Faculdade de Design, Tecnologia e Comunicação
Universidade Europeia

2021

**Heidi Marion Weber**

# Cognitive Processes in Design Thinking Optimization of perception, processing and reasoning

Dissertação apresentada ao IADE – Universidade Europeia, para cumprimento dos requisitos necessários à obtenção do grau de Doutor em Design pela via de opção de realização de um programa doutoral realizada sob a orientação científica do Doutor Américo da Conceição Leonor Mateus, Professor Auxiliar da ISMAT - Portimão Lusófona, da orientação do Doutor António José de Macedo Coutinho, Design Phd., Professor Associado da Universidade Lusófona e da orientação da Doutora Sara Patrícia Martins Gancho, Professora Auxiliar da IADE, Faculdade de Design, Tecnologia e Comunicação, Universidade Europeia.

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# Processos Cognitivos em Design Thinking Otimização da perceção, processamento e raciocínio

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**o júri**

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And with all my heart and for more than I can tell … you know.

**palavras-chave** Design Thinking, Psicologia Cognitiva, Neurociências, Emoções e Mindsets

**resumo**

Esta dissertação documenta um esforço de pesquisa sobre os processos cognitivos em Design Thinking. Teve como objetivo identificar a forma ideal de pensar, nas várias fases de um projeto de Design Thinking.
O design, a neurociência, as psicologias positiva e cognitiva, servem de base para analisar o processo de Design Thinking, mapeando e relacionando modos de pensamento com fases do processo.

A revisão da literatura cobre:
Uma visão mais abrangente do método do Design Thinking, suas origens e fundamentação científica. A criatividade como um produto social e os seus processos cognitivos mais relevantes.
A relação entre emoção e criatividade e a abordagem Limbic® Map.
Finalmente, são introduzidos métodos de reconhecimento automático da emoção com algoritmos de inteligência artificial, baseados em *deep learning*.

Uma fase de investigação empírica, revelou que as emoções e os outros estados afetivos não são adequados para esta investigação.
Pode demonstrar-se ainda que “mentalidade” não possui uma definição cientificamente consensual, tornando o conceito incredível para a investigação.

Investigações semelhantes, identificam cinco pares de funções cognitivas necessárias. Três deles, abordam o processamento de informações (Aquisição de Dados, Alinhamento da Perceção e Avaliação de Informações e Ideias) e dois abordam o controle do fluxo cognitivo (Atenção a uma tarefa específica e Consciência do Processo Cognitivo). Aplicaram-se métodos para ativar e guiar as funções cognitivas, num projeto de Design Thinking.
Revelou-se a importância de incluir profissionais criativos no processo, pois uma pesquisa em neurociência indica habilitações específicas de pessoas criativas, nas conexões neuronais do seu cérebro.
Novos contributos na “Groan Zone”, indicaram que uma mudança de atitude no momento “Groan Zone”, poderá alterar consideravelmente o resultado de um projeto de Design Thinking.

**Keywords** Design Thinking, Creativity, Emotions, Cognitive Psychology, Perception

**Abstract** This dissertation documents a research endeavour into the cognitive processes in Design Thinking. The goal was to identify the optimal way to think in the various phases of a Design Thinking project.
The research draws on the findings in design, positive psychology, cognitive psychology, and neuroscience to analyse the Design Thinking process and to map and match thinking modes with the phases of the process.

The fundamental literature review covers three topics:
The research into Design Thinking provides a comprehensive insight into the method and its scientific fundament. Then, creativity as a social product and the cognitive processes relevant to creativity are documented. Thirdly, emotion and its relation to creativity and the Limbic® Map approach are presented. Finally, automatic emotion recognition with deep learning based artificial intelligence algorithms are introduced.

The first stages of empirical research revealed that emotions and other affective states are unworkable for reliable research results. Similarly, it could be shown that “mindset” has no scientifically approved definition, making the concept unsuitable for robust research.

Further research identified five pairs of cognitive functions needed in Design Thinking. Three pairs address information processing (*Acquisition of Data, Alignment of Perception*, and *Assessment of Information and Ideas*), and two address flow control of cognition (*Attention to a specific task* and *Awareness of the Cognitive Process*). The research further investigated methods to activate and guide the cognitive functions in a project.

Moreover, the importance of including creative professionals in a Design Thinking process was revealed. Research in neuroscience indicates specific abilities of creative people identifiable in the very brain network connections. The research also discovered new insights into the “Groan Zone”. The findings indicate that a change in the attitude and approach to the “Groan Zone” could considerably change the outcome of a Design Thinking project.

# Table of Contents

## List of Figures and Tables

### List of Figures

**List of Tables**

## List of Abbreviations

| | |
|---|---|
| API | Application Programming Interface |
| AR | Action Research |
| AU | Action Unit |
| BMC | Business Model Canvas |
| CSF | Critical Success Factors |
| CPS | Creative Problem Solving |
| CR | Critical realism |
| DMI | Design Management Institute |
| DMN/DN | Default Mode Network or Default Network |
| DSR | Design Science Research |
| DT | Design Thinking |
| DVI | Design Value Index |
| ECN | Executive Control Network (also called CEN: Central Executive Network, CNN: Cognitive Control Network, or fronto-parietal control network) |
| e.g. | exempli gratia (latin): for example |
| FHV | Fachhochschule Vorarlberg → Vorarlberg, University of Applied Sciences |
| i.e. | id est (latin): that is to say |
| MIT | Massachusetts Institute of Technology |
| MVP | Minimum Viable Product |
| MW | Mind Wandering |
| MySQL | My Structured Query Language |
| PHP | PHP: Hypertext Preprocessor (recursive initialism) |
| POV | Point of View |
| SLR | Single-Lens Reflex Camera |
| SN | Salience Network |
| TCO | Theory of Constructed Emotion |
| TISDD | This is Service Design Doing |
| VPS | Value Proposition Canvas |
| UCD | User-centred design |
| VN | Visual Network |
| WYSIATI | What You See Is All There Is. |

## List of Acronyms

| | |
|---|---|
| AFAR | Automated Facial Affect Recognition |
| DREPT | Design Relevant Explanatory/Predictive Theory |
| FACS | Facial Action Coding System |
| MOCA | Model of Creativity and Attention |
| OCEAN | Big Five personality traits: Openness, Conscientiousness, Extraversion, Agreeableness Neuroticism |

## Glossary

| | |
|---|---|
| Business Model Canvas | "The Business Model Canvas, developed by Alexander Osterwalder, is a visual representation of current or new business models, generally used by strategic managers. The Canvas provides a holistic view of the business as a whole and is especially useful in running a comparative analysis on the impact of an increase in investment may have on any of the contributing factors." (Luenendonk, 2019, para 3) |
| Digital Transformation | Digital Transformation is "a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies" (Vial, 2019, p. 121) |
| Entity-Relationship-Model | A high-level conceptual data model "frequently used for the conceptual design of database applications" (Elmasri & Navathe, 2016, p. 89) |
| Heat Map | A representation of data where the values of an entry are represented as different colours (Skiena, 2018, p. 178). |
| Interoception | Interoception is "the perception of inner bodily states". It "includes a whole range of 'inner perceptions' from the physical measure of the heart rate and rhythm of breathing to emotional signatures and to conscious awareness" (Kukkonen, 2019, p. 107). |
| Lotus Effect | "The term lotus effect […] refers to a combination of wetting behaviours exhibited by the lotus leaf (Nelumbo nucifera): a very high water contact angle (WCA) and effortless roll-off of water droplets (Xu et al., 2020, p. 1692) |
| Quantum Mechanics | "'Quantum mechanics' is the description of the behaviour of matter and light in all its details and, in particular, of the happenings on an atomic scale." (Feynman, 1963, p. para 1) |

# 1. Introduction

The world is full of problems that need to be solved. The range of issues is vast: from personal issues, the constant requirement of organisations to improve and innovate, even to the critical challenges of the world fighting hunger, epidemics, ecological devastation, and many more. Design Thinking has proven to be an effective methodology to find solutions for many challenges. Companies like Toyota, Apple, and Nike use it with great success and have even built their company philosophies around it. The social impact of Design Thinking solutions is impressive: learning tools for autistic children, sanitation products for the poorest people in Ghana, the right approach for new opera audiences … the list grows every day. It is not by chance that Lewrick et al. (2020) just published a book that serves as a guide to personal improvement using Design Thinking.

