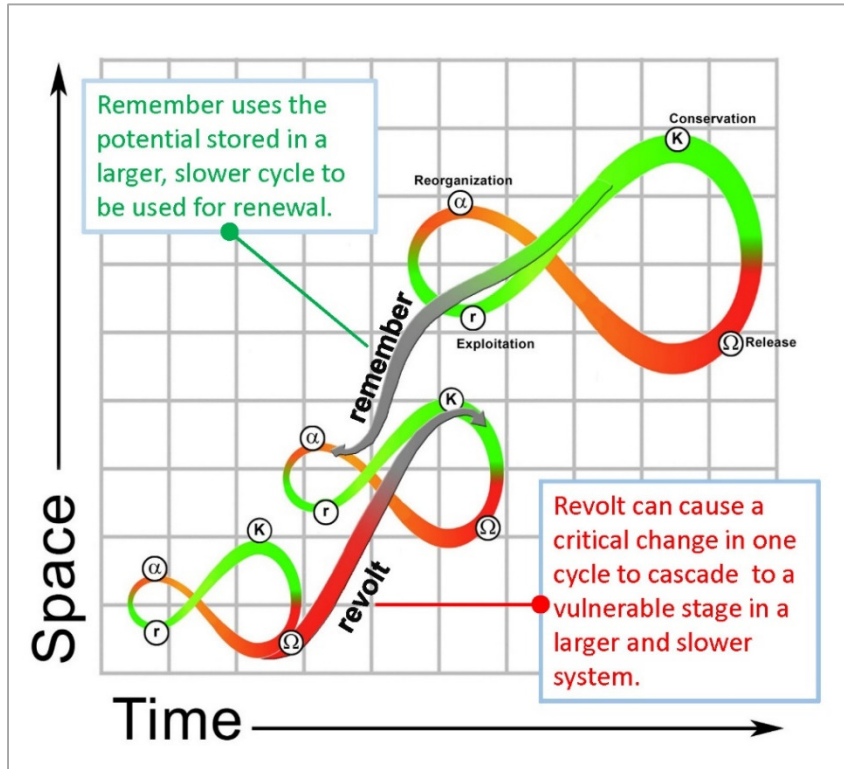
Figure 6.9: *Panarchic connections. Illustration of the concepts of cross-scale interaction which are so important for the concepts of change and renewal, combining learning by fast levels with continuity provided by the slower levels (based on Holling & Gunderson, 2002. pp.74,75) illustrated by Sayeh Dastgheib-Beheshti, June 2017.*

Based on previous discussions, it is easy to see how the activity of design could be envisioned as a system, with the elements we previously identified such as user needs, business opportunities, cost, profit and manufacturing capabilities, all playing a role. While we know that there are interconnections between all these elements, they are harder to detect. Shareholder value may be one such connection that affects decisions regarding product quality and profit, but as Meadows noted, often relationships are not evident.

6.4. Taking a Systemic Approach to Product Design

Looking at the fundamental structure of the design industry, Boehnert (2014) identifies a deep-rooted structural problem where designers are trapped by the systemic bias of capitalism which operates on highly reductive economic feedbacks. Even when designers want to address

ecological concerns, they are trapped within a system that only sees short-term profit, and

denies long-term social and ecological consequences (Boehnert, 2014). This concept is very

much in line with what has been observed in **Figure 6.5** and the causal loop diagram illustrating

the effects of socializing externalities.

One thing I noticed when I tried to represent the concept of the nested systems using the

logarithmic scale used by Holling and Gunderson in **Figure 6.8** is that this type of scale fails to

indicate the varying scales. Instead, I have chosen a linear scale to illustrate how I believe the

historical placement of the design system has changed within the nested panarchic system

model.
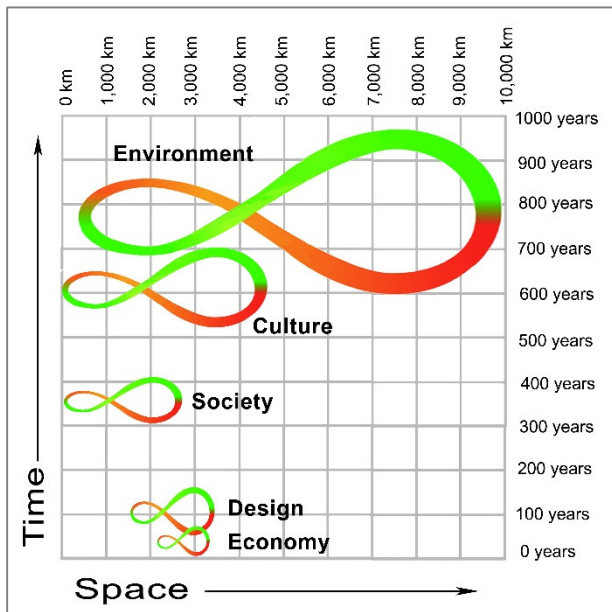
Figure 6.10: Historical position of design and economy in a nested system represented with a linear scale - Sayeh Dastgheib-Beheshti,
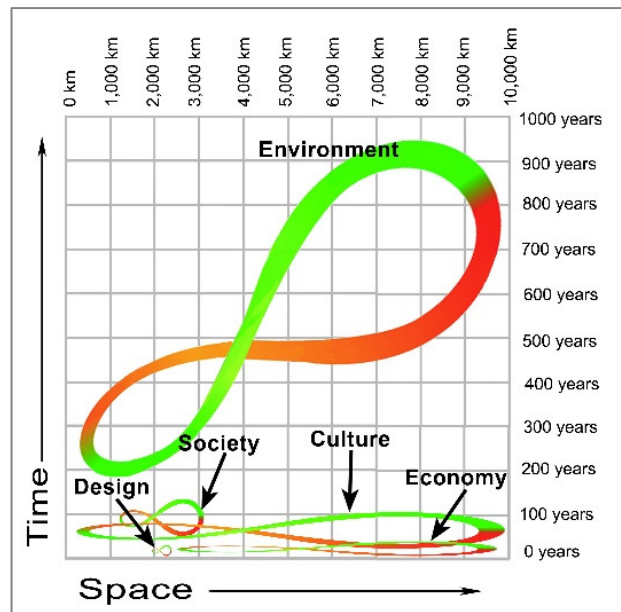
Figure 6.11: Current positioning of design and economy in a nested system represented with a linear scale - Sayeh Dastgheib-Beheshti, 2017.

Figure 6.10 represents an illustration of the historic position of design in relation to the

environment and economy. For simplification, the maximum timeframe indicated is 1000 years

even though in reality the environment uses a timeframe of millennia. Including it would just

render the representations of design and economy almost invisible. In the case of design,

considering that it was a gradual building and sharing of meaning, it operated over a scale of

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hundreds of years, over distances that defined a culture which I estimate as having a range of a country (up to 4000 km). The economy however, focused on faster transactions and trade, operated over a scale of tens of years, but over greater distances.

Figure 6.11. illustrates the current position of design and the economy. The loop representing the environment has been angled to broadly represent the multitude of time/space scales it encompasses. It can be noted that the scale of both design and the economy have changed quite a bit. Thanks to globalization, the economy and a homogenized culture now stretch across a larger area but operates in a much smaller timescale of a days to years. Design has also lost its role in creating meaning and has become a subsystem of the economy.

From the analysis in the previous chapter, it can be argued that design practice is presented by designers, the industry and media as a service industry, with designers offering very little critical thinking about social responsibility or environmental consequences. Is there an ideal location where the system is most receptive for the inclusion of ethical concerns and constraints on throughput?

A closer look at the cycle of adaptive change presented in **Figure 6.12.** indicates two different loops that act in complementary ways to assure perpetuation of the system. Holling and Gunderson describe the back loop of Ω to α as a phase of rapid re-organization that leads to renewal, with high levels of uncertainty. This loop leads to change and variety caused by increasing potential for change and resilience in which weakened connections create an environment for creative experimentation and testing new combinations (Holling & Gunderson, 2002, p.45, 47). Based on the findings described by Cross (2009) regarding how designers work, this sounds like the space that is navigated by designers who thrive by embracing uncertainty and ambiguity.

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Of the many ideas that are generated leading up to α, not all survive the increasing

interconnections that are created in the move to the r phase and subsequent exploitation

(Holling & Gunderson, 2002, p.45, 47).
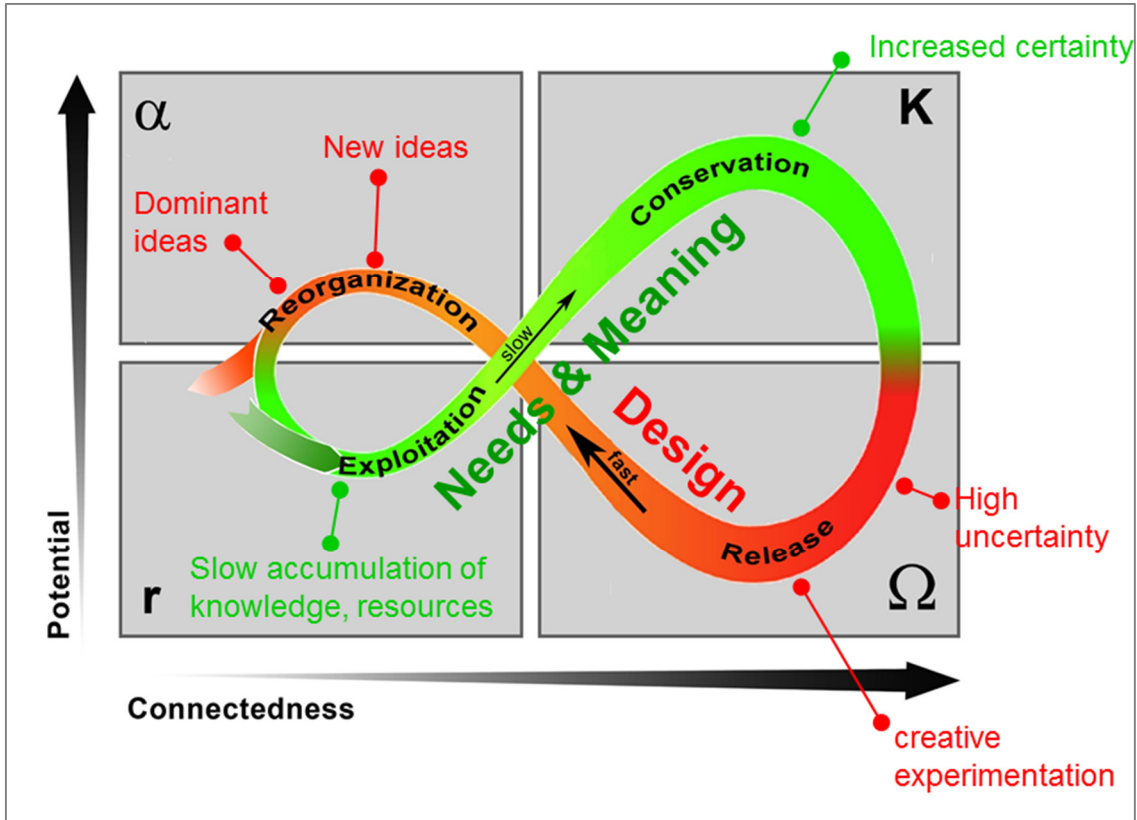
Figure 6.12: *Adaptive Cycle for Product Development with locations for events based on Holling & Gunderson, 2002, p.34 by Sayeh Dastgheib-Beheshti, 2017*

The front loop of **r** to **K** on the other hand is a slow, incremental phase consisting of

growth and accumulation, which we can now expand to indicate accumulation of knowledge,

capital, and resources that increasingly result in rigid connections and certainty. These

structural rigidities can also be caused by optimized production and increased efficiencies,

removing any redundancies that allow the system to be resilient. This loop maximizes

production and accumulation and growth. Holling and Gunderson go on to speculate that any

adaptive complex system will have to produce these two complementary loops in sequence,

each one setting the stage for the two opposites phases which include change and variety in

one, and growth and stability in the other (Holling & Gunderson, 2002, p.47). The various phases of the product development process are highlighted on **Figure 6.13.**
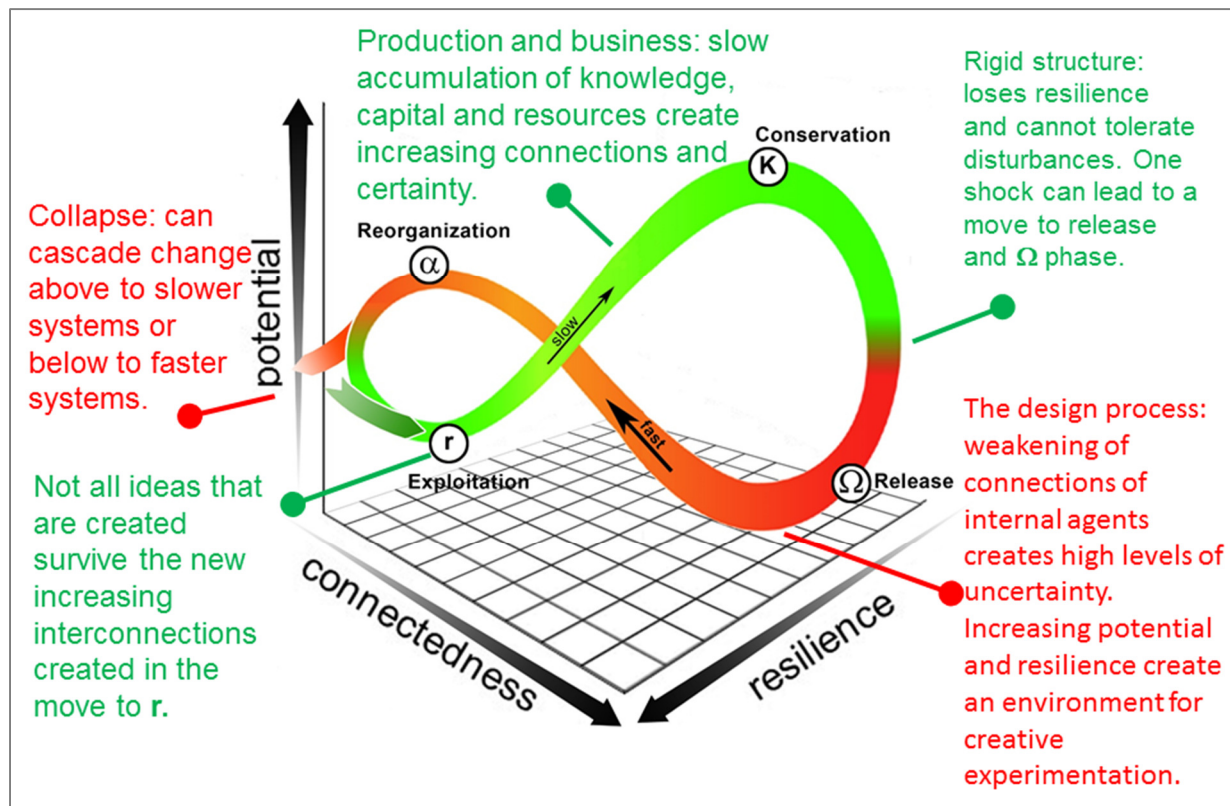
Figure 6.13: *Occurances in an Adaptive Cycle - based on Holling & Gunderson, 2002, p.41 by Sayeh Dastgheib-Beheshti, 2017*