Design Thinking is intensely dedicated to human centeredness, experimentalism and integrative thinking. Its methods quicken creativity but also make sure that solutions are implementable by checking them against *desirability*, *viability*, and *feasibility*. The methodology is an enabler for fruitful innovation.

Efficient projects are carried out by a team consisting of interdisciplinary specialists and people affected by the challenge the projects strive to tackle. This is because solving complex questions requires versatile know-how and perspectives. The co-creation is facilitated by a process with clear phases and a wide-ranging portfolio of tools to cover multifaceted demands.
Lay people who are not used to working in a creative project especially need a process to support their designing, because: "To innovate, people have to take their normal thinking to a much higher level. Most of us have to be taught how to do that" (E. D. Hess, 2014a, para 3). Design Thinking helps to lead even heterogeneous teams through an innovation/problem-solving project, directing the abilities of each team member in the best way.

Design Thinking demands extreme variation in thought and work processes: Inquiry and synthesis alternate, divergent switches to convergent thinking, adventurous phases lead to down-to-earth structuring and judging. This requires ever-changing workstyles from the project members. Each phase of the Design Thinking process develops and needs its unique *feeling* that must be acknowledged by the team and particularly by the facilitators (T. Brown, 2019, p. 70).

With the success, various publications on Design Thinking found their way to the interested reader. Most of them explain *how* to do Design Thinking, giving tips for the process and providing tools for each and every phase. The presented research seems mainly interested in creating more convenient processes and quicker tools. Publications researching *what* Design Thinking is and *why* it works are missing. In their comprehensive mapping study, Paula and Cormican (2016, p. 64) reveal this lack of research into the very nature of Design Thinking. Other authors uncover similar gaps, pointing out the missing theoretical background and the threat that Design Thinking will become vague over time without a solid scientific foundation (Bouwman et al., 2019, p. 1443; J. Schweitzer et al., 2016, p. 84).

Prud'homme van Reine (2017, p. 57) focusses on the lack of definition for what it means to be Design Thinker: "Although there is general agreement that the essence of design thinking is empathy with user needs and putting the final customer central, there is a lot of confusion about what it needs to become a design thinker."

So it seems to be time to apply "the intrinsically human-centred nature of *design thinking*" (T. Brown, 2019, p. 121) on Design Thinking itself.

The research interest of the author is not only literature driven. Based on her own experience with Design Thinking projects, the author noted that there are sometimes periods in a project where the team felt irritated and lost, not knowing how to proceed. The facilitators were able to help when this occurred, but it felt awkward, like "just getting over it" and not proceeding fruitfully. There was a gap in the process – the question remained how the team could have managed the phase properly and not just "muddle through" it. Reflecting several Design Thinking projects, the author missed the *thinking* in Design Thinking as the tasks lead just from *doing* this to *doing* that. Even if the project was successful, she could not see why.

The author wants to contribute to the scientific background of Design Thinking. The most interesting starting point is creativity, researched in psychology, neuroscience, sociology, and other fields. So, the author's research will start with a thorough investigation of Design Thinking and creativity. As emotions are the main factor that lead our decisions and our behaviour (Damasio, 2004; Häusel, 2011), it seems reasonable to investigate the role of emotions in Design Thinking. After an in-depth dive into emotion, especially emotion in connection to creativity, empirical research is conducted that directly investigates Design Thinking projects to find out why Design Thinking works and how Design Thinkers act and think. The goal is a better understanding of Design Thinking and a contribution to its fundamental processes.

# 2. Methodology

The differentiation between research methodology and research methods in this thesis follows Saunders et al. (2015). They define methodology as the "theory of how research should be undertaken" (p. 4) in contrast to methods that are the "techniques and procedures used to obtain and analyse data" (p. 4).

## 2.1. Objectives

The goal of this thesis is to analyse the phases of the Design Thinking practise and to identify the cognitive processes that are effective (and efficient) at each stage. The research should not only add to the theoretical background but also contribute to the Design Thinking practise by enhancing the awareness of Design Thinking practitioners and by giving them knowledge on how to achieve these cognitive processes in their teams.

The planned research has a strong theoretical side with a wide range of literature review. The author believes the applied side is also relevant and should manifest in a communicable and applicable statement to implement the insights in Design Thinking practice. With this generation of practical, relevant knowledge, the research should be counted as *Mode 2* research: research with an intense connection and interaction with the practice and the practitioners of the field (Hodgkinson & Starkey, 2011, p. 360; Saunders et al., 2015, p. 7).

As the author has no feasible possibility to work with a research team, and as no funding is granted for the project, the research has to be realisable for a single person during the duration of the PhD studies.

### 2.2. Research Question

As explained in the introduction, the goal of the research documented in this thesis is to find out which states of mind might be helpful for the success of a Design Thinking project. As states of mind is a broad area, including mood, emotion, feeling and attitude, the first task was to focus on one specific area. The first choice was emotion, as the prevalent state of mind that ensures the survival of the species. Emotions spark various actions that enable proper reactions on the external elicitor of the emotion (Häusel, 2019b, pp. 48–49), and therefore evoking the right emotions can activate recipients to great performance and better the results of a project (Häusel, 2019a, p. 28).

The starting point of the research documented in this thesis was formulated as follows:

**Theme and Problem Statement**
Each step in the innovation process driven by Design Thinking needs a certain emotion/mood – how can you keep and modulate it through the whole process?

**Initial Research Question**
How can the mood base of a design thinking tool be determined? How could a specific tool be optimised to support/activate the desired mood?

This question needs deep research into the nature of creativity. It is relevant to see, if there is already a basis in Design Thinking. This leads to

**Sub-Question I.1:**
What is Design Thinking and is it based on scientific methods or is it just something IDEO invented (Seitz, 2018, para 1)?

After establishing knowledge in Design Thinking, it is relevant to understand the nature of creativity and emotion:

**Sub-Question I.2:**
What is creativity and what are relevant aspects in Design Thinking?

**Sub-Question I.3:**
What is emotion, how can it be identified, and how does it affect creativity?

After this, the empirical research can strive to answer the following questions

**Sub-Question I.4:**

Every phase of the design thinking process needs a special kind of mood/emotion to be successful. How can the appropriate mood for every phase be specified?

**Sub-Question I.5:**

Depending on the task, each phase of the design thinking process needs tools that lead the team to a special mood/emotion/mindset. How can these tools be determined?

**Sub-Question I.6:**

Depending on the team structure, the team leader needs to select the tools to nudge the mood to achieve better and more efficient results. How can he/she identify the appropriate nudge?

During the advancement of the research process the question needed some adaptation, as is appropriate to the iterative style of the selected research design (Dresch et al., 2014, p. 119)

**Final Research Question:**

What are relevant cognitive functions in a Design Thinking project?

The first three questions stay the same, as the first empirical research is based on them:

**Sub-Question F.1:**

What is Design Thinking and is it based on scientific methods or is it just something IDEO invented (Seitz, 2018, para 1)?

**Sub-Question F.2:**

What is creativity and what are relevant aspects in Design Thinking?

**Sub-Question F.3:**

What is emotion, how can it be identified, and how does it affect creativity?

As emotion turned out to be the wrong approach and dichotomous cognitive functions emerged

**Sub-Question F.4:**

Which cognitive functions support which stage of a creative process?

Finally, the results should be confronted with Design Thinking reality:

**Sub-Question F.5:**

How can facilitators guide Design Thinking team members to activate these cognitive functions?