What would be the ideal location for the inclusion of ethical and environmental constraints? **Figure 6.14.** illustrates the changing levels of the three different variables of potential for change, connectedness and resilience within the complex adaptive cycle. To ensure success, the considerations would need to be included at locations with high potential for change. Of the four stages, only α and **k** qualify. In addition, we would need high levels of resilience, allowing the system to tolerate the disturbances these new constraints would cause. This means that α,the realm of design, is the ideal space to include these new constraints. While not all ideas may survive the increasing connections that develop as the system moves to **r**, it still offers the best hope of success.
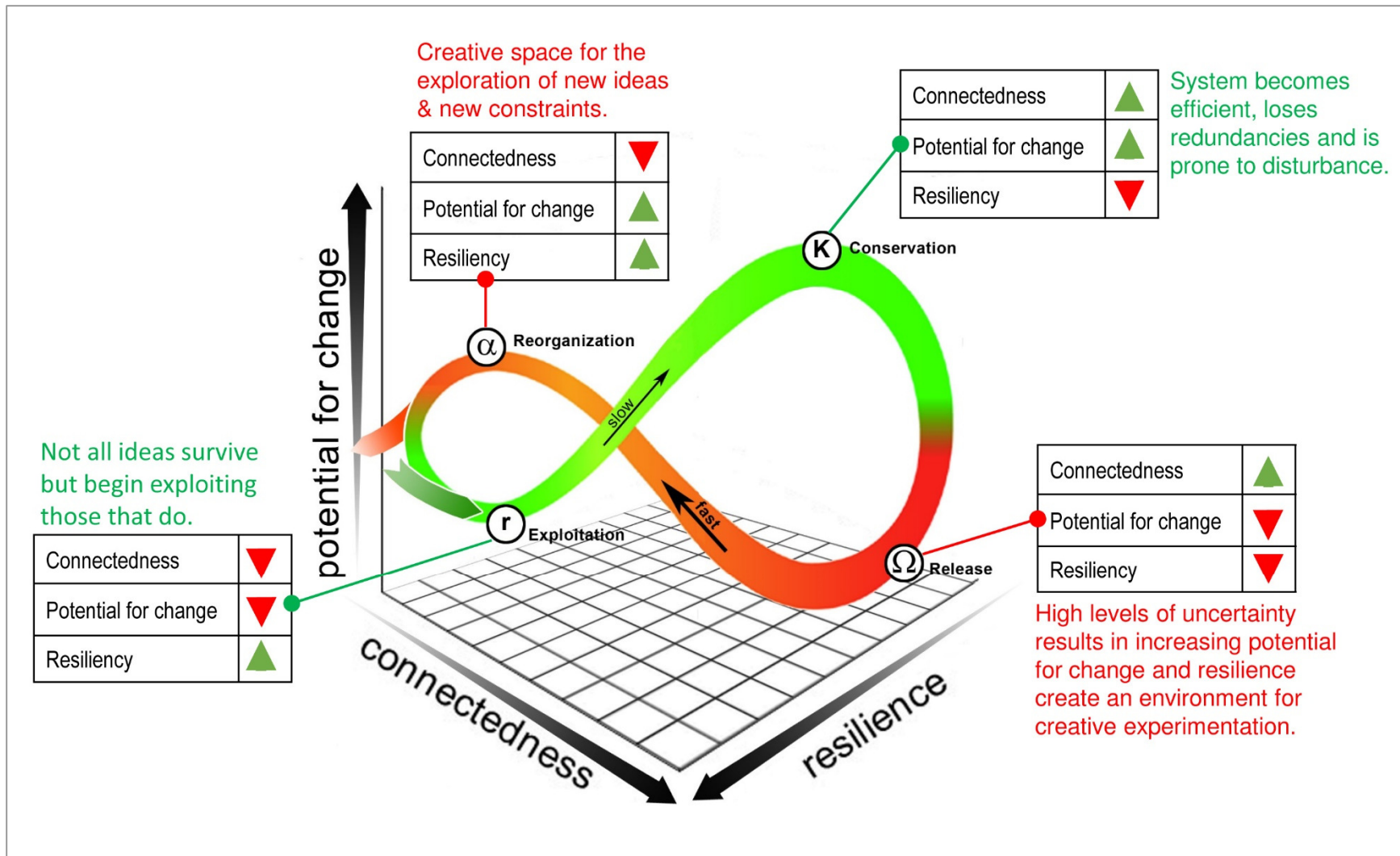
Figure 6.14: *Changing Values in an Adaptive Cycle for Product Development - based on Holling & Gunderson, 2002, p.41 by Sayeh Dastgheib-Beheshti, 2017.*

Conclusion

Throughout this paper, I have looked at the inadequate explanations mainstream economics offers regarding the value of design, how the agenda is being set for the types and scope of products that are created, and the lack of consideration for the various socio-economic and environmental impacts of products through their life-cycles. Under the guise of "growth", material and energy throughput has grown exponentially and using the process of socializing externalities, manufacturers have created a self-reinforcing system that provides them with no incentive to change.

I have looked at the product design cycle as a causal loop diagram that highlight structural problems I see with the current status and impact of product design within our economic system. Most notably, the product design practice has lost its role in creation of social wealth and is now acting as a service industry tasked with profit maximization for a capitalist economic system.

I have also presented arguments on how product design would be best represented as a complex adaptive system embedded within a hierarchical panarchic model. I have presented arguments on how the role and placement of product design has changed with relation to society and the economy. By presenting design and business as two complementary aspects of the same complex adaptive cycle, I have concluded that ethical and ecological concerns are best served by being a part of the design process, during the α phase where there is increased resilience as well as increased potential to change.

Designers have always been visionaries and it's this continued optimism and looking towards the future that can help us define solutions within planetary boundraries. We need to imagine a better world, one which Ehrenfeld (2008, p.49) envisions as one that allows humans and other life to flourish.

One inevitable conclusion from this paper is the importance of taking a holistic approach in addressing the complex social and environmental problems we face. These 'wicked problems' need a new approach that is based on thinking on a deeper level to move past symptoms and get to the root causes of complex problems that have often been caused by incomplete product design methodologies and a biased economic system.

While this paper has only scratched the surface of what promises to be a fascinating intersection between product design, systems thinking and ecological economics, I look forward to continue to work towards building a more tangible model that can be used as a teaching aid in higher education.

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Appendix A: 2016 Living Planet Report

The 2016 Living Planet Report (WWF, 20016) points to the impacts humans have on the planet and that the planet's natural resilience has been greatly strained by growing population and resource use, with the natural capital faster than it can be replenished (WWF, 2016, p.50). An overview of nine critical earth systems presented in **Figure A.1.** indicates that four systems have already been pushed beyond the limits of safe operation (WWF, 2016, p.60). Since the mid-20th century, human activities are endangering environmental systems and the demand on nature is projected to become 75% more than what nature can renew by 2020 (WWF, 2016, p.83) and that the well-being of humans, and populations of all other life-forms, is being jeopardized. (WWF, 2016) According to the report, renewable resources are being used 1.6 times faster than renewal rates. CO_2 is also being released faster than can be sequestered by nature. (WWF, 2016, p.60).
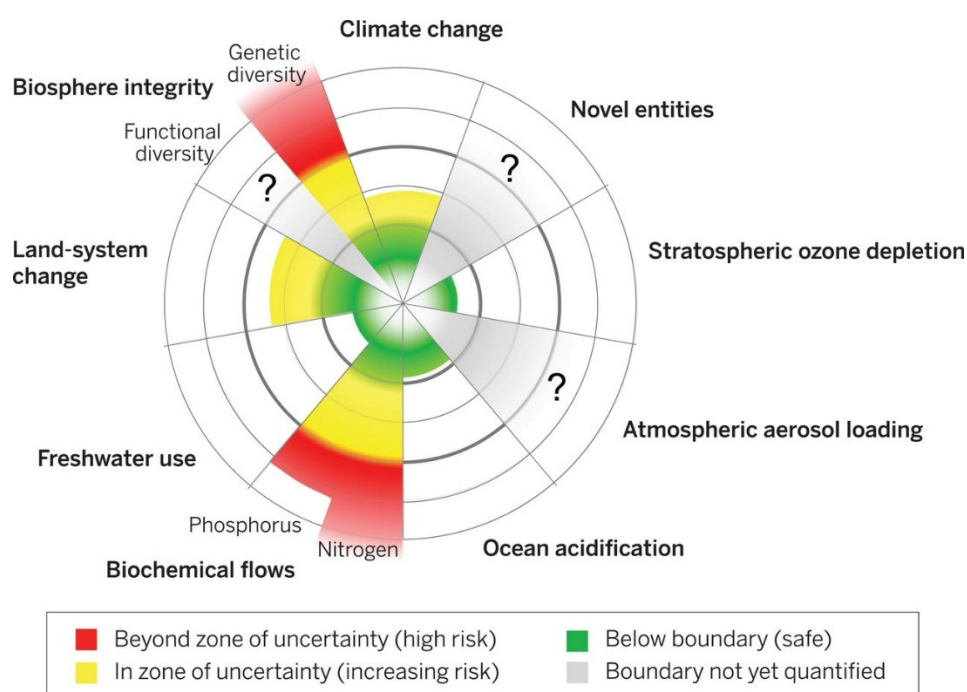
Figure A.1: *Planetary Boundaries (Steffen et al., 2015) have mapped the uncertainty associated with 9 critical planetary systems that each have the potential for disrupting the entire planetary system. (As cited in WWF, 2016, p.61)*

Appendix B: 2013 Rana Plaza Factory Collapse

One example of such a case is highlighted in the 2016 report compiled by International Labour Rights Forum (ILRF) and other organizations: Dangerous Delays on Worker Safety. In the aftermath of the deadly Rana Plaza factory collapse in April 2013 that killed 1,137 people in the world's worst garment factory disaster in Sana, Bangladesh (ILRF, 2016). The Alliance for Bangladesh Workers Safety ("The Alliance"), a voluntary organization formed in the summer of 2013 by Walmart, Gap, VF Brands, Target and Hudson's Bay Company, pledged to take all actions necessary to correct safety hazards in their supply chain factories. The report found that although The Alliance gave passing grades to Bangladeshi factories that have yet to implement life-saving safety changes the retailers pledged to put in place. The report provides statistics that workers continue to work in buildings in which 62% lack viable fire exits and do not have a functioning fire alarm system as well as 47% have major uncorrected structural problems. While these life-saving changes were slated to be completed within a year of the disaster, The Alliance has already extended this deadline two times, with 2018 now set as the final date for completion, the same year its mandate is completed, leading to the question of whether it is serious about implementing changes or is prioritizing the protection of the reputations of the members brands (ILRF, 2016).

Appendix C: Lock-in of the Internal Combustion Engine

Beginning in the 1700's until the 20th century, there was a lot of diversity in the engines designed for locomotion using hydrogen, steam, electricity as well as fossil fuels ("History", n.d.). At the turn of the 20th century, 40% of the automobiles in the United States, just over 35 thousand, were powered by steam, while 38%, almost 34,000 were electric. Gasoline-powered cars, which had been around since 1885, were considered dirty, noisy, polluting and due to gunpowder shots, cranks or pulleys needed to start them, very dangerous to operate, so they only held 22% of the market ("History", n.d.). How did fossil-fuel powered cars move from occupying fifth place to becoming the only option by the end of the 1920s?

Several factors played key roles, including the invention of the electric engine starters in 1912 which eliminated the dangers of starting cars, the discovery of large petroleum reserves which provided a very low-cost fuel, and Henry Ford's mass production techniques that reduced the costs of manufacture ("History", n.d.). With improved infrastructure and the promotion of driving as a leisure activity, everyone could now display their new-found status as they drove around ("History", n.d.). Subsequent policies in the 1950s through bipartite policymaking allowed automotive companies to greatly influence legislation, dismantle public transportation systems, leaving people with no choice but to purchase cars ("History", n.d.).

While the internal combustion engine is one of the least efficient ways of utilizing the energy embodied in gasoline, yielding only 17-26% depending on driving conditions, continues to persist for a variety of reasons.

Dastgheib-Beheshti & Doherty (2015) pointed to the work of Perkins (2003) which identifies the two main reasons for existence of lock-ins as the existence of a technological paradigm and successes from increased adoption (Perkins, 2003, p.1). Perkins believes that tendency of people to stay with what works is based on a technological paradigm that occurs when people only trust what has been proven to work in the past (Perkins, 2003, p.1). The success with this broad based adoption creates a positive feedback loop that reinforces the paradigm, ensuring all investments occur in the field which is known to succeed leading to lower costs, technological interdependencies with related products, increases adoption rate by others and as well as learning economies (Perkins, 2003, p.2), (Dastgheib-Beheshti & Doherty, 2015).

Lock-ins are normally considered market failures, since the market fails to allocate resources in the most efficient way, allowing an inferior technology to persist. The strength of the lock-in also means that innovation is hindered since it's too costly to conduct R&D and there is little incentive to innovate. In the case of the lock-in of the internal combustion engine, there are the added environmental issues caused by toxic by-products and greenhouse gas emissions created during oil extraction, refining and combustion (Perkins, 2003, pp.4-5), (Pollutions issues, n.d.) that damage public health and the environment as well and produce one quarter of greenhouse gas emissions in the United States alone (Pollution issues, n.d.).

A simple act of designing the internal combustion engine has had implications beyond anything anyone ever imagined, locking societies all around the world into pathways that has undermined social, cultural and ecological values. It may be argued that the short-term benefits of the internal combustion engine made humans blind to its consequences. One such consequence could be the construed as its impact on modern agriculture, speeding up the process and surface.

Figure C.1: *Causal loop diagram exploring the lock-in of the internal combustion engine as dominant form of transportation- Sayeh Dastgheib-Beheshti, 2015*

Appendix D: Cross

Summary of: Design thinking: Understanding how designers think and work. (2011). Cross, N. Berg.

In an attempt to provide grounded theory (systemic generation of theory from systemic research) for understanding the creative and cognitive abilities of designers, Nigel Cross uses an abductive process based on interviews, direct observations, analysis, reflection and theorizing from three designers and one three-person design team (Cross, 2011, p.7). Since design thinking ability is a highly sophisticated cognitive skill that cannot be observed directly, Cross hopes that the combination of various techniques, can provide some insight.

Cross (2011) refers to research conducted by Robert Davies in which he describes that although at first glance designers offer intuitive responses, their lack of need to provide rational explanations or justification for their decisions likely stems from their large bodies of experience and prior learning (Cross, 2011, p.11). Observing how designers approach the dualities of problem and solution, Davies believed the process to be utilizing aspects of emergence in that the concept of the meaning of both problem and solution were developing at the same time, evolving into something more complex than either one separately (Cross, 2011, p.11). This level of uncertainty, even ambiguity, and the willingness to embrace it (Cross, 2011, p.15), is very important to designers, since as Larry Bucciarelli noted, it is essential to the design process since it allows designers the space to "maneuver independently within object worlds" and "recast meaning in negotiation with others" (as cited in Cross, 2011, p.19).

Cross proposes the following defining features as common in the process used by creative designers in achieving innovative design through a process illustrated in **Figure D.1.**:

1. Broad systemic approach: this begins with not accepting the initial narrow problem description that has been offered and instead taking a holistic overview of the interconnected nature of how things relate to each other (Cross, 2011, p.63).

2. Defining or "framing" the problem to be solved in a distinctive way, by reformulating the problem, often in a personal way, leading to the creation of a pattern to suggest new pathways to solutions (Cross, 2011, p.63).

3. Designing from 'first principles (Cross, 2011, p.62) referring to the continued search for fundamental physical principles. Cross has illustrated the process as such:

Cross (2011, p.102) defines the characteristics of good designers as:

1. Ability to operate "seamlessly across different levels of detail, from high-level systemic goals to low-level physical principles".
2. "Apply their intelligence to the wider context" to look beyond the problem as given "and suggest imaginative, apposite solutions that resolve conflicts and uncertainties".
3. "They have cognitive skills of problem framing, of gathering and structuring problem data and creating coherent patterns from the data that indicate ways of resolving the issues and suggest possible solution concepts."
4. Possessing design intelligence as "an intense, reflective interaction with representations of problems and solutions."
5. "Ability to shift easily and rapidly between concrete representations and abstract thought, between doing and thinking" (Cross, 2011, p.102).
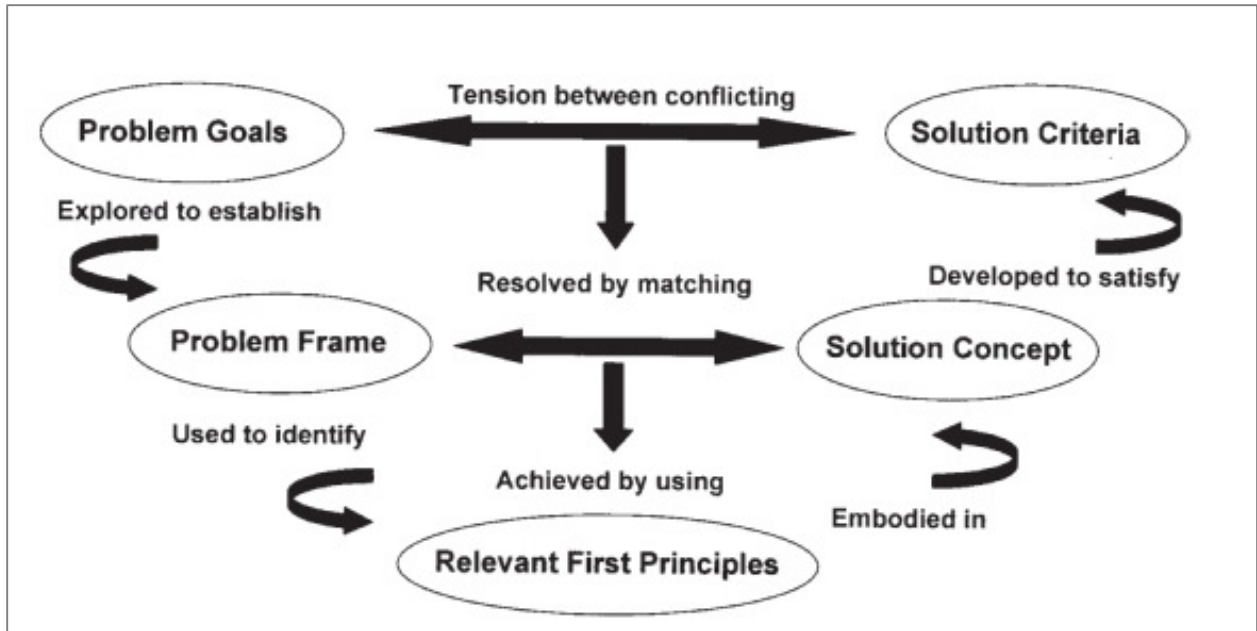
Figure D.1: *Model of the design strategy followed by creative designers from Cross, 2011, p. 65*

Summary of: The all new universal traveler: A soft-systems guide to creativity, problem-solving, and the process of design (1972) ([Rev. ed.] --.). Koberg, D., & Bagnall, J. [Los Altos, Calif.: W. Kaufmann.

With the publication of "The All New Universal Traveler" in 1972, Koberg and Bagnall, two professors of Architecture at California Polytechnic State University in San Luis Obispo, California set out to create a universal problem solution methodology. Using the analogy of traveling, Koberg and Bagnall have studied specific scholars and various problem solution processes, and extracted their essential characteristics to develop their own methodology (Koberg & Bagnall, 1972, p.16).They present various activities and methodologies based on the works of such notable academics as Arnold, Churchman, Dewey, General Electric, Gordon, Guilford, Kepner-Tregoe, Osborn, Parnes, Pert, Rossman, Stanislawski, Wallas, Zwicky and the Military, while basing others on popular themes with no referenced foundation

Their simplified, often unconventional methodology for problem solution is based on a 7-step design process that includes acceptance, analysis, definition, ideation, selection, implementation and evaluation which may occur partially, in sequence as a linear format or a circular format.

1. Acceptance: declare initial objectives, "buy" into it and set aside resources and dedicate time to work on it, give the problem life (autonomy, assume responsibility, make the problem a part of yourself, establish motives(Koberg & Bagnall, 1972, p. 37), and allow problem to become the primary generator of the process (Koberg & Bagnall, 1972, p. 17) .

- **1.1.** **Ad Valorem:** Increasing the value of a problem situation by increasing their importance and your interest.
- **1.2.** **Personal priorities Matrix Method:** Use a simple matrix (grid of squares) to plot graphically plot out what is facing you.
- **1.3.** **What's in it for me? :** By making a list of all the benefits you expect (direct and indirect ones), can help you decide if the benefits are worth the investment and cost, both in time and money.
- **1.4.** **Self-hypnotism:** By removing all distractions and meditating on the problem, you can remind yourself how good it will feel once the problem is solved.
- **1.5.** **Conformity:** By accepting and becoming the problem, you can begin to understand it.
- **1.6.** **Give it up:** Using Zen philosophy, begin on thinking what your solution is and how you can attain it.
- **1.7.** **Who's in charge? :** By accepting the responsibility to change your life, you acknowledge that you can make conscious decisions and "be in charge".
- **1.8.** **I am responsible:** Imagine a tough job to realize your own work is easy by comparison.
- **1.9.** **Tragic scenario:** By imagining all the worst things that could happen if the problem was not solved, you can build a strong case in your mind that compels you to action.
- **1.10.** **Analogy acceptance:** When it's difficult for you to accept a situation, you can think of how other people or things accept their own situations. (Ex. Door accepting a person, toaster accepting toast, cat accepting affection…)
- **1.11.** **Contingency management:** Some of the ways of changing habits can help deal with negative inertia and include: being strict and consistent, being reasonable, understanding limits and giving yourself incentives (reward or punishment)
- **1.12.** **Declaration of acceptance:** Writing down the reasons you believe solving your problem is worth the effort.

1.13. **What's holding you back? :** There are usually seem to be 4 main reasons for procrastinating: having to endure what seems like punishment, another activity seems more enjoyable, relevance of taking action not clear and other issues seem more pressing.

1.14. **Stanislavski method:** Treating the problem as important and memorable and celebrated as an event and dropping any preconceptions.

1.15. **Habit maker:** Make a list of habits standing between you and your goals, knowing that you may have to adopt new habits to achieve your goals.

2. Analyse: Discovering the world of the problem by getting the ins and outs (Koberg & Bagnall, 1972, p. 17) by getting to know more about the problem situation while clarifying what you already know. This is a convergent phase. The methods in this step are:

2.1. **The basic questions:** With a strong desire to determine the what, why, where, who, when or how within a certain time limit, it can help you gain a much better understanding.

2.2. **The clever pack rat:** Everyday, spend some time by finding a new source, angle, expert, problem situation to bring back to your collection of information. Afterwards, try to relate the information together and creating a clearer picture of your problem.

2.3. **Synectics/ forced relationship:** By questioning the similarities (synectics) or forcing relationships between two components, you can gain a deeper insight.

2.4. **Start a journal:** this can become a dedicated record book and a place for comparisons and interrelationships, relating it back to things you are already familiar with.

2.5. **Back to the sun:** By reducing anything back to its primary energy source, the sun, you can get a better understanding about it.

2.6. **Attribute listing:** can be separated into physical, psychological and social characteristics of things. This step can help identify what makes something unique.

2.7. **"Record all you know about it":** beginning with the obvious, write down all that you know about the problem.

2.8. **"What have others done":** understanding that present problems are a part of a long list of inter-related events, shows that it is important to understand past steps of people dealing with similar situations.

2.9. **Analysis models:** creating an abstract model of something, can help clarify the situation. Creating models can help illuminate the problem. One way would be to list all the problem variables, categorize them and systematically combine them to understand all possible variations. You can even make simple 3D geometric shapes to understand possibilities.

2.10. **Matrix:** Creating a grid to plot the inter-relationships can help determine which one is more dependant/ independent. The important step is to create a system which consistently deals with all decisions in the matrix.

2.11. **Search for patterns:** Problems are usually based on smaller sub-situations which by understanding, you can get closer to a collective end. The larger the number of patterns identified and understood, the greater the understanding of the overall situation.

2.12. **The expert consultant:** When the going gets tough, reaching for real or imaginary experts can help gain insight.

2.13. **Expanding objectives:** With new insights, old objectives should be revisited and clarified.

2.14. **The idea-dump:** By discarding the obvious solution which seems perfect, and cleansing your mind, you open up the possibility to consider other options. Be sure to share ideas and gain valuable insight, but consider that you may still end up using all or parts of your original idea.

2.15. **The sensitivity game:** by opening up your sensory responses, it may change how you perceive things. Often things are different from our expectations so this can be quite enlightening.

2.16. **Squeeze and stretch method:** A combination of divergent and convergent thinking, this method, stretching a problem by asking a chain of questions based on "what?" allows us to see how much is contained within the problem. To squeeze a problem down to its essentials, you ask a chain of questions beginning with "why?"

3. Define: Acts as a bridge between how things are, and how you would like them to become (Koberg & Bagnall, 1972, p.65). Decide on the main issue of the problem and clarify goals (Koberg & Bagnall, 1972, p.17). This depends largely on each person's "unique environment established by individual experiences, physical realities and values" (Koberg & Bagnall, 1972, p.59) as well as worldviews. As a bridge between analysis and synthesis, definition will act as a filter, only allowing relevant matters to proceed.

3.1. **Points of view:** Listing the people you think might have an opinion of the situation you are dealing with, and attempt to see the situation as they might. You can then determine which parts are relevant for you.

3.2. **Essence-finding chart:** A chart that lists all the attributes or components of a problem, can help compare them individually, against each other to determine their degree of dependence or independence within the group.

3.3. **"Happiness is…":** Based on the definition expansion method used by Charles Shultz in his "Happiness is" cartoon book, this method can be utilized to find as many definitions as possible for the problem you are dealing with, and use in subsequent analysis.

3.4. **King of the mountain:** Based on a children's game where others try to unseat the "king", a similar procedure can be used to play elements, components, objectives and attributes of a problem, to determine the hierarchy of importance.

3.5. **Key word distillery:** Writing a general statement that contains the most important objectives, concerns and relevant points, allows you to highlight the most important aspects by identifying key aspects. Those key aspects and disjointed words can then be rewritten, through this deductive technique, into a cohesive set of instructions.

3.6. **Problems within problems:** Identifying the sub-situation within a situation, can be one of the best ways to solve the problem.

3.7. **Talk it out:** Talking out the situation with another person is one of the simplest ways to defining things. Definitions are essentially the bridge

3.8. **Paraphrase:** One proven way to increase familiarity and gain insight is saying the same thing in many different ways. Each new way of saying the same thing will force you to slightly modify your viewpoint.

4. Ideate: Generating options and searching for means to achieve objectives (p.17).

4.1. **Brainstorming:** This idea generating method focuses on coming up with alternatives by aiming for a quantity of ideas, letting loose and allowing ideas to flow, tagging on new ideas to what you already have, and deferring any judgment.

4.2. **Manipulative verbs:** You can rethink the structure of your problem by manipulating the subject in some way. This can be with regards to changing its position, altering its shape, size, function, etc. Using verbs such as magnify, minify, rearrange, alter, modify, substitute, reverse or combine, you can imagine new possibilities.

4.3. **Synectics:** Questioning similarities can generate new ideas.

4.4. **Tell me, stranger:** Often we create psychological barriers around problems that we are personally vested in. Another person might not have the same barriers and be able to look at it with fresh eyes.

4.5. **Go to the library:** Asking a reference librarian for new sources might point you in a new direction.

4.6. **Attribute analogy chains:** This method is an inertia-breaker, facilitating a free flow of ideas. Using problem attributes identified in the analysis stage, you can generate new ideas.

4.7. **Get out of town:** Distancing yourself (mentally or physically) from the problem environment might offer a new perspective.

4.8. **Morphological forced connections:** By creating a list of alternatives for attributes already defined, you can make random connections to create new solutions.

4.9. **Seeds of ideas:** by analyzing the situation to find the principles involved, you can try to apply that principle to multiple situations (simplification of processes, movement, tasks….)

5. Select: Determining best way forward by looking at ideas both objectively and subjectively.

5.1. **Screening by personal opinion:** Comparing choices and deciding which one best fulfills the statement of definition or intentions.

5.2. **Ideas/objectives comparison method:** Listing specific objectives and ranking and weighing them allows you to order ideas in order of importance. By removing duplicates, you can focus on distinct ideas, noting their differences and which ones can be understood clearly/

5.3. **The potpourri:** When it's hard to choose amongst several good ideas, one option is to combine all the best parts of the ideas to get one that contains something from each idea.

5.4. **The Indian scout:** Based on the idea of what could possibly happen if an idea was implemented, you try to imagine the experience of each idea. Similar to the PERT (Program Evaluation Review Technique), a "critical path", the sequence of options with the most important consequences, is identified.

5.5. **User/chooser:** Simplify the defined criteria to eliminate confusion and facilitate choice.

5.6. **One at a time:** If unable to decide, take each option through an experimental sequence to flesh out the best choice.

6. Implement: taking action or planning on how to give form to the selected "best way" (Koberg & Bagnall, 1972, p.17) and translating an idea into a solution (Koberg & Bagnall, 1972, p.80)

6.1. **Time-task schedule:** Creating a list of all the tasks that are required to complete the project, determine the amount of time you have for the project, assign reasonable portions to each of the tasks identified and illustrate it with a graph.

6.2. **Brainwashing:** As you may be exhausted and demoralized, you may need to revisit some of the original motivations that got you started on the process.

6.3. **Performance specification:** Similar to objectives and includes desired qualities.

6.4. **Advocacy:** Helping an idea help itself, by explaining it to beneficiaries and getting them to get involved and help with the implementation.

6.5. **Attribute analog:** Creating a sliding rule of attributes (like an analog computer), might allow for reconfiguration between two values.

6.6. **'Live up to your name':** Finding a name for a product can help pull all of its parts together and make it cohesive.

6.7. **The native artisans- Flea market:** A wide collection of methods and tools:

6.7.1. **Principles of design:** harmony, contrast, balance, order, unity

6.7.2. **Diagram and schematics:** as visualization tools

6.7.3. **Models or mock-ups** leading to a finished model and prototype to study the final prototype.

6.7.4. **Bionics:** the science of interrelating natural and man-made systems is also an approach on the models technique, and looks to natural solutions for inspiration.