### 2.3. Research Design

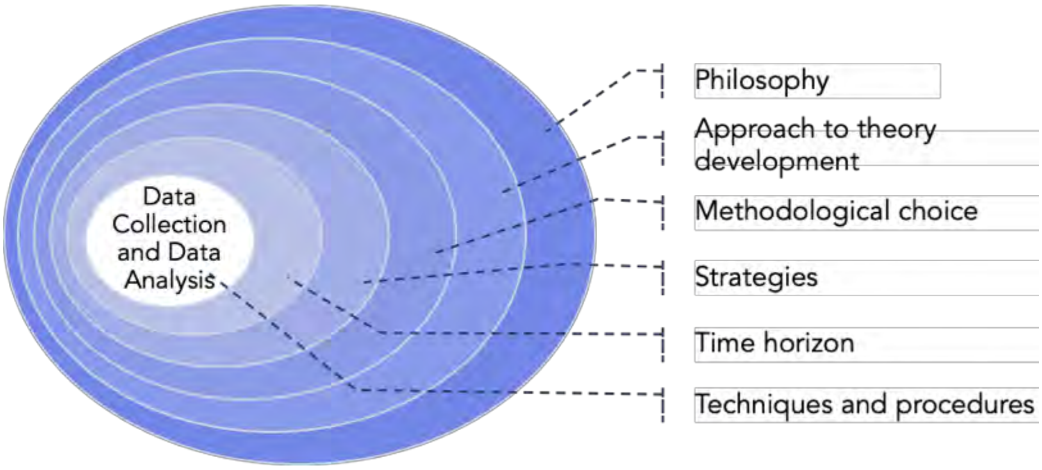



*Figure 1*. The Research 'Onion' after (Saunders et al., 2015, p. 124)

Following the model of Saunders, Lewis and Thornhill (2015, p. 124) with its research 'onion' (see *Figure 1*) the research will have the following structure listed in *Table 1*.

*Table 1*. Research Structure of this thesis

| | |
|---|---|
| **Philosophy** | Critical realism |
| **Approach to theory development** | Abduction / Retroduction |
| **Methodological choice** | Mixed-method |
| **Strategies** | Design Science Research - Design Relevant Explanatory/Predictive Theories |
| **Time horizon** | Sequential longitudinal studies |
| **Techniques and procedures** | Surveys, observation, interviews, photo documentation, protocols |

Devised by author

#### 2.3.1. Philosophy

Blaikie and Priest (2017, p. 21) emphasize the high importance of a deliberately selected epistemological philosophy and paradigm, as the elaboration and explication of this selection greatly influences how the research question will be handled. The choice made should enhance the likelihood of a successful research project. Denzin (2012) calls the philosophy "… a doctrine of meaning, a theory of truth" (p. 82).

To discuss the prevalent variants would exceed even the scope of a doctoral thesis that is not working on research philosophies as the main topic. So, this chapter presents only the philosophy of choice: critical realism.

Critical realism (CR) acknowledges a twofold view of the world: On the one side the world is an object that is independent from the observer, on the other side "part of that world consists of subjective interpretations which influence the ways in which it is perceived and experienced" (O'Mahoney & Vincent, 2014, pp. 2–3). As a realist, philosophy ontology and the world as an intransitive domain play an important role. Still, knowledge production is perforce a human activity, and therefore a transitive construct of a natural object (Zachariadis et al., 2013, p. 856). Critical realism, along with constructionism, questions objective views in science as they are influenced by the paradigms of the scientific field, and thus are only objective in the domain of these paradigms. In contrast to constructionism, critical realism still accepts and uses scientific data gathering and interpretation, albeit with a critical eye on possible social biases (O'Mahoney & Vincent, 2014, p. 5).

The experience of the world is only possible through our senses, and therefore only takes place with perceived manifestations in this world (Saunders et al., 2015, p. 139). Therefore, abduction and retroduction is vital for a researcher to comprehend what he or she observes. Abduction is the act of generalising and abstracting from the observables while retroduction seeks for patterns to explain what is observed (O'Mahoney & Vincent, 2014, p. 17). The initiator of the philosophy, Roy Bhaskar, identified three strata of observation (see Figure 2):

- The Real: the structure and mechanism of the observed
- The Actual: All that is perceivable
- The Empirical: What the observer perceived and thus the basis of the research (Mingers, 2015, p. 321; Zachariadis et al., 2013, p. 857)

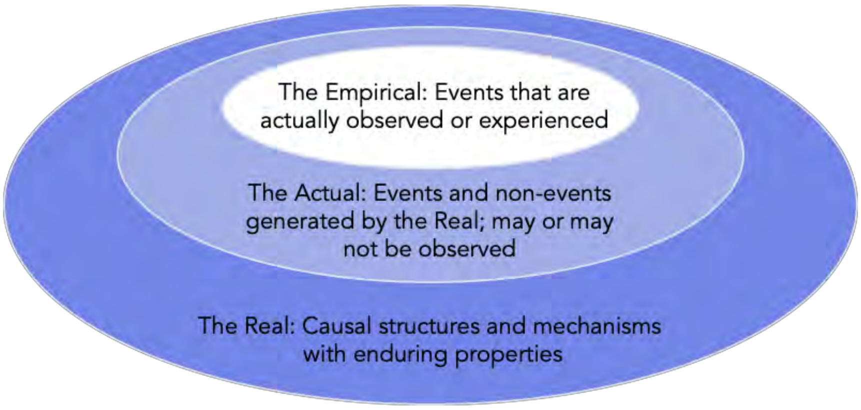



*Figure 2.* Critical Realist Stratified Ontology
After (Saunders et al., 2015, p. 139 after Bhaskar (1978))

"This important illustration helps us understand that even though there is one reality it does not follow that we, as researchers, have immediate access to it or that we are able to observe and realize its every aspect" (Zachariadis et al., 2013, p. 857). Or as Denzin (2012) points out: "Objective reality can never be captured. We only know a thing through its representations" (p. 82).

In addition, critical realism differentiates closed and open systems. Closed systems allow for causation between events, but are only achievable in controlled environments. Open systems always include non-observables and thus only allow for indication but never binding evidence; "the social world is inherently open" (Mingers, 2015, p. 321).

"For CR-guided researchers, the role of a research method is essentially to connect the inner world of ideas to the outer world of observable events as seamlessly as possible" (Ackroyd & Karlsson, 2014, p. 21). An engaged research design, as needed to answer the given research questions, is possible and recommended within critical realism. Active influence and the direct application of change personally observed within the context gives intense and first-hand data. This strategy minimizes the effect of obscuring the acquired information (Ackroyd & Karlsson, 2014, pp. 36–37). "CR acts as a general orientation to research practice, providing concepts which help create more accurate explanations of (social) phenomena than those which currently exist" (O'Mahoney & Vincent, 2014, pp. 12–13). Considering these findings and taking into account the goal of this research project, critical realism provides the right philosophical basis for this thesis. This also fits with the personal beliefs of the researcher on philosophical attitudes that should also be included in the philosophy selection (Creswell, 2009, p. 6).

### 2.3.2. Approach to Theory Development

The two basic methods for theory development are inductive and deductive reasoning.
As shown in *Figure 3*, deductive reasoning starts on the theoretical side and leads from the development of the hypothesis to an observable test and with a positive evaluation, to a confirmation of the hypothesis (Trochim et al., 2015, p. 22).