6.7.5. **Following a similar model:** Looking at others for inspiration on how their solutions were implemented is one form of apprenticeship.

6.7.6. **Pattern language:** Identifying a large number of sub-problems within a system, can make it easier to create small, easily acceptable solutions that can be related to current experiences.

6.7.7. **Archetypical form:** can be considered the stereotype of a form, something that is a learned response to a situation. They include our preconception of what things typically are.

6.7.8. **Common denominator:** Complex or multi-part solutions are more easily implemented if we locate an element, unit or component that gives all parts a common relationship.

6.7.9. **Essential unit building block:** As a variation of the common denominator method, this method includes small units that following specific rules, can be combined into larger systems.

6.7.10. Holistic or total form method: as the opposite of essential unit building blocks, this method begin with wholes and breaks them down into smaller components.

6.7.11. Response to human needs: Based on the idea that all problems in some way begin as unsatisfied needs, the solutions must satisfy those needs. They can include physical and survival as well as psychological needs.

6.7.12. "Implications" technique: involves "building a vocabulary of concrete solutions for each idea abstraction" (Koberg & Bagnall, 1972, p.90)

6.7.13. Consultants team technique: By becoming a team leader and dividing your idea down to distinct sections and getting "experts" in each area to deal with a section, you can get stronger and better results.

6.7.14. Structural limits: Use the underlying structure that stabilizes and holds the form together to be the limiting factor. Adapted from civil engineering, this method can work for other areas too.

6.7.15. Sensory checklist: Using the five senses as a checklist, no solution should be deemed complete unless it addresses each sense and includes features to enhance perceptions through senses.

6.7.16. Charade /role-playing method: by "becoming the thing", and playing the role of people affected by your solution, you can live through the implementation before it happens.

6.7.17. Notation systems technique: developing your own system of notation to deal with complex or repetitive operations, can greatly simplify the process.

6.7.18. Inspiration or lightning bolt approach: highly unreliable and untrustworthy, trying to achieve goals by discipline and intention works much better.

6.7.19. Trial and error method: a strategy of implementing and evaluating in an experimental way, is one of the best ways to proceed regardless of methodology.

7. Evaluate: measurement of both quantity and quality of process includes a critical review, assigning value and reflecting on achievements.

7.1. **Three phases of evaluation:** 1. Statement of goals as measurable objectives, 2. Quantitative review of objectives reached, qualitative review of benefits accrued, contingencies of unforeseen benefits, problems or additional objectives, as well as point-by-point comparison of goals and achievements. 3. Planning for the future by reviewing and reinforcing behavioural changes.

7.2. **Progress chart:** Review your progress to see how far along you are in meeting your objective.

7.3. **Who else has an opinion:** getting different viewpoints through specific questions leading to suggestions, can provide very useful feedback.

7.4. **Step outside for a minute:** during evaluation, when our good intentions in beginning a project are challenged, we may become "offensively-defensive". By stepping outside your own self-image, you can look objectively at what has taken place, and be more open to improvements.

7.5. **Letter to your best friend:** By writing a letter to yourself describing your achievements and what they mean, you can revisit the situation in a few days to determine the value of your intentional achievements.

7.6. **Academic:** Use grading to evaluate your results by assigning a letter grade.

8. Additional side-trips: These are methods and techniques that can be utilized at any time, to enhance the design process. **Creativity games:** habit-making and habit-breaking exercises to expand creativity

8.1. Games to develop humor: 1. Laughter (changing a normal, expected situation into an unexpected one), **2. Mimicry**, (mime and role-playing: make you smile at your own behaviour), **3. Punning** (seeing the double-meaning in several facets of life, can free up tension).

8.2. Games to develop awareness: Pretend you are **1. eating something for the first time** and use all 5 senses or take your **2. senses on a field trip** with the goal of getting the maximum out of the experience and record it in a notebook.

8.3. Games to renew the child in you: In your mind, try successively **1. jumping into other people's shoes**, or take **2. quick action** without thinking about consequences, or allow yourself to **3. Experience something** without thinking about it.

8.4. Games to develop belief in self: 1. Write a column in a local paper, 2. design a monument to your dreams, 3. explain your proficiency to friends, 4. imagine that you have just won the Nobel Prize, 5. go for a week without explaining or excusing yourself to anyone or 6. Imagine yourself as a senior citizen giving advice to college sophomores.

8.5. Games to develop freedom from pride: 1.having someone make a move of you that includes unflattering shots, can help you discover how different you are from what you think. 2.Breaking fear habits such as answering the phone, speaking up or 3. turn what is boring into relevant and engaging.

8.6. Games to develop constructive discontent: 1. seeing a problem from someone else's viewpoint and 2. Turning a personal loss into a positive and enjoyable experience.

8.7. Games to develop wholeness: seen as awareness of your full potential to act in a holistic way (Koberg & Bagnall, 1972, p.107) these games allow you to use your full logical and emotional potential. 1. Use perpendicular mirrors to see how other see you, 2. take two pictures (serious and playful) and keep them as reminders of your two natures.

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Appendix F: Kelley & Kelley

Summary of: Creative confidence: Unleashing the creative potential within us all. (2013). Kelley, T., & Kelley, D. Crown Business.

As one of the earliest promotion of design thinking for management, this book describes 6 basic tools to unleash creative potential arguing from the position that design thinking is different from other problem solution techniques. They quote the work of Stanford professor Albert Bandura as the theoretical grounding for the importance of the appropriate belief system and how setting ones sights high allows one to accomplish more as well as be more resilient when faced with obstacles (Kelley & Kelley, loc. 224-228).

They present successful solutions as those residing in the "sweet spot" between technical feasibility, business viability and desirability by people. Their proposed creativity process is presented as 4 steps: inspiration, synthesis, ideation and implementation, each presented through examples of inspirational cases occurring in business environments.

In conclusion, this book seemed to offer a very non-judgmental, encouraging view that any problem is valid and can be solved creatively.

Design thinking is a way of finding human needs and creating new solutions using the tools and mindsets of design practitioners. (Kelley & Kelley, loc.396). While analytical thinkers are anxious to provide an answer to an unresolved question and move on, creative thinkers, confronted with the same open-ended question realize that there may be several possible solutions, before converging on a solution.

An Adobe Systems poll of five thousand people on three continents reports that 80 percent of people see unlocking creative potential as key to economic growth. Yet only 25 percent of these individuals feel that they're living up to their creative potential in their own lives and careers (Kelley & Kelley, loc.161-163). d.school was founded in order to unleash the creativity Kelley & Kelley argue exists within each person.

"As legendary psychologist and Stanford professor Albert Bandura has shown, our belief systems affect our actions, goals, and perception. Individuals who come to believe that they can effect change are more likely to accomplish what they set out to do. Bandura calls that conviction "self-efficacy." People with self-efficacy set their sights higher, try harder, persevere longer, and show more resilience in the face of failure" (Kelley & Kelley, loc.224-228).

One way to achieve creativity is guiding the creative process with step-by-step progression, gradually increasing the level of challenge while a large part of the process involves having empathy towards your intended users. Successful solutions find the sweet spot of feasibility (technical), viability (business), and desirability (people):

- Technical factors - technology needs to work

- Business factors - needs to be produced and distributed in an economically viable way

- Human factors - deeply understanding human needs. Beyond just observing behaviours, this third aspect of successful innovation programs is about getting at people's motivations and core beliefs.

Their proposed process contains the following four steps:

Inspiration: empathy, connecting with the needs, desires, and motivations of real people

Synthesis: Sense-making: recognize patterns, identifying themes, and find meaning, create empathy map. Translate what has been uncovered in research into actionable frameworks and principles.

Ideation and experimentation: generate ideas, consider divergent options. Quick and dirty. Feedback from users and stakeholders is used to work towards "human-centered, compelling, workable solutions". (Kindle Location 386).

Implementation: roadmap to marketplace

"Many organizations or teams use benchmarking when they want to innovate. They check out what their competitors are doing and pick what they consider "best practices." In other words, without questioning current ways of doing things or seeking new insights, they copy and paste" (Kelley & Kelley, loc.1151-1153).

A large part of the emphasis of Kelley's book is about building empathy with people. They articulate" Empathy is more about understanding latent needs, even if people can't articulate them to you. By watching real people and their actions, you can learn things you'd never find out if you asked them straightforward questions alone. Here are a few techniques adapted from IDEO's Human-Centered Design (HCD) Toolkit. Try practicing them with a partner before you go out into the field (Kelley & Kelley, loc.1291-1294).

Some tools to help unleash creative potential:

Divergent & creative thinking: Mindmaps; Using a large piece of paper, you begin by writing a central topic or challenge. You ask yourself "what else can I write on the map that is related to the theme?" and add avenues of thought as you branch out. You may identify additional hubs which have ideas that branch out. Not only they help capture thoughts you already have, but also help generate new leads.

Increasing creative output: have methods to capture ideas as soon as you have them.

Generating ideas: when you generate ideas, you are balancing two goals: fluency (the speed and quantity of ideas) and flexibility (ideas that are truly different and distinct). (Kelley & Kelley, loc. 2796-2797)

Empathy map: 4 quadrants labeled say, do, think and feel. Using post it notes and color-coding them for positive/negative feelings, you are able to populate the two left-hand quadrants (say and do) and then begin inferring the two right hand ones of feel and think. This allows you to come up with valuable insight and begin to see patterns.

> I like/ I wish allows for constructive comments.

> Build empathy with the customer and look beyond your narrow definition of your offering to consider the total customer experience (journey map).

> "Societal pressures and corporate norms nudge us toward ideas and behaviours that are "appropriate" or expected. But the rewards for creativity and individuality are well worth the effort." (Kelley & Kelley, loc. 3064-3066).

Appendix G: IDEO

Summary of: The Field Guide to Human-Centered Design. (2015). Retrieved from:
http://www.designkit.org/resources/1

Under the leadership of CEO Tim Brown, since its establishment in 1991, this prominent global design
consultancy has been one of the most active promoters of design thinking. In 2011 IDEO.org was
registered as a non-profit dedicated to applying human-centered design to alleviate poverty. To this end,
IDEO.org offers free and paid classes and material to all those interested in pursuing this path.

The Field Guide to Human-centred design is a free, downloadable design kit that utilizes the "inspire,
ideate, implement" design thinking methodology. The process includes three stages: Inspiration (19
methods/tools), ideation (24 methods/tools) and implementation (14 methods/tools). There are 11 distinct
tools offered at the end of the method section. One thing that makes this technique unique is that it is
cross-disciplinary team-based, and not driven by designers, but just one of many participants, truly
pushing forth the idea that "anyone can design". The concept of human-centered design is formulated
through continuous engagement with the final users during all phases to ensure the final solution meets
their needs.

One of my strongest critiques regarding this level of focus on the human-centered element is that is
becomes very reminiscent of the concept of human domination of nature through the ages and the type of
thinking that has led to anthropocentric thinking that has led to our crisis in sustainable living. If human-
centered thinking was truly about improving the human condition, that might have been an issue that
could ethically be approached, but in many of the examples provided by IDEO, it seems that the line
between marketing and ethics becomes quite blurred.

In a case documented on page 62 regarding health insurance sold through a mobile money platform, it
seems to be an elegant marketing ploy, using community members to discover what kind of messaging
would entice them to purchase this new service.

In human-centred design there has been a move away from target market and instead "people you are
designing for…. "where in fact, the people you are designing for are the ones going to make a profit from
the product.

1. Inspiration: This phase is focused on better understanding people through observation and
communication (IDEO.org, 2015, p. 11) and opening up to creative possibilities (IDEO.org, 2015, p. 29)
and remaining grounded in the desires of the community being engaged (IDEO.org, 2015, p. 29).

- **1.1. Frame Your Design Challenge:** (includes worksheet): Write a single sentence that captures the
  essence of your design challenge, and decide who the design will focus on, framing it.
- **1.2. Create a Project Plan:** This plan should capture a timeline, identify your workspace, staff,
  budget, skills needed, trips and deliverables. This will allow you to identify constraints and
  develop ways to work around them.
- **1.3. Build a Team:** Create cross-disciplinary teams to get unexpected results.
- **1.4. Recruiting Tools:** You will need to build a strategy on how you will talk to the right people while
  being mindful of a variety of demographic factors as well as social dynamics.
- **1.5. Secondary Research:** Learning about the broader context of an issue through secondary
  sources.
- **1.6. Interview:** (Interview guide worksheet) as the most important part of the inspiration phase,
  interviews can provide the best way to understand the hopes, desires, aspirations of the people
  you are designing for.

1.7. Group Interview: can provide a compelling look at the larger social dynamic, as long as you ensure that everyone's voice is heard.

1.8. Expert Interview: Talking to experts in a specific area might provide great insight, specifically system-level views of your project area.

1.9. Define Your Audience: Get to know the needs, context and history of the target audience as well as other relevant groups in the area.

1.10. Conversation Starters: It is important to come prepared with points that can get the conversation started with your group. They can be in the form of questions, images, objects, or games.

1.11. Extremes and Mainstreams: Designing a solution means that you must consider both the "broad mainstream and those at the extreme of the spectrum" (IDEO.org, 2015, p. 49). Often the extreme users can spark creativity by exposing opportunities.

1.12. Immersion: One of the best ways in understanding the people you are designing for is immersing yourself in their lives and communities, and understanding the context of the problem.

1.13. Analogous Inspiration: Observations in an analogous setting may help you isolate elements of an experience, interaction or product and apply then to another problem.

1.14. Card Sort: (card sort template) Asking people to rank simple cards, each with a simple picture or work, can provide deeper insight or start a conversation about what each person values.

1.15. Peers Observing Peers: In certain cases, asking the people you are designing for to some of the research on their peers.

1.16. Collage: Asking people you are designing for to make a collage for you can help you understand how they think.

1.17. Guided Tour: As an offshoot of the immersion technique, this allows direct observations of home, workplace or daily activities, revealing details as well as routines and habits.

1.18. Draw It: A quick drawing can serve as a great clarification tool, conversation starter or allow deeper insight.

1.19. Resource Flow: Listing or drawing assets that enter or exit a setting can be a great tool.

2. Ideation: In this phase, you make sense of all the information gathered, generate lots of ideas and identify opportunities for design. You will also test and refine concepts (IDEO.org, 2015, p. 11) by sharing the ideas with the people you've learnt from, and get their feedback (IDEO.org, 2015, p. 75).

2.1. Download Your Learnings: In a team setting, you will share your information by writing on post-its and clustering them on boards. It is important to do this following an interview or after a day in the field so that the ideas are still fresh.

2.2. Share Inspiring Stories: Building a repository of inspiring stories to tell and retell is important in building the narrative for the solution. Stories should include both specific (details) and descriptive (physical senses) as well as any quotes and observations.

2.3. Top Five: From time to time, the team members should take a break and just pull out the top five ideas that stand out for them. This can help uncover themes and isolate key ideas.

2.4. Find Themes: Look across your various findings to see if a pattern emerges? Putting ideas on post-its allows you to move them around and regroup them in search of patterns and themes.

2.5. Create Insight Statements: (includes worksheet) Using your themes, you will try to generate 3 – 5 succinct statements that act as building blocks that will help drive you to solutions.

2.6. Explore Your Hunch: Explore hunches you've had from the beginning or something that just popped into your head.

2.7. How Might We: (includes worksheet) Framing insight statements as "how might we…" questions can create opportunities for design.

2.8. Create Frameworks: Using diverse techniques like 2x2s, relational maps and journey maps, frameworks are a visual representation of a system that allows for an easy way to make sense of all the information that has been gathered. You can highlight key relationships, understand the context.

2.9. Brainstorm: Generating lots of ideas based on rules that promote openness, lots of ideas and creativity.

2.10. Brainstorm Rules: Focus on producing a quantity of ideas in a visual way, while deferring judgement, encouraging wild ideas and building on the ideas of others. You must also stay focused on topic, and hold only one conversation at a time.

2.11. Bundle Ideas: consolidate ideas into more complex solutions.

2.12. Get Visual: Illustrate ideas through charts, pictures, diagrams, sketches, sculptures or collages.

2.13. Mash-Ups: Similar to Analogous inspiration, posing bold and even unreasonable questions can speed up thinking

2.14. Design Principles: As the most important elements of your solution, these short and memorable phrases will not evolve throughout the process but align with the themes you have identified.

2.15. Create a Concept: As your ideas become more polished, they can lead to a concept which is a more polished form of solution.

2.16. Co-Creation Session: Incorporating the people you are designing for into the process can empower them to be a part of the solution and provide valuable insights.

2.17. Gut Check: Look at your ideas critically and decide which ideas deserve to move forward.

2.18. Determine What to Prototype: Identify the testable components which will give you the necessary answers and proceed to prototype those.

2.19. Storyboard: (template included) as a quick, low resolution prototype, storyboards can help refine ideas and to test interactions.

2.20. Role Playing: Getting into character and acting out a situation can help test an idea or experience.**2.21. Rapid Prototyping:** Prototypes that are built quickly, can help identify problems and issues and earlier solutions.

2.22. Business Model Canvas: (worksheet included) Keeping your business model in mind is important in deciding which ideas to develop and take to implementation.

2.23. Get Feedback: Share your concept with the people you are designing for to get feedback.

2.24. Integrate Feedback and Iterate: Learn from the people you are designing for is the best way to ensure your solution will be embraced and adopted.

3. Implementation: This phase is about bringing solutions to life, getting them to market and maximizing their impact (IDEO.org, 2015, p. 11).

3.1. Live Prototyping: One of the best ways to test your product in the market place where you test your product for a short time directly in real-world situations, allowing you to understand the feasibility and viability of your solution.

3.2. Roadmap: Provides a timeline and plan of action in which you assign responsibility to each element.

3.3. Resource Assessment: (worksheet included) can help you develop a practical implementation method.

3.4. Build Partnerships: It may be important to build partnerships to help get your idea off the ground.

3.5. Ways to Grow Framework: (Chart included) can help you understand whether your solution is incremental, evolutionary or revolutionary and how your solution can be implemented with your current implementation capacity.

3.6. Staff Your Project: In order to implement your solution, you will now need to identify the specialized know-how, technical capacity, funding and external partners needed.

3.7. Funding Strategy: Focused on short-term funding to launch your solution, this can be quite different from your long-term income.

3.8. Pilot: Long-term test of your solution with all the staff, spaces and resources required that exposes it to market forces.

3.9. Define Success: Mapping out what success looks like at each phase of your project.

3.10. Keep Iterating: Tweaks at each stage can help improve the final solution.

3.11. Create a Pitch: (includes worksheet) A pitch communicates your solution to funders, partners, consumers and the general public. While the style and method may vary, the main pitch will remain the same for all groups.

3.12. Sustainable Revenue: Create a spreadsheet which looks at donations, grants, and projected income as well as how to get repeat customers or an expanded offering.

3.13. Monitor and Evaluate: You will constantly need to monitor and evaluate your solution and its impact and this should be done in conjunction with stakeholders.

3.14. Keep Getting Feedback: Make sure you are always getting feedback in all stages.

Separate worksheets/ tools:
Frame your design challenge form
Interview guide form
Resource flow fill-in diagram
Printable card sort set comprised of 24 designed cards and blank ones
Create insight statement form
Create "how might we" question forms
Storyboard template
Business Model Canvas template
Resource Assessment template
Ways to grow framework
Create a pitch form

Table G.1: *Overview of the application of methods and tools within IDEO's fieldguide – Sayeh Dastgheib-Beheshti, 2017*

	Method	Inspiration	Ideation	Implementation
1	Frame Your Design Challenge	X		
2	Create a Project Plan	X		
3	Build a Team	X		
4	Recruiting Tools	X		
5	Secondary Research	X		
6	Interview	X		
7	Group Interview	X		
8	Expert Interview	X		
9	Define Your Audience	X		
10	Conversation Starters	X		
11	Extremes and Mainstreams	X		
12	Immersion	X		
13	Analogous Inspiration	X		
14	Card Sort	X		
15	Peers Observing Peers	X		
16	Download Your Learnings		X	
17	Share Inspiring Stories		X	
18	Top Five		X	
19	Find Themes		X	
20	Create Insight Statements		X	
21	Explore Your Hunch		X	
22	How Might We		X	
23	Create Frameworks		X	
24	Brainstorm		X	
25	Brainstorm Rules		X	
26	Bundle Ideas		X	
27	Get Visual		X	
28	Mash-Ups		X	
29	Design Principles		X	
30	Create a Concept		X	
31	Co-Creation Session		X	
32	Gut Check		X	
33	Determine What to Prototype		X	
34	Storyboard		X	
35	Role Playing		X	
36	Rapid Prototyping		X	
37	Business Model Canvas		X	
38	Get Feedback		X	
39	Integrate Feedback and Iterate		X	
40	Live Prototyping			X
41	Roadmap			X
42	Resource Assessment			X
43	Build Partnerships			X
44	Ways to Grow Framework			X
45	Staff Your Project			X
46	Funding Strategy			X
47	Pilot			X
48	Define Success			X
49	Keep Iterating			X
50	Create a Pitch			X
51	Sustainable Revenue			X
52	Monitor and Evaluate			X
53	Keep Getting Feedback			X

Summary of: The Bootleg Bootcamp Method Cards, Both & Baggereor. (n.d.). Retrieved 18 October, 2016 from https://dschool.stanford.edu/resources/the-bootcamp-bootleg

Background: The Hasso Plattner Institute of Design at Stanford University is commonly known as d.school was founded in 2004. Originally envisioned as a school to change the self-image of students and allow them to perceive themselves as being more creative, it integrates business, law, medicine, the social sciences and humanities with engineering and product design education *(*Roethel, 2010).

The technical universities currently teaching design thinking include: Aalto University in Helsinki, Paris-Est d.school at Ecole des Ponts, Hasso Plattner Institute at the University of Potsdam, University of St.Gallen, Karlsruhe Institute of Technology, Norwegian University of Science and Technology in Trondheim, Pontificia Universidad Javeriana in Cali, Swinburne University of Technology in Melbourne, Trinity College Dublin, Tongji University in Shanghai, Universidad Nacional Autonoma de Mexico, Universit_a degli studi Modena e Reggio Emilia in Modena, Stanford University, Universidade de Sao Paulo, University of Science and Technology of China, and University of Zurich.

The d.school "bootcamp bootleg method cards" is a free, downloadable beginner resource to access introductory information about d.school's thinking methodology. They have separated the process into 5 Modes: (Empathize, define, ideate, prototype, test as illustrated in **Figure H.1.**) and 39 methods shown in **Table H.1.**
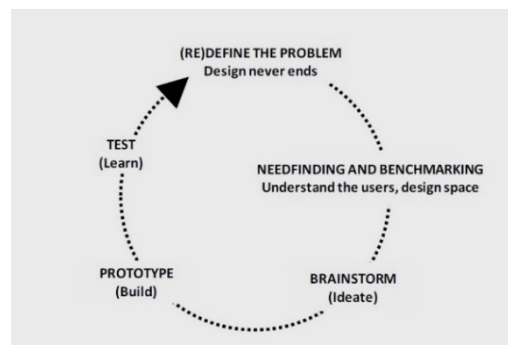
Figure H.1: *Design Thinking process the HPI School of Design Thinking (Skogstad 2009)*

Empathize Mode: As the foundation of a human-centered design process (Both & Baggereor, n.d., p. 1) empathy allows you to understand the people for whom you are designing. Through the observation of user behaviour in daily life, engagement with users and immersion in their experiences, one can get clues about how they think and feel, capture intangible experiences, and uncover hidden needs.

Define Mode: This mode will allow you to "unpack and synthesize empathy findings into compelling needs and insights, and scope a specific and meaningful challenge."(Both & Baggereor, n.d., p.2). Allows for the creation of an actionable problems statement referred to as "point of view".

Ideate Mode: "represents a process of "going wide" (Both & Baggereor, n.d., p.3) in terms of concepts and outcomes" with the goal of exploring a wide solution space both in terms of quantity and diversity of ideas.

Prototype Mode: Visualization of ideas as physical concepts. They are most successful when the design team and users can experience and interact with them. (Both & Baggereor, n.d., p.4) Not just a way to test functionality, prototypes allow for the deepening of the understanding of the design space, refining of

concepts with users, eliminate ambiguity, start a communication, or identify variables for further exploration.

Test Mode: Offers the opportunity to refine solutions as you learn more about the user and an "opportunity to build empathy through observation and engagement—it often yields unexpected insights." (Both & Baggereor, n.d., p.5) It can also illustrate whether the problem has not been framed correctly.

Table H.1: *Toolkit from d.school's "bootcamp bootleg cards" based on readings – S.D.Beheshti, 2017*

		Empathize	Define	Ideate	Prototype	Test
1	Assume a Beginner's Mindset	X				
2	What? How? Why?	X				
3	User Camera Study	X			X	X
4	Interview Preparation	X			X	X
5	Interview for Empathy	X			X	X
6	Extreme Users	X			X	X
7	Analogous Empathy	X		X		
8	Story Share-And-Capture	X				
9	Saturate and Group	X	X	X		
10	Empathy Map	X				
11	Journey Map	X				
12	Composite Character Profile	X	X			
13	Powers of Ten			X		
14	2x2 Matrix		X	X		
15	Why-How Laddering		X	X		
16	Point-of-View Madlib		X	X		
17	Point-of-View Analogy		X	X		
18	Point-of-View Want Ad		X	X		
19	Critical Reading Checklist		X	X		
20	Design Principles		X	X		
21	How Might We . . .?		X	X		
22	Stoke			X		
23	Brainstorm Rules			X		
24	Facilitate a Brainstorm			X	X	
25	Selection			X	X	
26	Bodystorming	X		X	X	
27	Impose Constraints			X	X	X
28	Prototype for empathy	X			X	X
29	Prototype to test				X	X
30	Testing with Users					X
31	Prototype to Decide				X	X
32	Identify a Variable				X	X
33	User-Driven Prototyping				X	X
34	Wizard of Oz Prototyping				X	X
35	Feedback Capture Grid		X		X	
36	Storytelling				X	X
37	Shooting Video	X				
38	Video Editing				X	X
39	I Like, I Wish, What If		X	X	X	

Tools:

1. Assume a Beginner's Mindset – Put aside your personal biases (mis-conceptions and stereotypes) which can restrict empathy. Some guidelines include engaging without value judgements (Don't judge), question everything with an open mind, be curious while searching for patterns, threads or themes that emerge from engaging with users, and listen.

2. What? How? Why? This tool allows you to move from observations to the abstract concepts of emotions and motives. By utilizing "descriptive phrases packed with adjectives and relative descriptions" (Both & Baggereor, n.d., p.7) it allows the making of informed guesses and reveal assumptions that can be tested.

3. User Camera Study - Observations of pictures a user takes of their experience, can lead to the highlighting of the context surrounding the experience.

4. Interview Preparation - Initially all potential questions are noted, then themes are identified allowing for questions to be grouped, leading to a much more natural flow of conversation during the interview. It is best to practice the interview with colleagues, but also leave room for additional deeper questions about how the user feels.

5. Interview for Empathy - The goal is "to understand a person's thoughts, emotions, and motivations, so that we can determine how to innovate for him or her" (Both & Baggereor, n.d., p.10). By asking about specific instances, encouraging stories, looking at non-verbal cues or looking for inconsistencies between action and observation, can lead to interesting insights. While questions need to be neutral, it is best to stay away from binary questions since the conversation and stories need to be built up.

6. Extreme Users - Extreme users often have amplified needs and utilize amplified work-arounds (Both & Baggereor, n.d., p.11) or other extreme behaviours that can serve as inspiration. By listing a number of facets that could be explored within your design space, you can identify users that might be extreme in those facets.

7. Analogous Empathy - This method is best used when direct observation of a needfinding space is difficult. One first identifies a particular aspect of the empathy space, then looks for spaces that are tangential to the design challenge (Both & Baggereor, n.d., p.12)

8. Story Share-And-Capture - As part of a team sharing experience, this method lets all members get up to speed on different observations and compare experiences, while drawing out more nuance and meaning from an experience (Both & Baggereor, n.d., p.13) Using individual post-it notes, headline quotes are pulled as members recount experiences.

9. Saturate and Group - As a follow-up to the Share-And-Capture method, you utilize post-it notes, each with a single headline, and try to "synthesize data into interesting findings and create insights which will be useful to you in creating design solutions."(Both & Baggereor, n.d., p.14)

10. Empathy Map - Using a quadrant grid of Say, Do, Think and Feel, you note observations and in turn infer intangible thoughts/beliefs or feelings/emotions. This allows for the identification of needs (verbs) and insights - Insights are identified as "a remarkable realization that you could leverage to better respond to a design challenge" (Both & Baggereor, n.d., p.15). Both needs and insights are noted on the side of the empathy map.

11. Journey Map - is a systematic representation of steps and milestones of a process and is a valuable tool to gain empathy for a person or understanding their experience. You begin by considering a process or journey that is relevant and tangential to your problem space (Both & Baggereor, n.d., p.16). By

organizing the data into a timeline and comparing it with others, it becomes easier to identify patterns and anomalies and question the reason for certain occurrences.

12. Composite Character Profile - to avoid getting hung up on outlying or non-essential characteristics of potential users, teams can create a composite character profile that captures commonalities of users. Dimensions of complementarity (not shared by all users but interesting to the team) should also be considered (Both & Baggereor, n.d., p.17).

13. Powers of Ten - Is an "intentional approach to considering the problem at varied magnitudes of framing." (Both & Baggereor, n.d., p.18) By imagining different magnitudes and "What if's?" you can frame the need space differently and break the lull in idea generation.

14. 2x2 Matrix - By selecting two spectra for the two axis of the 2x2 axis, you can explore various relationships and observe the formation of groups. You can see if quadrants are full or empty, and if any opportunities exist.

15. Why - How Laddering- While asking 'why?' leads to abstract yet meaningful statements, asking 'how?' yields specific and actionable statements. (Both & Baggereor, n.d., p.20). The combination of the two can lead to a laddering effect to lead to a meaningful yet actionable stratum of needs.

16. Point-of-View Madlib - Point-of-view is"reframing of a design challenge into an actionable problem statement that will launch you into generative ideation." (Both & Baggereor, n.d., p.21). Using a formula of [USER] needs to [USER'S NEED] because [SURPRISING INSIGHT], and flushing out concepts flowing from the unpacking and synthesis of observations, it can lead to a statement that can be leveraged for designing a solution.