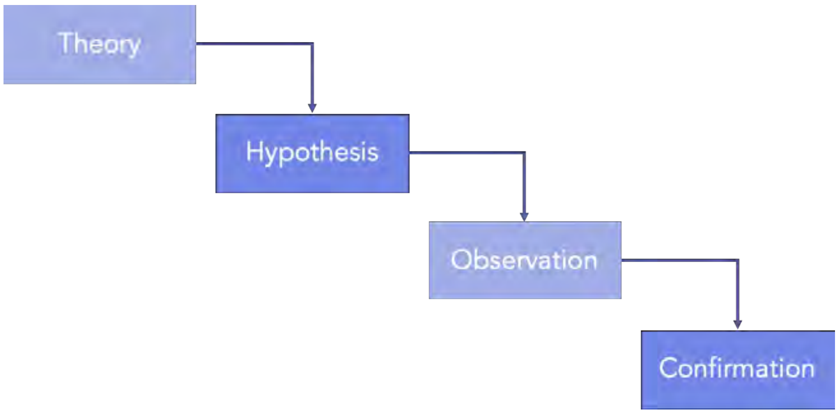



*Figure 3.* Deductive Reasoning – After (Trochim et al., 2015, p. 22)

Dresch et al. (2014) illustrate an exemplary approach:

> The researcher starts from previous theoretical knowledge and, in a logical manner, proposes some possible relationships among the variables. Later, he or she seeks concrete data to confront the model with reality. Based on the results obtained, the researcher can explain or even predict some behaviors of the system being studied. (pp. 18-19)

Deductive reasoning is tautological; it does not generate something new. It transfers truth. If the rule is true, then the application of the rule leads to truth (Reichertz, 2011, p. 284).
Inductive reasoning (induction), in contrast, starts with information about the object of interest – be it observations, measurements, survey-results, or other. From this data, the researcher detects patterns and develops a generalisation (Blaikie & Priest, 2017, p. 13). Inductive reasoning is based on experience and pattern recognition, whereas deductive reasoning is based on (extensive) knowledge and logic (Dresch et al., 2014, pp. 17–18). The inductive reasoning process is almost reverse to deductive reasoning, as shown in *Figure 4*.

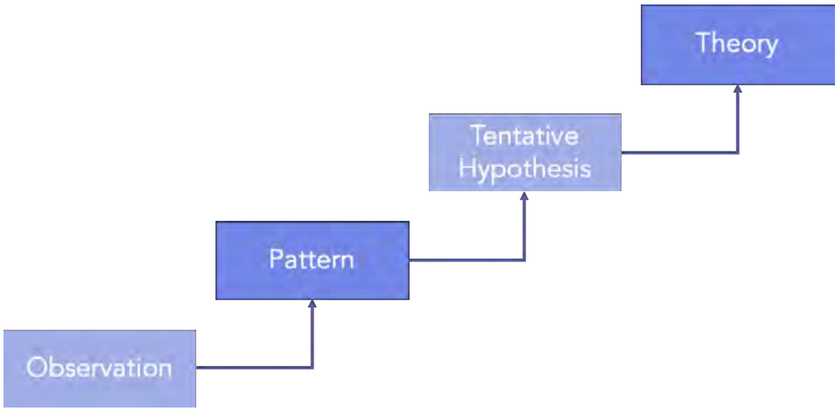



*Figure 4.* Inductive Reasoning – After (Trochim et al., 2015, p. 23)

Induction has its weaknesses, particularly (but not exclusively) from the perspective of a critical realist. There is always the danger of the inductive leap, which is the transformation from given observables to a general rule while ignoring or not being aware of some phenomenon that falsifies the reasoning (Dresch et al., 2015, p. 17). No matter how many cases are regarded, one can only generalize that something is probably true. The results are also tautological, as no new knowledge is generated, but given knowledge is extended (Reichertz, 2011, p. 285).

To make sure that inductive reasoning stays true, Chalmers (2013) lists three rules that should be strictly followed:

1. The number of observations forming the basis of a generalization must be large.
2. The observations must be repeated under a wide variety of conditions.
3. No accepted observation statement should conflict with the derived law. (pp 42-43)

As Chalmers elaborates (2013, pp. 43–45), following these rules is extremely difficult if not impossible. "So, our knowledge of induction is not perfect, and never can be" (Thomas, 2017, p. 168). To solve this dilemma, researchers use methods like triangulation (see chapter 2.3.3.1) or constitute the likelihood of their hypothesis by using probabilistic inference, for e.g. Bayesian probability (Chalmers, 2013, pp. 48, 161).

*Abduction* can be explained in short as the creative construction of hypotheses to explain an observed phenomenon (Dresch et al., 2014, p. 61). The term was initiated by Charles Sanders Peirce (1978) who defines it like this:

> Accepting the conclusion that an explanation is needed when facts contrary to what we should expect emerge, it follows that the explanation must be such a proposition as would lead to the prediction of the observed facts, either as necessary consequences or at least as

> very probable under the circumstances. A hypothesis then, has to be adopted, which is likely in itself, and renders the fact likely. This step of adopting a hypothesis as being suggested by the facts, is what I call *abduction*. (pp. 121-122)

Reichertz (2011) coined this as the secret charm of abductive thinking: "Being a syllogism it is reasonable and scientific, then again it reaches into spheres of deep understanding and facilitates new insights" (p. 282).

Peirce also introduced the term *retroduction* in the context of inference processes. The etymology of this word gives us the meaning 'leading backwards' (Chiasson, 2005, p. 3). Peirce used the term to describe the whole process of abductive inference. Retroduction is not only composed of abductive reasoning but of a recursive procedure that includes abduction, induction and deduction. This strategy allows the development, loop by loop, an acceptable hypothesis for further scientific examination (Chiasson, 2005, p. 7). As abduction without the process of retroduction is not scientifically reasonable, Peirce started to use the terms interchangeably, which might have led to the fact that the two terms are sometimes regarded as synonymous (Chiasson, 2005, p. 1). Reichertz (2011) expresses critique to retroduction:

> "Certainty about the validity of abductive reasoning can't even then be reached, when the abductively gained hypothesis is subject of an extensive verification, that is deriving consequences with deduction, then inductively detecting them and repeating these three steps over and over." (p. 289)

O'Mahoney and Vincent (2014) identify retroduction not as a recursive process, but more as simultaneously used independent approaches to the subject: "Multiple theoretical lenses can be considered for what they tell us about the various and stratified influences that are affecting the things we observe" (p. 18). They also underscore the addition of abduction and retroduction to induction and deduction as this interdisciplinary approach "can say much more about the world" (O'Mahoney & Vincent, 2014, p. 18).

Abduction in design is considered to be significantly different to abduction in philosophy, as Peirce's abduction is initiated by an aberration to the norm, while abduction in design derives from working on a problem that defers conventional treatment (Koskela & Kroll, 2019, p. 248). The design view to abduction will be discussed in chapter 3.2.3.

*Table 2* provides a quick overview to the three reasoning processes.

*Table 2*. Deduction, Induction and Abduction: From Reason to Research

| | **Deduction** | **Induction** | **Abduction** |
|---|---|---|---|
| **Logic** | In a deductive inference, when the premises are true, the conclusion must also be true | In an inductive inference, known premises are used to generate untested conclusions | In an abductive inference, known premises are used to generate testable conclusions |
| **Generalisability** | Generalising from the general to the specific | Generalising from the specific to the general | Generalising from the interactions between the specific and the general |
| **Use of data** | Data collection is used to evaluate propositions or hypotheses related to an existing theory | Data collection is used to explore a phenomenon, identify themes and patterns and create a conceptual framework | Data collection is used to explore a phenomenon, identify themes and patterns, locate these in a conceptual framework and test this through subsequent data collection and so forth |
| **Theory** | Theory falsification or verification | Theory generation and building | Theory generation or modification; incorporating existing theory where appropriate, to build new theory or modify existing theory |

After (Saunders et al., 2015, p. 145)

Zachariadis et al. (2013) developed a retroductive process for critical realism that consists of four phases (see *Figure 5*): "*description* or *appreciation* of the research situation" (p. 866), "*retroductive analysis* of the data" (p. 866), "critical *assessment* and *elimination* of the alternative explanations" (p. 866), and "*action*" (p. 866) which means distribution of the findings. The second phase includes an iterative process that uses the *constant comparison* practise found in grounded theory (Manuell & Graham, 2017, p. 79). "It involves iterative cycles of reflection between academic literature (original theories), data, and propositions in an effort to achieve analytical stability about the mechanisms (activated or unactivated) characterizing an event or outcome" (Zachariadis et al., 2013, p. 866).

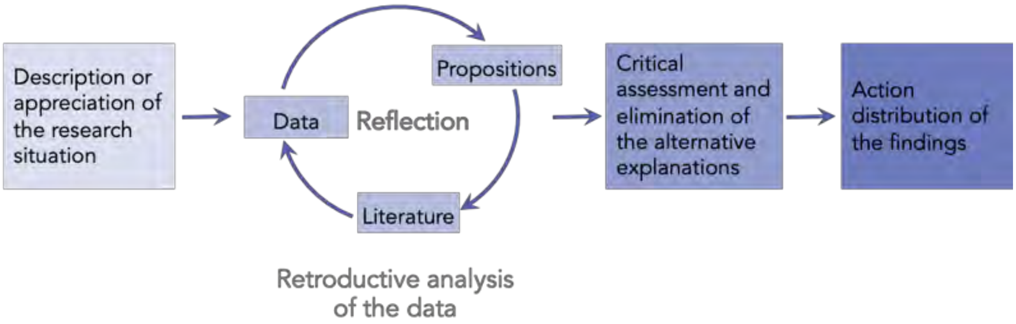



*Figure 5.* The Retroductive Process – Graphic following Zachariadis et al. (2013, p. 866)

As abduction/retroduction work well within CR and are a good basis for theory generation. Thus, the approach should be the best choice to work on the given research question.

### 2.3.3. Methodological Choice

The methodological choice determines whether the approach to the research is more quantitative, qualitative or mixed-methods oriented (Saunders et al., 2015, p. 164). The quantitative approach leads to numerical data, whereas qualitative research leads to various non-numerical results, including text, visual, auditive, and audio-visual media (Creswell, 2009, p. 3; Saunders et al., 2015, p. 165; Thomas, 2017, p. 157).

A second distinction is relevant when talking about quantitative and qualitative research: First there is the general approach to the research that is the main topic of this chapter (the methodological choice), and second there is the data collection technique for a discrete research task (Creswell, 2009). Quantitative and qualitative research should not be seen as dichotomous or even conflicting, but complementary to each other (Thomas, 2017, pp. 158–159). The methodological choice will typically not only be one or the other, but rather "*tends* to be more qualitative than quantitative or vice versa" (Creswell, 2009, p. 3).

Trochim et al. (2015) present an even more pointed view:

- All qualitative data can be coded quantitatively.
- All quantitative data are based on qualitative judgement. (Trochim et al., 2015, p. 68)

For example, Mayring (2014, p. 41) asserts that quantitative analysis of qualitative data can be valuable when inductive reasoning is pursued. The simplest variant is to count the appearance of phrases. More complex statistical methods, derived from text mining and analysis, are deployed to substantiate generalization. In quantitative data the relation is even stronger. For one e.g., an interviewee has to understand what the numbers in a quantitative question stand for, and – even more importantly – the researcher has to interpret the results of the research and state the meaning of a resulting number (Trochim et al., 2015, pp. 69–70). Lingard et al. sum it up as: "Qualitative research emphasises an inductive-subjective-contextual approach and quantitative research emphasises a deductive-objective-generalising approach, but these broad tendencies are neither absolute nor mutually exclusive" (Lingard et al., 2008, p. 461).

Specific data collection techniques are demanded in the course of a study to answer and examine the necessary questions. To limit oneself to only quantitative or qualitative techniques would impede the research (Thomas, 2017, p. 224). Creswell defines qualitative research as "a means for exploring and understanding the meaning individuals or groups ascribe to a social or human problem" (Creswell, 2009, p. 4), and quantitative research as "a means for testing objective theories by examining the relationship among variables" (Creswell, 2009, p. 4). For Creswell, a mixed-methods strategy is the systematic combination of both approaches. The synergy effects of this conduct can lead to stronger studies than possible with only one of them (Creswell, 2009, p. 4).

According to Blaikie and Priest (2017), some researchers erroneously lift the selection of qualitative, quantitative or mixed-methods to the level of a research paradigm. "What this trend has done is to elevate to a fundamental level a feature of data collection and analysis that is secondary when compared with the fundamental choice between research paradigms, between ontological and epistemological assumptions and logics of inquiry" (Blaikie & Priest, 2017, p. 19). This practise leads to bypassing the complex and highly relevant question of the philosophical attitude adopted by the researcher in her or his practise. Even if some paradigms match well with certain methods, the connection is breakable and the decision of the paradigm does not automatically lead to the corresponding method (Blaikie & Priest, 2017, p. 20).

#### *2.3.3.1. Corroboration Through Triangulation*

To get strong evidence in favour of the research hypothesis – even if uncontradicted proof is not realistic in social sciences (Thomas, 2017, p. 22) – researchers use several data gathering methods to evaluate the same point. This method is called *triangulation* – a metaphorical reference to the geodesic technique to find a location (when drawing lines from two different starting points towards a destination, these lines cross at a target point (Flick, 2011, p. 11). The term used in social science defines neither the number of measures nor the use of two standpoints (Thomas, 2017, p. 152). The relevant point is the use of different ways to observe or to measure (Zachariadis et al., 2013, pp. 855–856). "The use of multiple methods, or triangulation, reflects an attempt to secure an in-depth understanding of the phenomenon in question" (Denzin, 2012, p. 82). If the results of the different methods converge towards the tested hypothesis, this strengthens the evidence of the study (Creswell, 2009, p. 191). If they diverge the hypothesis has to be rechecked and revised (Thomas, 2017, p. 153). "Triangulation involves using more than one source of data and method of collection to confirm the validity/credibility/authenticity of research data, analysis and interpretation" (Saunders et al., 2015, p. 207).

Triangulation strategies can use combinations of all available investigation methods to achieve strong research results. Flick (Flick, 2011) elaborates the classification that Denzin established in 1970 (Denzin, 2009 / 1970):

- *Data triangulation* uses different data sources but does not change the method to get to results. The triangulation is made by collecting data that differ in time, place and/or people investigated/involved. This tactic explores the same phenomenon with a purposeful variation of specific variables. The analysis can be further distinguished by regarding people as individuals, in context of their interactions with other individuals or groups, or as members of a group (Flick, 2011, p. 13).
- *Investigator triangulation* can obviate personal biases as two or more skilled investigators observe the object of research and compare their findings (Flick, 2011, p. 14).
- *Theory triangulation* enables "approaching the data with multiple perspectives and hypotheses in mind" (Denzin in Flick, 2011, p. 14). This method is so effective because it helps omit presumptions or miss alternative explanations (Flick, 2011, p. 15).
- *Methodological triangulation* is considered to be the most important variant. It can be subclassified in within-method and between-method triangulation (Flick, 2011, p. 15). Saunders et al. (2015, p. 170) illustrate further differentiations regarding the chronological sequence of the observations as shown in Figure 6, whereupon the mix of methods does not have to be used necessarily for triangulation.
- Thomas (2017, p. 153) adds *frame triangulation* as a possibility to mix different frameworks or research strategies (that will be discussed in 2.3.4), and so extends the scope of triangulation from the data gathering method in the general approach to that of the research subject.