17. Point-of-View Analogy - An analogy for a Point-of-view can offer a concise and compelling way of capturing your definition of the design challenge.

18. Point-of-View Want Ad - reframing POV into an actionable problem statement to launch idea generation.

19. Critical Reading Checklist - is a good starting point "to ensure that your team's POV is valid, insightful, actionable, unique, narrow, meaningful, and exciting." (Both & Baggereor, n.d., p.24) By answering the four questions regarding the angle, validity, value-addition and significance of the POV, you can evaluate the usefulness of your POV.

20. Design Principles - "Design principles are strategies to solve a design challenge independent of a specific solution." (Both & Baggereor, n.d., p.25) Designers articulate the principles to translate findings into directives. By developing a list of imperatively-phrased statements, create a guideline that states findings in terms of a broad solution.

21. How Might We . . .? are short questions that launch brainstorms. Resulting from POV statement or design principles, these questions should be formed in a way to offer a wide range of solutions within boundaries that make the results meaningful.

22. Stoke - "A good stoke activity not only increases energy but also requires each person to actively engage, listen, think, and do." (Both & Baggereor, n.d., p.27) The activity should be 3-10 minutes.

23. Brainstorm Rules - Brainstorming aims to leverage collective group thinking resulting from engagement, listening, and building up of ideas. Trying to produce as many ideas as possible without judging them, begin with a How-Might-We…. Question.

24. Facilitate a Brainstorm - A good facilitator keeps the ideas flowing. By keeping watch on the group, you can make an adjustment to the question if you feel the group is slowing. Create a variation of the original question to adjust the momentum in a new direction. Adding constraints may spark new ideas.

25. Selection - When selecting the results of a brainstorming session, you want to maintain a breadth of ideas to carry forward. Hang on to ideas that are exciting, amusing or intriguing. Various selection methods such as post-it voting, four category votes (rational choice, most likely to delight, darling and longshot) or to select innovation through form factors that allow you to build a physical, digital and experience prototype.

26. Bodystorming - "Is physically experiencing a situation to derive new ideas". (Both & Baggereor, n.d., p.31) Very useful in creating physical environments.

27. Impose Constraints - During ideation it can help focus solutions. During prototyping, it can help with visualization.

28. Prototype for empathy - also referred to "active empathy" (Both & Baggereor, n.d., p.33) specific prototypes or situations are created to bring out new information without proposing a solution. These prototypes help better understand the design space and people's mindsets. They can include games, drawings, or simulate particular aspects of user interaction.

29. Prototype to test - "Prototyping to test is the iterative generation of low-resolution artifacts that probe different aspects of your design solution or design space." (Both & Baggereor, n.d., p.34). The creation of low-resolution objects or scenarios within specific contexts that probe questions, can create experiences allowing users to provide meaningful feedback. It is important to identify a variable and answer a particular question with each test.

30. Testing with Users - as a fundamental part of the human-centered approach, it not only allows for additional feedback, but also seen as an opportunity for gaining more empathy for users. It is important that it be tested within a context that provides the most meaningful feedback. Having users talk though their experience is a useful tool in conjunction with observations and follow-up questions on usage and perception.

31. Prototype to Decide - When faced with a fork in the decision tree, a prototype can often resolve disagreements and identify the best direction to proceed. The design needs to be distilled down to its most discrete elements so the meaningful variable to be tested can be identified.

32. Identify a Variable - Prototypes are used to learn about the mindset of users or specific aspects of a solution. In that regards, identifying a variable that can be tested becomes very important. The most useful prototypes are based on fleshing out variations of a variable, offering users a chance to evaluate and provide feedback.

33. User-Driven Prototyping - By allowing the user to create a prototype, we can gain valuable insight into different assumptions and desires, while revealing needs and features that may not have been previously visible.

34. Wizard of Oz Prototyping - offers the illusion of a function without actually creating it. By leveraging existing tools, users can experience the proposed solution, offering valuable insight into functionality and features that should be incorporated.

35. Feedback Capture Grid - facilitates real-time or post-mortem analysis of feedback on presentations and prototypes (Both & Baggereor, n.d., p.40) By using a quadrant to identify useful features, constructive criticism, questions that were raised, and ideas that were spurred.

36. Storytelling - "sharing pertinent details that express surprising meaning and underlying emotions" are a great way to connect people with ideas…. Stories are a great way to connect people with ideas, at a human level" (Both & Baggereor, n.d., p.41). To make connections, stories need to have a distinct point, be authentic and character-driven, include action, conflict and transformation while including details.

37. Shooting Video - as a means to communicate insight and stories, videos allow you to direct attention, highlight and capture important information.

38. Video Editing - is another way to draw attention to the topic.

39. I Like, I Wish, What If - as a means to providing feedback, expression personal feedback beginning with I, can often be most meaningful.

Appendix I: Martin

Summary of: *The design of business: why design thinking is the next competitive advantage* Martin, R. L. (2009)., Harvard Business Press

Martin begins by describing business model as a knowledge funnel which begins with a mystery, identifies heuristics to develop an algorithm to solve it.

A mystery is a question while heuristics is defined as "a rule of thumb that helps narrow the field of inquiry and work the mystery down to a manageable size." (Martin, 2009, loc. 179-180) and open-ended prompts. While heuristics offer an incomplete understanding of the mystery, "the beauty of heuristics is that they guide us toward a solution by way of organized exploration of the possibilities (Martin, 2009, loc. 288). Algorithms are defined as certified production processes (Martin, 2009, loc. 213) and formulas for solving the mysteries.

Roger Martin (2009) describes the two schools of thought for innovation:

Analytical thinking, harnesses deductive and inductive reasoning to declare truths and certainties about the world. "The goal of this model is mastery through rigorous, continuously repeated analytical processes. Judgment, bias, and variation are the enemies." (Martin, 2009, loc. 141-143) institutions with this mentality maintain the status quo and stick to tried and true methods to build size and scale. Companies become focused on exploitation of information.

Intuitive thinking is the art of knowing without reasoning; the unanalyzed flash of insight and the creative instinct (Martin, 2009, loc. 149-150). Institutions with this mentality have fast and furious innovation cycles that wax and wane with individual intuitive leaders (Martin, 2009, loc. 157).

The vast majority of businesses follow a common path. The company is birthed through a creative act that converts a mystery to a heuristic through intuitive thinking. It then hones and refines that heuristic through increasingly pervasive analytical thinking and enters a long phase in which the administration of business dominates (Martin, 2009, loc. 350-353).

But Martin believes that instead of representing a binary choice, the two modes of thought need to be reconciled and that "the most successful businesses in the years to come will balance analytical mastery and intuitive originality in a dynamic interplay that I call design thinking" (Martin, 2009, loc. 160-161).

At the heart of design thinking is abductive logic is abductive logic (Martin, 2009, loc. 410), the "logical leap of the mind" or an "inference to the best explanation" to imagine a heuristic for understanding the mystery. (Martin, 2009, loc. 413-414). As such, abductive logic sits squarely between the past-data-driven world of analytical thinking and the knowing-without-reasoning world of intuitive thinking. Rather than being confined to regressing the past to hone and refine within the current knowledge stage, the design thinker can add abductive logic to the reasoning repertoire to drive the organization through the knowledge funnel in a steadily cycling process. Businesses that become defined by this balanced approach, become design-thinking businesses. (Martin, 2009, loc. 422-424). Design thinking, with its balance of exploration and exploitation, has the ability to increase the velocity of movement through the knowledge funnel to provide "most powerful formula for competitive advantage in the twenty-first century" (Martin, 2009, loc. 430-431).

Martin believes that to become a design thinker, one must develop the stance, tools, and experiences that facilitate design thinking. Stance is your view of the world and your role in it. Tools are the models that you use to understand your world and organize your thinking. Experiences are what build and develop your skills and sensitivities over time (Martin, 2009, loc. 474-477).

Martin point to the difference and incompatibility between reliability and validity which he notes is at the heart of the innovation dilemma. While the goal of reliability is to produce consistent and predictable outcomes (Martin, 2009, loc. 549). Systems like Total Quality Management (TQM), Six Sigma, Knowledge Management (KM) and Customer Relation Management (CRM) are all aimed at streamlining business and "enable the modern corporation to crunch data objectively and extrapolate from the past to make "scientific" predictions about the future, all part of the quest for reliability (Martin, 2009, loc. 586-587).

Validity's goal is "to produce outcomes that meet a desired objective" (Martin, 2009, loc. 553-554). Validity is difficult to achieve with only quantitative measures, because those measures strip away nuance and context. Typically, to achieve a valid outcome, one must incorporate some aspects of the subjectivity and judgment that are eschewed in the quest for a reliable outcome (Martin, 2009, loc. 556-558). Many research-intensive companies like pharmaceuticals and information technology and consumer goods spend billions of dollars each year to explore the mysteries of consumer desire to create products to satisfy them, choosing validity as their goal. Since this kind of exploration does not have a pre-determined schedule, it is inherently risky (Martin, 2009, loc. 627).

The risk associated with choosing validity and exploration points to the reason that the business community chooses exploitation and reliability as the business model. This rigidity in reliability, while reducing and fine-tuning the variations in business algorithms, can run into cataclysmic events when "the future no longer resembles the past".

Martin (2009) believes that a business that fails to balance the pursuit of reliability with the equally important pursuit of validity, will often lose the ability to solve mysteries and move through the knowledge funnel and lose the ability to design and redesign themselves continuously. With the rapid changes in the world and continuous changes, businesses need to be able to tackle emerging mysteries.

In most large business organizations, three forces converge to enshrine reliability and marginalize validity: the demand that an idea be proved before it is implemented, an aversion to bias, and the constraints of time (Martin, 2009, loc. 642-643).

Deductive logic allows one to go from general to specific, while inductive reasoning goes from specifics to generalities. One interesting development was the concept that new ideas are not generated from these traditional forms of declarative logic and needs "logical leaps of mind" when personal observations did not fit within existing models. Peirce, who first presented this notion, called it an "inference of the best explanation" where the first true step of reasoning was wondering. Peirce named this "abductive reasoning" in which it posits what could possibly be true.

Whether they realize it or not, designers live in Peirce's world of abduction; they actively look for new data points, challenge accepted explanations, and infer possible new worlds (Martin, 2009, loc. 917-919). The main flaw of this type of reasoning is that it cannot be proven in advance but it opens up possibilities.

Martin believes that as knowledge moves through the funnel, costs fall (Martin, 2009, loc. 1035-1036).

While delving into mysteries is the most costly step, and often not economically viable. When looking at a mystery, design thinkers use abductive reasoning to look at an amorphous whole and try to discern a pattern. This search can lead to false starts and blind alleys, while once the mystery has been decoded, developing a heuristic can yield results much quicker.

We believed that design thinking for business broke down into three essential components: (1) deep and holistic user understanding; (2) visualization of new possibilities, prototyping, and refining; and (3) the creation of a new activity system to bring the nascent idea to reality and profitable operation (Martin, 2009, loc. 1226-1228).

Wicked problems, first identified by mathematician and planner Horst Rittel in the 1960s, are messy, aggressive, and confounding (Martin, 2009, loc. 1310-1311). They are ill-defined, unique in their causes, character and solution" (Martin, 2009, loc. 1314-1315). There are many things that contribute to it so that the causes of the problem are "not just complex but deeply ambiguous; you can't tell why things are happening the way they are and what causes them to do so".

• The problem doesn't fit neatly into any category you've encountered before; it looks and feels entirely unique, so the problem solving approaches you've used in the past don't seem to apply.

• Each attempt at devising a solution changes the understanding of the problem; merely attempting to come to a solution changes the problem and how you think about it.

• There is no clear stopping rule; it is difficult to tell when the problem is "solved" and what that solution may look like when you reach it." (Martin, 2009, loc. 1316-1323).

Design thinkers, thrive on setting and solving problems, may offer the best way to solve them. Martin (2009) defines financial planning and reward systems as the two components in a company's infrastructure that can promote or stifle design thinking.

Companies that want to embark on validity-oriented activities need to rethink their traditional approach to financial planning by focusing on setting goals to achieve the breakthrough the company is seeking and setting the necessary innovation budget.

The reward system also needs to be modified from rewarding running large departments to solving wicked problems.

Martin argues that in quest to increase reliability in business we are forgetting that validity is actually what progresses real knowledge and allows businesses to innovate and propose new heuristics for the new mysteries. Our world is constantly changing, in one area, speaking with a geneticist, Martin (2009) notes that nature provides a lot of redundancy in systems. By removing the redundancies, we are in fact making the system more fragile and susceptible to shock. Martin (2009) believed that one's personal knowledge system is based on three mutually reinforcing components (Martin, 2009, loc. 2051):

Stance: How you define the world around you and see yourself in it. Design thinkers take for granted that the world can change and that they can bring about that change, in a very open and optimistic way.

Tools: you use to organize your design thinking are efficiency vehicles that offer a conceptual toolkit and can include, theories, processes and rules of thumb.

Experiences: are the final component in the personal knowledge system and form the most practical and tangible knowledge. While the experiences you collect may be a product of your stance and tools, they allow us to develop skills (consistent capacities to perform activities) and sensitivities (make distinctions between conditions).

Martin (2009) believes that design thinking has some similarities in Stance, with the purpose being balancing reliability with validity (Martin, 2009, loc. 2147).

The main tools are

1. Observation: deep, careful, open-minded observation that looks for new insights that help push knowledge forward and patterns that help turn a mystery into a heuristic.
2. Imagination: design thinkers hone it into a powerful tool of inference and testing loop. In situations with insufficient information, taking a leap of faith and testing if it may be true.
3. Configuration; translating the idea into an activity system that will produce the desired business outcome, how a situation will fit into the larger scheme of business.

Experiences for design thinkers: one should consciously use experiences to support integrative thinking in which you combine two or more seemingly different ideas to create a synergistic one that improves on all.

Design thinkers: (1) reframe extreme views as a creative challenge; (2) empathize with your colleagues on the extremes; (3) learn to speak the languages of both reliability and validity; (4) put unfamiliar concepts in familiar terms; and (5) when it comes to proof, use size to your advantage. (Martin, 2009, loc. 2238-2240).

Appendix J: Ogilvie & Liedtka

Summary of Designing for Growth: A Design Thinking Toolkit for Managers. Ogilvie, T., Liedtka, J., (2011). (Columbia Business School Publishing). Columbia University Press. Kindle Edition.

Ogilvie and Liedtka (2011) have written a very easy-to-read, inspirational book to allow design thinking to be adopted by anyone for business, making this, an extremely well-reviewed book. Inspired by the work of Martin, Ogilive and Liedtka (2011) have identified design thinking as "a systematic approach to problem solving" (Ogilive and Liedtka, 2011, loc. 149) (Appendix F). Based on the idea that maximizing productivity and re-engineering processes have been fully utilized, they believe that a whole new tool kit of design thinking methodologies can result in creative solutions. They have utilized a business language and perspective to unpack design thinking into a systematic process to allow for profitable business growth. (Ogilive & Liedtka, 2011, loc.187)

While at first the core values and assumptions of business thinking (rationality, objectivity, quantifiable and precise) and design thinking (Human experience, messy, qualitative and uncertainty) seem very different, Ogilvie and Liedtke have proposed a 4-stage process that utilizes varying levels of divergent thinking. These 4 stages are labeled as: what is, what if, what wows, what works, and each include visualization tools as "meta" told that are integral to their execution.