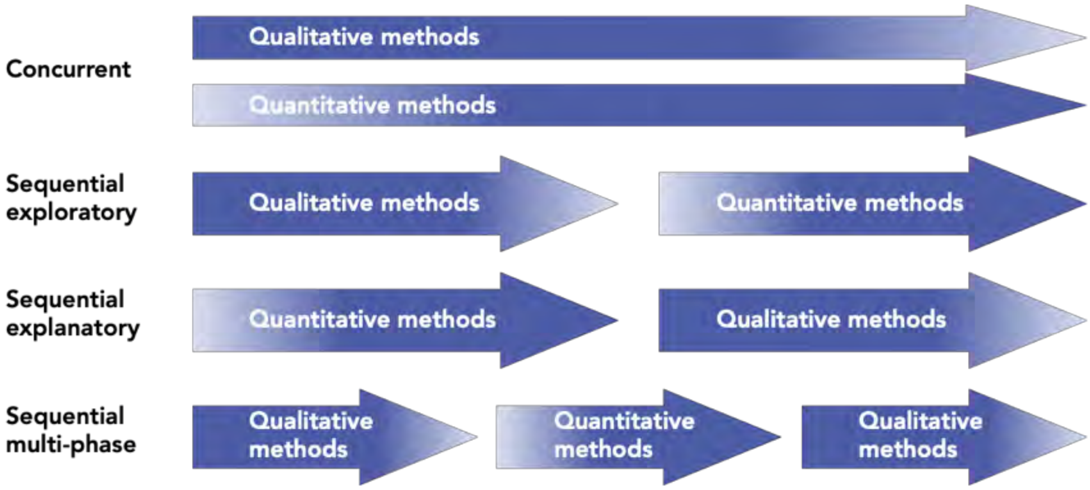



*Figure 6.* Chronological Variations in Mixed-Method Strategies
After (Saunders et al., 2015, p. 170)

In summary: "The combination of multiple methodological practices, empirical materials, perspectives, and observers in a single study is best understood as a strategy that adds rigor, breadth complexity, richness, and depth to any inquiry" (Denzin, 2012, p. 82).
As explained in the following chapter, the research strategy used in this dissertation is Design Science Research. This strategy has an iterative approach. Within these iteration circles concurrent mixed-methods are used with various data gathering techniques.

#### 2.3.4. Strategies

In principle, the critical realism approach allows for every strategic variant. However, it is recommended to use a strategy that embraces the abductive and retroductive approach (Ackroyd & Karlsson, 2014, p. 24).

The research question of this thesis suggests repetitive observation of Design Thinking projects. The author has the means to effectuate this. With this basis, Grounded Theory, Action Research, and Design Science Research seem to be the methods to consider (Creswell, 2009, p. 13; Dresch et al., 2015; Lingard et al., 2008). All three are allotted to the qualitative methods as the observance of events is core to these strategies. With a more pragmatic attitude than Action Research, Grounded Theory and Design Science Research use quantitative data in the course of data collection and belong because of this to the group of mixed-methods approaches (Creswell, 2009, pp. 16–17; Dresch et al., 2015, p. 1129; Glaser & Strauss, 2010, pp. 32–35).

#### *2.3.4.1. Grounded Theory*

"Grounded Theory was […] developed as a process to analyse, interpret and explain the meanings that social actors construct to make sense of their everyday experiences in specific situations" (Saunders et al., 2015, p. 193). Grounded Theory is a strategic method to generate theory (Glaser & Strauss, 2010, p. 39). The researcher immerses themselves in a situation without having a theory to start with. The theory develops from ideas that arise during the observation process (Thomas, 2017, pp. 248–249). "Grounded theory begins with inductive data, invokes iterative strategies of going back and forth between data and analysis, uses comparative methods, and keeps you interacting and involved with your data and emerging analysis" (Charmaz, 2014, p. 1).

Grounded Theory has developed to a highly valued research strategy in various research areas (Charmaz, 2011, p. 181). Manuell and Graham (2017) identify seven important problems that were unmet before Grounded Theory's emergence:

- the need to go out into 'the field' to discover what is really taking place;
- the essential importance of data in the formulation of a theory and then how this theory can be used data to develop a discipline that becomes a reliable basis for social action;
- the complexity and variability of phenomena and of human actions;
- the belief that persons are actors and take an active role in responding to problematic situations;
- the realisation that people act on the basis of meaning and that the understanding that meaning is defined and redefined through interaction;
- a sensitivity to the evolving and unfolding nature of events (process);
- and an awareness of the interrelationship among conditions (structure), action (process) and consequences. (pp. 75-76)

The primary concept, as developed in the mid-sixties by A. Strauss and B. Glaser (2010) was strictly inductive: Abduction was not incorporated. But Strauss appreciated Pierce's work and taught abductive thinking in his early lectures. Furthermore, although he initially rejected it, Strauss supported abductive thinking in Grounded Theory in his later publications (Charmaz, 2011, p. 191). Originally, Grounded Theory research demanded observers who experienced the given situation without resorting to theoretical knowledge. Later Strauss conceded that such knowledge influenced the interpretation of the data. But Glaser insisted that codes and categories must emerge directly from within the research generated data without influence through prior knowledge. This point, together with the attitude towards abduction, led to the separation of Straus and Glaser (Reichertz, 2011, p. 280).

Chalmers (2013) contradicts the view for data generation articulately, even calling it silly. He points out that observance without the guidance of knowledge can't lead to significance. "What is more, the very idea that the adequacy of our scientific knowledge should be tested against the observable facts would make no sense if, in proper science, the relevant facts must always precede the knowledge that might be supported by them" (Chalmers, 2013, p. 12). Reichertz (2011, pp. 290–295) illustrates that abduction – if not explicitly, then implicitly – is part of Grounded Theory Methodology in Strauss' and Corbin's approach to it.

#### *2.3.4.2. Action Research*

Action Research is a research strategy for practitioners. The core questions that are investigated are: "How do I do this? How do I learn to do it better?" (McNiff, 2017, p. 13). Kurt Lewin developed the first concept for the strategy. He explained: "It is a type of action-research, a comparative research on the conditions and effects of various forms of social action, and research leading to social action" (Lewin, 1946, p. 34).

Thomas (2017): summarises the key points of Action Research. He claims it …

– is research done by practitioners, at their own behest – not someone else's;
– is primarily about developing practice and empowering practitioners;
– involves a commitment to change and to action based on reflection;
– involves moving forward, always building on what you are discovering, using the process of planning, reflection and re-planning. (p.155)

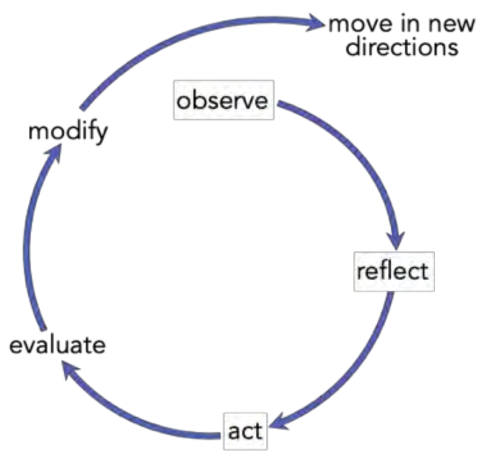



*Figure 7.* A Typical Action-Reflection Cycle – After (McNiff, 2017, p. 12)

The iterative working model (see *Figure 7*) is a landmark to Action Research. The idea is to build upon the knowledge of preceding reflection cycles while working in practical projects. In this vein, an upwards knowledge spiral is built, strengthening the area of expertise with each observed and elaborated loop (McNiff, 2017, p. 12; Thomas, 2017, p. 113).

The explicit focus on practitioners working on practical problems to advance the research area also needed an attitude change in the scientific community. Donald Schön's seminal book "The Reflective Practitioner" initiated a modification in the way that professionals are regarded when it comes to creating knowledge in their field of practise that is downright revolutionary (McNiff, 2017, pp. 23–24). Schön (1983) depicts the gap between the theorists who work aloof from daily struggles of practical demands and the practitioners who deal with and overcome frequent disarrays that contradict theoretical rules. Nevertheless, the practitioners are depreciated and their knowledge is seen as secondary. To end this, Schön demands: "Let us search, instead, for an epistemology of practice implicit in the artistic, intuitive processes which some practitioners do bring to situations of uncertainty, instability, uniqueness, and value conflict" (Schön, 1983, p. 49).

McNiff notes that things have changed considerably since Schön's book was written. The relevance of practical knowledge is acknowledged. Even more, the change has shown "the need for all to regard themselves as practitioners and to study their practice collaboratively, in a disciplined and scholarly way, and to make their accounts of practise public, so that others in their communities and elsewhere can learn and benefit" (McNiff, 2017, p. 24).

*Table 3.* Typology of reflective practices

| | | | | |
|---|---|---|---|---|
| **Reflection-on-experience** | The practitioner reflects on a particular situation after its event in order to learn from it to inform further practice. | Doing reflection | Technical rational | Increasing criticality |
| **Reflection-in-action** | The practitioner stands back and reframes the practice situation in order to proceed towards desired outcome. | | | |
| **The internal supervisor** | The practitioner dialogues with self whilst in conversation with another as a process of making sense and response [Casement 1985]. | | | |
| **Being mindful** | Seeing things for what they really are without distortion. | Being reflective | Professional artistry | |

After (Johns, 2017, p. 7) Johns' Casement reference is: Casement, P. (1985) *On learning from the patient.* Routledge, London.

The act of reflecting varies with the thinker and his/her stance to the considered situation, from a very pragmatic *Doing reflection* looking for optimisation in the practice, to a rather detached *Being reflective* analysing the sense and the position of oneself (see *Table 3*). The perspective the observer takes changes from within the job, searching for solutions for specific situations, to a somewhat detached view that reflects the relevance and the significance of act and actor (Johns, 2017, pp. 6–8).

When considering the first two statements of this chapter from Jean McNiff and Kurt Lewin, Action Research seems purely practise oriented and not suitable for theoretical advancement. Eden and Ackermann (2018) have a different view of this: "Action Research is an obvious candidate research method when the objective is to explore theory in relation to practice" (p. 1147). They developed a modification for the first loop of the Action Research circle (see *Figure 8*) that takes theory building into account. Highly relevant for this approach is the deep understanding of both theory and practise not only when coming to the stage of documentation, but *within* the circle itself. In combination with a trigger – the event or need that started the Action Research investigation – this drives the research and leads to relevant results (Eden & Ackermann, 2018, p. 1147).

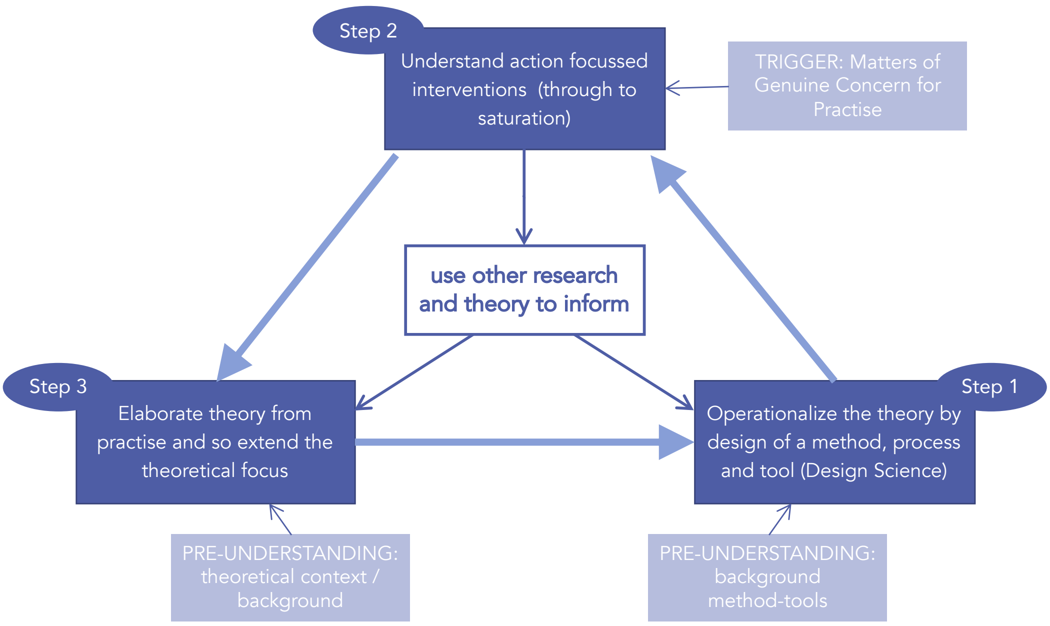



*Figure 8*. The Action Research cycle – After (Eden & Ackermann, 2018, p. 1148)

As the above-introduced trigger in Action Research typically is the desire to improve a situation (Silverman, 2015, p. 717), Action Research pursues *design* in the very fundamental way Herbert Simon (1969, 1996) defined it: “Everyone designs who devises courses of action aimed at changing existing situations into preferred ones.” (1969, p. 55, 1996, p. 111). H. Silverman (2015) infers on the basis of this statement:

> 1) the understandings and repertoires cultivated through the study and performance of the design arts can inform how one designs in non-traditional context and situations;
> 2) at the same time, designerly ways, broadly construed, need not arise from the experiences of the design arts; and
> 3) it is important to note: ways in which the design arts’ traditional focus on material and informational artifacts may skew the development of designerly understandings and repertoires. (p. 716-717)

So, “designerly ways” might be beneficial for performing Action Research. The dualism of research action and action researched possibly lead to favourable synergies – but also might lead to unwanted interferences.

##### *2.3.4.3. Design Science Research*

With his seminal book "The science of the Artificial" (1969, 1996) Herbert Simon initiated the movement of Design Science by emphasising the importance of bringing forward a science that deals with the conceiving and generating of artifacts (Dresch et al., 2014, p. 56). Where exploration, explanation, description and prediction is the main goal of most science, Design Science also wants to provide prescriptions for how to solve design problems and thus fills a gap between theory and practise (Dresch et al., 2014, p. 48; van Aken & Berends, 2018, p. 11). "Above all, Design Science is a science that seeks to develop and design solutions to improve existing systems, solve problems, or even create new artifacts that contribute to better human performance, whether in society or in organizations" (Dresch et al., 2014, p. 56).

To devise a taxonomy of business problems and to provide exemplary solutions for relevant types of problems is, to van Aken and Berends (2018), a major task in Design Science Research. The goal is to educate young professionals and to provide consultancy for practitioners: "The mission of professionals is to use understanding of that which is to realize what can or should be" (van Aken & Berends, 2018, p. 223). Design, as the intention to optimize a given situation or to solve a problem, "…is the core of all professional training, it is the principal mark that distinguishes the professions from the science" (Simon, 1996, p. 111). With this statement Simon defines a wide but distinct frame for the area of design. He explicitly involves not only those who "are centrally concerned with the process of design" but also engineers, health and social professionals, educators, architects, managers and advocates (Simon, 1996, p. 111). Design Science Research has prospered particularly in Information Systems, but is also gaining relevance in the other above-mentioned areas (Dresch et al., 2014, pp. 6–7).

Design Science Research is an iterative process. The iteration derives from the idea that knowledge (in design) is created by using given knowledge to create an artifact. By reflecting and analysing the result, new knowledge is generated and can be applied in the next cycle (Vaishnavi et al., 2017, pp. 5–6).

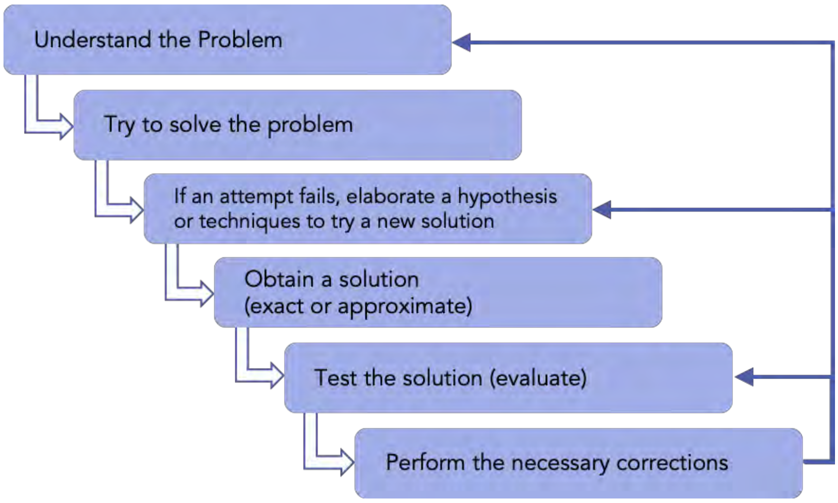



*Figure 9.* Steps for Conducting Technological Research – After (Dresch et al., 2014, p. 73)

As illustrated by Dresch et al. (2014, pp. 72–73) M. Bunge developed in 1980 the first research method that formed the basis for Design Science. His model, shown in *Figure 9*, has six steps that have to be followed sequentially but that finally lead via back loops to preceding steps of the process.