There is a total 9 additional tools and 4 Project Management aids that often link stages and are used throughout the process.

Looking at design thinking as a tool for managers, they identify design thinking as "a systematic approach to problem solving" (Ogilvie & Liedtka, 2011, loc. 149). Based on the idea that maximizing productivity and re-engineering processes have been fully utilized, they believe that a whole new tool kit of design thinking methodologies can result in creative solutions. They have utilized a business language and perspective to unpack design thinking into a systematic process to allow for profitable business growth (Ogilvie & Liedtka, 2011, loc. 187).

While at first the core values and assumptions of business thinking (rationality, objectivity, quantifiable and precise) and design thinking (Human experience, messy, qualitative and uncertainty) and seem very different. They have 4 stages marked with varying degrees of divergent and convergent thinking: *What is? What if? What wows? What works?*

1. Visualization- seen as a "meta" tool that shows up at every stage has been summarized in **Table J.1.** Visualization "inserts visual imagery into our work process and focuses on bringing an idea to life, simplifying team collaboration and (eventually) creating stories that go to the heart of how designers cultivate empathy in every phase of their work and use it to generate excitement for new ideas (Ogilvie & Liedtka, 2011, loc. 532-533). There are 8 different kind of visualization:

- Simple drawings can help 'think out loud".

- Breaking down problems into components (who, what, how much, where, when, how and why?

- Thinking in metaphors (linking two seemingly unrelated things) and analogies (partially similar things) can open the thought process and "identify and communicate a deeper set of relationships and possibilities" (Ogilvie & Liedtka, 2011, loc.988).

- Photographs.

- Storyboarding- series of panels that sketch out a series of events (Ogilvie & Liedtka, 2011, loc.1004-1005).

- Personas- fictional characters derived from initial research that can make the concept of a customer very personal and relatable.

- Storytelling: weaving bits of information into a narrative (Ogilvie & Liedtka, 2011, loc.1048) which allow you to access emotion and emphasize experiences…making "ideas concrete, tangible and personal" (Ogilvie & Liedtka, 2011, loc.1053).

- Guided imagery: creation of a particular kind of story.

Table J.1: *Simplified table of toolsets described in Ogilvie & Liedtka (2011), by Sayeh Dastgheib-Beheshti, 2017*

In all stages	Visualization Meta-tools	Stages	Tools	Communication protocol to link design thinking process to established project management structures.
Visualization	• Drawings • Breaking into components • Metaphors • Photographs • Storyboarding • Personas • Storytelling • Guided imagery	What is	Journey mapping	PMA 1 Design Brief • Formalizes the growth project • Defines goals, resources, timelines, etc. • Serves as a "North Star" throughout the project
			Value chain analysis	
			Mind mapping	
		What if?	Brainstorming	PMA 2 Design Criteria • Sets criteria to evaluate alternative designs (derived from study of user needs and business requirements) • Becomes part of the design brief
			Concept development	
		What wows?	Assumption testing	PMA 3 Napkin Pitch • Crystalizes communication of solution concepts (after brainstorming and concept development) • Describes each of the best few (3–5) solutions that meet the design criteria in a template that allows for apples-to-apples comparison
			Rapid prototyping	
		What works?	Customer co-creation	PMA 4 Learning Guide • Defines an affordable level of resources to invest in learning whether (or not) the top 2–3 concepts are feasible.
			Learning launch	

There are also the following 9 additional tools and 4 Project Management aids

To Launch project and before A: PMA1: the design brief- Used to kick off the project, it is revisited at each milestone.

As the guiding principle reminding everyone where they are going and why? It sets the schedule, names the important milestones, and lays out the metrics that will assess the project. (Ogilvie & Liedtka, 2011, loc. 3324).

It has the following key components (Ogilvie & Liedtka, 2011, loc. 3335):

1. Project description:

- What is the business problem or opportunity?

- Describe the project in a few sentences like an "elevator pitch".

2. Intent Scope:

- What is within the scope of the project (and what is outside)?

- What efforts sit adjacent to this particular project?

3. Exploration questions:

- What key questions will you need to answer through your research? (customer needs, emerging technical possibilities, new business models, etc….).

4. Target Market: Who are you designing for? (Whom do you need to understand and why are they important?)

5. Research Plan: How will you explore your opportunity space? You will need a plan which includes timetable and milestones for both primary and secondary research.

6. Expected Outcomes: What outcomes would you like to see?

7. Success Metrics: How will you measure success?

8. Project Planning: What resources do you need? Why? At what stages? What is creating the time urgency? What is the relevant time frame for fulfilling the brief?

A. What is?

2. Journey mapping - flowchart of other representation of the customer's experience interacting to receive product or service. The journey map is a powerful tool to shift your focus from "What does my company want?" to "What is the customer trying to do" (Ogilvie & Liedtka, 2011, loc. 1121-1122)?

Journey mapping is identified as having the following steps:

1. Selecting customers whose experience you want to more fully understand. This can be through observation or printed research.

2. Draw a hypothetical view of their journey.

3. Narrow down to (12-20) customers that represent the demographics you are interested in

4. Conduct a few pilot interviews to see if your hypothetical journey matches what they felt.

- Interview: ask for stories and examples, look for surprises and inconsistencies, watch for gesture and tone, paraphrase and don't lead the interviewee, listen for inefficiencies, over-exertion and work-arounds.

- Ethnography: observe users in their natural context, watch for confusion, over-exertion, pain points, appropriation (use of product for new use) skipped steps (don't need or understand).

5. Finalize the questionnaire for interview.

6. Identify essential moments of truth (sense-making) and begin to look for themes and patterns.

7. Study the themes that have been uncovered to help reveal the differences in data and differentiating data.

8. Selection of two dimensions you feel are more revealing and creating a 2x2 matrix can create an archetype map.

9. Interviewees can be presented into a particular quadrant, identified by their habits, behaviours, attitudes, wants and desires (personas).

10 Map the journey of each persona. Identify low points representing pain points that represent the most valuable innovation opportunities.

Can be used in three stages (Ogilvie & Liedtka, 2011, loc. 1108-1112):

- What is: document existing customer experience and isolate highs and lows.

- What if: help generate ideas during brainstorming, during concept development can be used to consider ideal versus existing experiences.

- What wows? – used to prototype new experience.

3. Value chain analysis – regarded as journey mapping for company products, it is defined as "the study of an organization's interaction with partners to produce, market, distribute, and support its offerings" (Ogilvie & Liedtka, 2011, loc. 1277-1278), offers insights into the capabilities of upstream and downstream partners as current business vulnerabilities and opportunities.

1. By mapping clusters of activities, you can form the basic architecture of the chain. While activities do not take place in a linear fashion, thinking in terms of an "ecosystem" with lots of interaction, might be a better model.

2. Analysis of competitive environment for each cluster. This include identifying key players as well as their relative market share.

3. Identification of core strategic capabilities to highlight the source of the problems.

4. Evaluation of the bargaining power and influence of each player by identifying the drivers of performance and deciding if their contributions can be substituted by other parties. Another important factor is the perception of the value the players add by the end-users.

5. Determining the possibilities for improvement of power and profitability by identifying opportunities and setting the stage for generating the design criteria.

6. Assessment of vulnerabilities – by trying to predict which changes would put you at a disadvantage

7. Identification of themes related to bargaining power, capabilities, partners and defensibility (Ogilvie & Liedtka, 2011, loc. 1372).

The analysis of the value chain allows for the

- Making business case

- Capabilities question

- Positioning question

Lead to making the customer case

4. Mind mapping Looking for patterns in the large quantity of data collected in the "What is" exploration with the goal of establishing criteria for the "What if" idea generation stage. Working with captured data from the key constituents of customers, suppliers, your own operation and partners, "Mind mapping builds a common mind about current reality and thus decreases people's allegiance to the solutions they had going in to the project" (Ogilvie & Liedtka, 2011, loc. 1400-1402).

1. Laying out all the data that has been collected. Organize them into basic groupings.

2. Create groups of people to review and provide feedback (team members).

3. Lead each team through an overview of the information gathered.

4. Ask each member to browse individually and add learnings through post-it notes.

5. Cluster relevant findings together, once all relevant information has been clustered, you will see outliers that don't fit into existing groups, and any may hold valuable information.

6. Identify insights.

7. Translation of team insights into design criteria.

8. Combine various team insights into a common design criteria list.

Link between A & B - PMA2: Design Criteria- As the "succinct expression of the ideal end state of your growth project" (Ogilvie & Liedtka, 2011, loc. 3337-3338). It describes the attributes of an ideal solution and a concise list of relevant constraints and aspirations.

Summary of the table from location 3349:

Design Goal: What have you learned about the target customer?

What needs (functional, emotional, psychological, and social) does the design have to fulfill for the target customer? Why is it strategically important for your organization to address those needs?

User Perception: How important is your proposed offering to the target customer's well-being? Are there aesthetic attributes necessary to succeed with the target customer? Does the target customer expect the offering to have certain social, ethical, or ecological attributes?

What does **ease-of-use** mean to the target customer?

Physical Attributes:

Must the offering be able to capture, store and/or transmit information about usage?

Does the offering need to be designed for use in specific environments or situations?

Are there weight or size considerations for lifting, use, or transport?

Are there memory, bandwidth or connectivity issues?

Functional Attributes: Prioritized listing of accommodation of specific use-case scenarios as well as questions regarding applicable compatibility or standards.

Constraints: specific date for completions, existing manufacturing base, profit margin, leveraging proprietary technologies as well as regulatory concerns.

B. What if?

5. Brainstorming – contrary to the concept of thinking outside the box, brainstorming is very much about generating a multitude of solutions that fit within defined constraints. Some of the suggested tactics for a successful session include:

1- Using small (around 12), diverse groups that are free from internal political considerations (Ogilvie & Liedtka, 2011, loc.1720).

2- Focus on clearly stated challenges with key points of design brief often being included.

3- Create a right mind-set of a creator, not a critic.

4- Show human cost of problem to create empathy. This may be through personas previously created, explaining the personal journey as well as pain points.

5- Use "**Trigger questions**" framed in a constructive sequence that define the confines of the box of ideas that need to be generated. Other motivation could be provided through **quotes and stories** or **questioning assumptions** on how things are done. Using the nodes in the value chain analysis, you can come up with an alternative to each one, playing devil's advocate. Some other tactics include **exploring the extreme scenarios**, **changing the roles** and exploring **technology-driven changes**. Other insights can be gained by pretending you had another business model and **imagining how others would approach your problem. Imagining alternate futures** can also show the road to getting there.

6- Facilitation can be done in a multitude of ways and can lead to interesting results

7- Follow-up. It is important to understand that the output of brainstorming is not concepts but ideas that have the potential to become concepts.

6. Concept development choosing the best ideas from brainstorming and assembling them into detailed solutions. By laying out all the ideas, deleting redundant ones, grouping similar ones and identifying gaps, you can create a list of emerging themes. This will allow you to set priorities and identify the must-have ideas and themes.

You can choose 5-12 themes to serve as anchors for distinct concepts, then begin to form concepts by "picking and choosing elements that combine to create both compelling customer value and a viable business model." (Ogilvie & Liedtka, 2011, loc. 1924-1925). One method might be to identify all variables in a category, subdivide it into further detail (values) and create combinations of variables and values.

C. What Wows?

PMA3: Napkin pitch is the gateway to the What Wows stage: "It provides a simple, consistent format for summarizing and communicating new concepts" (Ogilvie & Liedtka, 2011, loc. 3349-3350), and offers a simplified concept that can be reviewed by others for validation. A simple napkin pitch answers four questions:

- Identify need: Which customers want this and what unmet need does it fulfill?
- Identify benefit: How will the customer. Company and other parties benefit?
- What is the approach: What asset or capability is leveraged, how can it create value and a sustainable advantage?
- What do competitors provide? What firms currently serve this need and how will they react to our offering?

7. Assumption testing is a tool for identifying the assumptions underlying each business concept, articulate and test them can be used in either '***what is', 'what works' or 'what wows'*** phase. It works on identifying critical elements such as levers that move the economics (price, cost and adoption rates).

1 - Generic business tests concept must pass: Value (customers will buy it), Execution (can create and deliver it at an acceptable cost), Scale (can build a volume to make it worthwhile) Defensibility (competitors can't copy you).

2 - Specific business tests: Using the design brief and design criteria to question the assumptions on how the important strategic goals originally identified are being addressed

3 - Make sure your assumptions are as explicit as possible regarding:

- Customers: Why this concept will create superior value for them, how much will they be willing to pay, do they represent a sufficient market size.

- Your organization: How will the organization produce and deliver the value, what capabilities will it leverage? Identify critical capabilities that are missing and whether you can partner with someone to get them.

- Competitors: Which ones are likely to be affected and how will they react, Can they cope or will they interfere?

4- Critical Assumption identification - identify which is the most critical assumption

5- Identify the data needed to test assumptions:

6- Sort information into three categories:

- What you know: Be wary of beliefs that are disguised as facts.

- What you don't know and can't: You can only make predictions and cannot test.

- What you don't know but could: Since getting data can be quite costly, it is important to only collect the most critical data. Sometimes your only way to test assumptions is to make the future happen and observe results.

7. Quickly get data regarding things you don't know but could.

8. Conduct quick experiments to gather data, keeping your eyes open for red flags.

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8. Rapid prototyping – creation of visual or experiential manifestation of concepts. They are a form of assumption testing of concepts that have detail, form and nuance. Prototypes are a part of the learning process with the goal of making mistakes faster, giving a chance identify areas for improvement. Rapid prototyping offers a low cost option of making abstract ideas tangible for feedback and invites other people into an experience (Ogilvie & Liedtka, 2011, loc. 2303).

1. Initial prototypes should be small and simple, the more unfinished it is, the more it leaves room for interpretation.

2. Visualize the story that should be told.

3. Create empathy by capturing details on how concept will work and how people will experience it.

4. Visualizing multiple options can allow people to make choices and work out details

5. Let other validate the prototypes since they are about testing assumptions and should not be personal.

Table J.2. Types of prototypes as described in Ogilvie & Liedtka, 2011, loc. 2346-2354, by Sayeh Dastgheib-Beheshti, 2017

	Type	Details	Examples
Types of prototypes 2D	Flowcharts	Set of sequential activities with arrows depicting relationships. Illustrate the building block of a new relationship.	Journey maps Flowcharts
	Storyboards	Simple sketches or digital photos of screen shots. Let's us move beyond the functional view to focus on the user and the problem being solved by the new experience	Storyboard shifts focus to the user and how the experience solves a problem
	Metaphorical prototype	Creating metaphors to convey a gut reaction.	A poster to illustrate a service
	Videos	Combines elements of storyboard and screenshots to create the appearance of a service before building it.	Flash videos
	Interactive building blocks	Using card-sort prototypes where users design the experience by selecting and organizing the sequence of cards.	Card sorts where users get to order cards in a way that makes sense to them
		Pick and Place: allows users to arrive at forks in the story board and make decisions.	Storyboard that lets users choose forks in road.
	Business concept illustration	Express an experience from multiple perspectives (user experience, technology, business model) with high fidelity prototypes that lets the audience Imagine the experience already exists.	Brand positioning imagery, ad copy.

D. What Works

PMA 4 Learning Guide is a mechanism for ensuring that with financial expenditures, you are focused with testing key assumptions.

The learning guide restates the strategic intent of the project and then defines the parameters for testing the remaining key assumptions (Ogilvie & Liedtka, 2011, loc. 3362-3363). *'What works?'* It is a great mechanism for defining (a) the overall intent of the new concept, (b) the key assumptions to be tested, (c) the financial resources that will be expended, and (d) the knowledge capital that must be returned, even if the project is not continued (Ogilvie & Liedtka, 2011, loc. 3364-3366).

 9. Customer co-creation "is the process of engaging a potential customer in the development of new business offerings." (Ogilvie & Liedtka, 2011, loc. 2524). By observing reactions towards prototypes, results can be used to iterate towards an improved offering. This can be through low-resolution or refined prototypes with the mindset that the sooner, the better. Some criteria would be:

- Enrolling a diverse set of customers who care and are not pressured to purchase. Customers respond best if engaged one a time, while still having 2-3 options for feedback. An unpolished visual guide may be quite useful in that it helps them visualize without the pressure of accepting a finalized solutions, and having the option of suggesting changes.

Efforts should be made to help customers communicate visually while leaving time for discussion. To make sure the customers feel valued, it's important for the business to let the customers know how their feedback was implemented.

10. Learning launch refers to a quick and cheap experiment conducted in the marketplace that serves as a bridge between customer co-creating and product roll-out. It is one of the best ways to test the remaining critical assumptions. It is a great way to simulate how the solution will scale.

Appendix K: Schindlholzer

Summary of Methode zur Entwicklung von Innovationen durch Design Thinking Coaching. Disseration. Schindlholzer, B. (2014), D-Druck Spescha, St.Gallen

Schindlholzer's Ph.D. dissertation, "Method of development of Innovations through Design Thinking Coaching" has been translated from German to English using Google Translate.

Schindlholzer (2014) takes steps in providing the academic base which even he notes has thus far been lacking in design thinking methodologies. He begins by recognizing that companies need coaches to facilitate and guide them through the process, and in order to meet scientific rigor standards, bases his work on method engineering principles. Early on he recognizes that the aim of his paper is "neither the explanation nor generation of knowledge, but a design-oriented research philosophy following the design of artifacts" (Schindlholzer, 2014, p.26). Through the use of participatory action research methods and observations of two case studies he conducted, he was able to develop generalized statements (Schindlholzer, 2014, p.27). The findings from utilizing a business engineering methodology included repeatability and traceability of changes, as well as strong orientation towards customer needs (Schindlholzer, 2014, p.33).

Schindlholzer (2014) summarizes and maps out 37 design thinking tools, and also identifies 11 methods for optimizing the group dynamic and coaching aspects of his methods as presented in **Table K.1.** While these are important for the optimization of problem solution projects, 10 of the methods fall into the realm of project management and are not part of the design thinking process. Only item 8, Agile Project management, is one that overlaps both the project management and design thinking processes.

As a meta-review of other prevalent design thinking toolkits however, at one point, he simply has to accept some of the anecdotal methods contained in other design thinking toolkits

In this thesis, Schindlholzer (2014) develops a method for Design thinking coaching targeting the Information and Communication Technology sector. His goal is to develop a method for organizing the early phase of Innovation processes, resulting in efficient development of innovative solutions for products and services.

Schindlholzer (2014) identifies challenges faced by IT organizations due to shorter product cycles and increased competition due to "standardization and commoditization of IT services" and increases in cost pressure (Schindlholzer, 2014, p.2). He notes that several factors during the early stages of the innovation process such as uncertainty and ambiguity, lack of focus in early stages of development, and intangibility of services envisioned (Schindlholzer, 2014, p.3) pose challenges to the development of services.

Schindlholzer (2014) notes that the "The early stages of innovation are ongoing research and unclear poorly-understood phase, known as a "Fuzzy Front End of Innovation" or the short form Is "fuzzy front end" (FFE) as described in the papers by Smith and Smith & Reinertsen (as cited by Schindlholzer, 2014, p.20) Most important factors to increase the innovative capacity in FFE are developing Strategies for dealing with new opportunities, improving communication Between the areas of research and development and marketing for improved concept development and a faster decision as noted by Smith & Reinertsen, and Khurana & Rosenthal (as cited by Schindlholzer, 2014, p.37)

Design thinking is a problem solving process for so called wicked problem that unlike deterministic problems have no clear solutions. The development of a solution represents a continuous, iterative

learning process where analog Analysis and synthesis solutions are developed (Schindlholzer, 2014, p.22).

Schindlholzer (2014) notes that the much accepted linear product development model of stage gate model (Schindlholzer, 2014, p.31) has been now widely replaced with the open stage gate model of Grönlund et al. (as cited by Schindlholzer, 2014, p.51) in which innovation is the result of non-linear iterative processes. Schindlholzer (2014) goes on to argue for a unified approach to developing goods and services (Schindlholzer, 2014, p.40)

Schindlholzer (2014) defines the design thinking in the following 8 steps: preparation, problem definition, design Research, generation of ideas, prototype development, prototype evaluation, specification, and transfer.

Schindlholzer (2014) has identified 11 methods for optimizing the group dynamic and coaching aspects. While these are important for the optimization of problem solution projects, 10 are not part of the design thinking process. Item 8, Agile Project management is the only one that overlaps both the project management as well as design thinking process, and are:

1. Template for the creation of the project contract- Listing of both scope and client expectations.

2. Design Thinking Coaching Project plan – identification of major milestones (project start, project kick-off, design space exploration, critical functional prototype, dark horse prototype, integrated production prototype, fuctional prototype, X-is-finished prototype, handover documentation and specification, end of project).

3. Checklist of Resources required: The resources required for each project vary but can include: IT resources: (hardware, software and other assets), Work environment and financial resources.

4. Clifton Strengths Finder- created by the Gallup organization, through a series of questionnaires, identifying strengths of participants.

5. Teamology- personality types are identified and placed in appropriate roles to maximize the impact of the team.

6. Stakeholder Management takes the various needs and interests of the all stakeholders by first identifying their power, legitimacy and urgency of needs using a matrix.

7. Guideline Design Thinking Team Training included 5 steps of forming, storming, norming, performing and adjourning.

8. Agile project management –This method uses engaged 15-30 minutes daily meetings between all team members (scrum method) to discuss problems and obstacles to reach collabourative decisions.

Three other methods at the end of the process are meant as reflections for future projects and part of team-building so again, not a part of the design thinking process

9. Provide feedback and promote self-reflection- The coach must provide the coachee with feedback as part of the learning process by supporting realising self-evaluation in an adequate way, providing specific suggestions for improvement while honestly highlighting positive and negative aspects.

10. Systemic Issues Interventions- In the working of teams, sometimes it becomes necessary to intervene to resolve either different perspectives, hypothetical questions, future issues or explanations (Schindlholzer, 2014, p. 179).

11. Solution Circle - as a combination of 8 elements that can be used to achieve solutions through the coaching process. The process begins with clarification (creating confidence between members), defining expectations, creating focus, tension resolution, envisioning the future, rating, benchmarks, personal notes.

Design thinking processes

1. Agile project management – 8.1. involved daily meetings (scrum method), between 15-30 minutes, aims to discuss problems and obstacles. 8.2. reach collaborative decisions

2. Framing and Reframing- reframing provides a new way of looking at a situation. You begin with identifying assumptions, questioning them and redefining them.

3. Root Cause analysis – identify the root cause using the *'5 Why'* method developed by Toyota (Schindlholzer, 2014, p. 137).

4. Point-of-View- allows the problem to be viewed from various viewpoints, leading to alternative solutions.

5. Stretch Goals – to aim for results that may be currently out of reach and stretch to achieve them.

6. Lead User Method – Observe more advanced users to see if they unearth new needs.

7. Interviews – as a qualitative method of research, help identify underlying attitudes, behaviour, motives and barriers.

8. Observation- whether quantitative (frequency of action) or qualitative (behaviour), observation offers many behavioural insights that are not normally captured by surveys.

9. Focus group – As a qualitative research method, where a group discusses findings. It works most effectively when directed and moderated.

10. Consumer Clinics – Customers and users interact with a product or service in real-life settings.

11. Ethnography- is a qualitative research method that can be exploratory, interpretive or descriptive, embedding researchers into the lives of people to study the interaction of people, society and culture.

12. Empathic Design- seeks to understand user problems and behaviours. It can lead to the discovery of new uses, real-life testing, alternate uses, intangible benefits, hidden user needs.

 13. Personas – composite images of potential users, can help clarify user roles, meet those needs or identify extreme behaviours.

14. Nethnography- ethnography that is based on the internet behaviour of people.

15. Business Model Canvas- framework for describing business model

16. Secondary research- form of market research based on secondary sources that are readily available. It helps confirm previous findings or provide historical oversight.

17. Brainstorming – creation of new ideas by association, aimed at generating the largest variety and is suitable for problems not solvable by analytical means. Using the four steps of preparation, procedure, moderator and evaluation.

18. Brainwriting - referred to as method 635. Six participants each generate 3 ideas as a written format.

19. Lateral Thinking / Six Thought Hats- based on the work of Edward De Bono, a problem is analyzed from six different perspectives, leading to lateral thinking. This process usually takes place within a group and can lead to valuable insight (Schindlholzer, 2014, p.154).

20. TRIZ- a Russian problem solving method, involves 4 steps in which the problem is analyzed in detail, abstracted to a new problem, new principles applied to the abstraction, returned to concrete form for solution.

21. Templates of Innovation- Products are refined through 5 innovation templates of subtraction (removing features), multiplication (copy of existing features found elsewhere), division (partial use of product), standardization and combination (combining and unifying different features) change Attribute dependency (defining a new relationship)/

22. Consumer Idealized Design – integration of customers in design process

23. Scenario Engineering – used to develop future development paths using either exploratory scenarios (What could be in the future?), normative scenarios (what can we develop for the future?) and combined scenarios where positions for future development are found.

24. Jobs to be Done Framework- identifying special niches that can be filled.

25. Bodystorming – role-playing in improvised situations offer insights, generate ideas or experiences, anchored in an environment.

26. Paper Prototyping – a simplified user interface is tested for websites, web applications, desktop software, mobile devices, mobile applications and hardware prototypes (Schindlholzer, 2014, p.162)

27. Role Playing – a controversial method since many argue that participants do not act truthfully in such a capacity. Different degrees of involvement (from low to high), familiarity with roles (known to unknown roles) as well as specificity (degree of freedom to improvise) are all factors that affect the results.

28. Virtual Reality- used as a human-machine interface of a computer generated world, allows for the observation of the behaviour of a user and refine products and solutions.

29. Wireframing can refer to visual representations through photographs and computer renderings used to test the functionality and structural aspects of a website or application.

 30. 3D Rapid Prototyping- fast creation of physical objects by which a 3D Computer Aided Design (CAD) model is created, the data converted to a suitable format, checked for coherence, manufactured and sometimes undergoes post-processing to complete the function or appearance.

31. Video Prototypes – Can be used for analysis (documentation of a user behaviour) or testing proposals that use alternate means to simulate time-intensive programming to users.

32. Service Blueprinting- means of identifying vulnerabilities in the operating system 5 components: physical evidence, customer activities, onstage and backstage activities and support processes.

33. Storytelling & Storywriting, can be oral, written, visual (animation or video) with a stated context, sources based on market and customer research. New design concepts in which there are altered behaviours or future scenarios can be described through storytelling.

34. Usability Testing, a key element in evaluation of products and services, refers to the systematic perform goal-oriented tasks in a controlled environment. It is the primary tool in evaluating user behaviour and satisfaction. Several methods can be used for usability testing:

Heuristic evaluation: evaluation of interactive elements to see if they meet market requirements.

Cognitive walkthrough: evaluation of whether people are puzzled and wonder: "Hey, what do you mean" (Schindlholzer, 2014, p. 173)?

Activity Analysis- records and analyses both formal and informal user behaviour.

Thinking Aloud – also referred to as "sound thinking" (Schindlholzer, 2014, p. 173) is the simplest form of usability testing in which a user constantly explains his thoughts and actions, allowing researchers to better understand the reasoning or confusion regarding certain parts.

Surveys: as an indirect form of usability testing, can be both qualitative and quantitative.

35. NABC Pitch – A term used by the Stanford Research Institute, The NABC pitch is an abbreviation of "Need, Approach, Benefit (Take), Competition" (Schindlholzer, 2014, p.174).

36. Design Review- Using the "I like" to provide positive and "I wish" to provide negative feedback, the overall design can be reviewed by an internal reviewer or outside parties.

37. Presentation of prototypes – prototypes mark a milestone in the design thinking process and can be used for both "integration of community and experts" as well as "collection of ideas and feedback" (Schindlholzer, 2014, p.177).

Table K.1: Use of the techniques in the phases of the design process –Modified from (Schindlholzer, 2014, p.122), by Sayeh Dastgheib-Beheshti, 2017

	#	Technique	preparation	Problem definition	Design Research	Generation of ideas	Prototype development	Prototype evaluation	Specification and transfer	Cross-project coaching
Optimization methods	1	Template for the creation of the project order	X							
	2	Design Thinking Coaching Project plan	X							X
	3	Checklist Resources Design Thinking Coaching	X							
	4	Clifton StrengthsFinder	X							X
	5	Teamology	X							X
	6	Stakeholder Management	X							X
	7	Guideline Design Thinking Team Training	X							X
	8	Agile project management	X	X	X	X	X	X	X	X
	9	Give feedback and promote self-reflection		(yellow)	(yellow)	(yellow)	(yellow)	(yellow)	(yellow)	X
	10	Systemic Issues Interventions		(yellow)	(yellow)	(yellow)	(yellow)	(yellow)	(yellow)	X
	11	Solution Circle		(yellow)	(yellow)	(yellow)	(yellow)	(yellow)	(yellow)	X
Design Thinking Tools	1	Agile project management	X	X	X	X	X	X	X	X
	2	Framing and Reframing		X						
	3	Root Cause analysis		X						
	4	Point-of-View		X						
	5	Stretch Goals		X						
	6	Lead User Method			X	X				
	7	Interviews			X	X				
	8	Observation			X	X				
	9	Focus group			X	X				
	10	Consumer Clinics			X	X				
	11	Ethnography			X					
	12	Empathic Design			X					
	13	Personas			X					
	14	Nethnography			X					
	15	Business Model Canvas			X					
	16	Secondary research			X	X				
	17	Brainstorming				X				
	18	Brainwriting				X				
	19	Lateral Thinking / Six Thought Hats				X				
	20	TRIZ				X				
	21	Templates of Innovation				X				
	22	Consumer Idealized Design				X				
	23	Scenario Engineering				X				
	24	Jobs to be Done Framework				X				
	25	Bodystorming				X	X			
	26	Paper Prototyping					X			
	27	Role Playing					X			
	28	Virtual Reality					X			
	29	Wireframing					X			
	30	3D Rapid Prototyping					X			
	31	Video Prototypes					X			
	32	Service Blueprinting					X			
	33	Storytelling & Storywriting					X			
	34	Usability Testing						X		
	35	NABC Pitch						X		
	36	Design Review						X		
	37	Presentation of prototypes						X		