The Design Science strategy demands the application of inductive, deductive and abductive methods. Abduction is typically deployed when the researcher develops a solution for the given problem. This demands for creative approaches to find new suggestions for these solutions (Baskerville et al., 2019, p. 15). During evaluation, logical thinking and generalisation is in demand and thus deduction is applied (Dresch et al., 2014, p. 62). *Figure 10* shows where the different cognitive processes are implemented in the research cycle. As the abstraction process is inductive (Trochim et al., 2015, p. 75), there are all steps of the Peirce's retroductive reasoning present. This allows the researcher to match Zachariadi's retroductive process (see *Figure 5*, p. 25) with the given process in *Figure 10*.

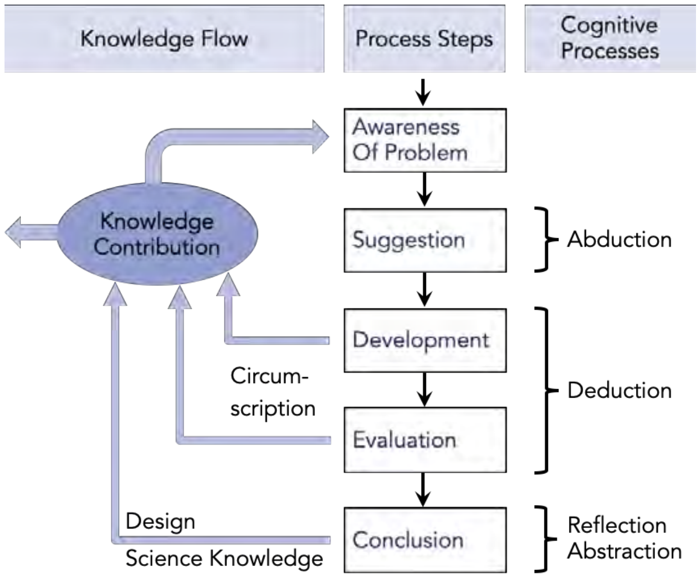



*Figure 10*. Cognitive Processes in Design Science – After (Vaishnavi et al., 2017, p. 11)

Since Design Science is highly practise oriented, it is not intuitively obvious what kind of theory could be created in Design Science Research: "A design theory is a set of prescriptive statements and outcome specification from which the implications can be drawn: if a system is constructed according to the (design) theoretical prescription, then that system will behave (or have outputs) as specified in the theory" (Vaishnavi et al., 2017, p. 17).

However, there is still the demand for research and theories that try to analyse and explain the *reason* for effects and good practise in design with the underlying natural scientific, sociological and psychological theories – called kernel theories. A theory "that augments the 'how' part of a DT [design theory] with explanatory information on 'why' one should trust the design action to work"(Vaishnavi & Kuechler, 2015, p. 23). The theories developed here are coined *Design Relevant Explanatory/Predictive Theory* (DREPT): "DREPTs are mid-range theories, conceptual intermediaries between the highly abstract space of potential problem solutions suggested by kernel theories or insights and the concrete problem solution of the implemented artifact" (Kuechler & Vaishnavi, 2012, p. 398).

Design Relevant Explanatory/ Predictive Theories try to create knowledge that builds the basis for further Design Science prescriptions that can be used as role models for concrete problem-solving (see *Figure 11*). DREPTs are abstract enough to serve for various problem spaces, but specific enough to fill the gap between broad explanatory theory and practice (Kuechler & Vaishnavi, 2012, p. 400).

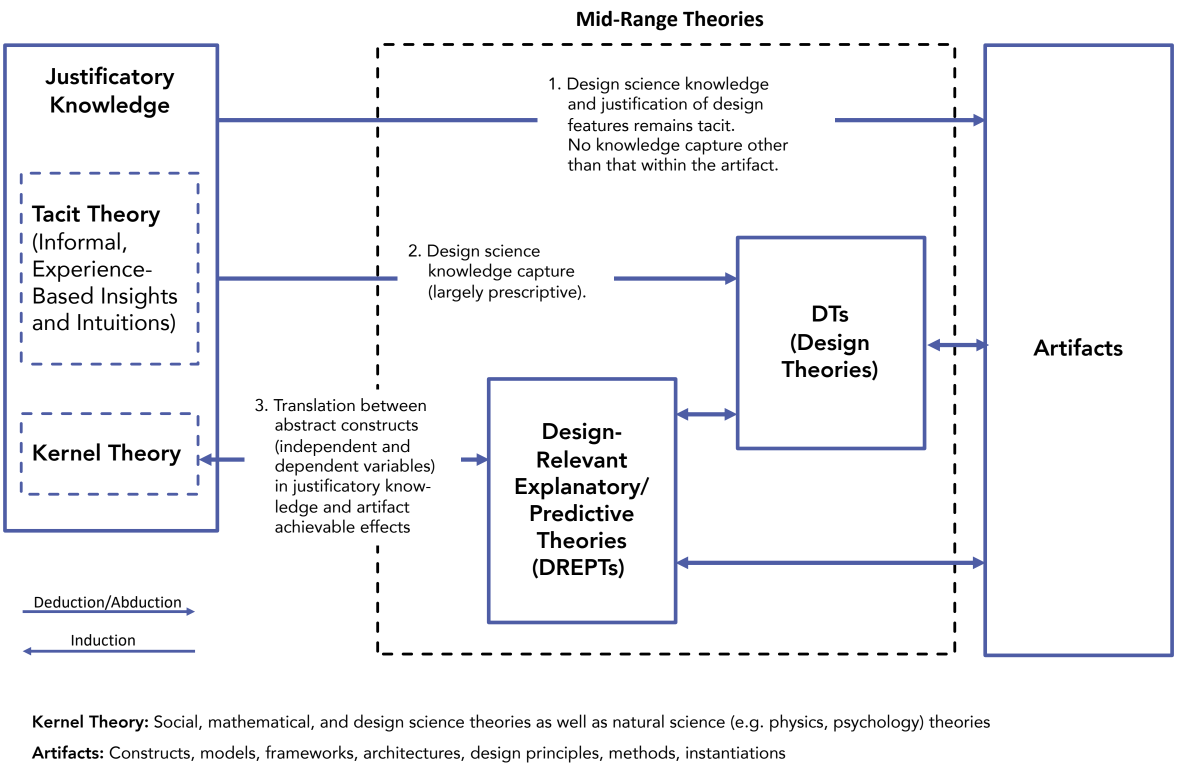



*Figure 11*. The Role of DREPT in Theory Development – After (Vaishnavi et al., 2017, p. 20)

Alturki (2016, p. 189) states that DREPTs are relevant inputs for design theories in information systems. He shows that the advancement of design theories is based upon new given problems and opportunities that develop through kernel theories (often bridged through DREPTs) to build new waves of theory innovation.

Design Relevant Explanatory/Predictive Theories use the process illustrated in *Figure 10*, with a strong focus on literature review that, especially for the kernel theories, has a basis that strongly includes transdisciplinary resources (Kuechler & Vaishnavi, 2012, p. 811). This provides a good foundation for the research endeavour documented in this thesis.

Thus, the research will use the Design Science Research methodology with a strong association to the process in Grounded Theory (Zachariadis et al., 2013, p. 866). And, as was shown in chapter 2.3.4.2 the techniques of Action Research will also be present as ideal means of data gathering.

### 2.3.5. Time Horizon

The actual research question and strategy determines if one can do research that works with the surveillance of an instant/concise time frame of a given situation, or if the examination must last for a more extended period of time and documents not only a status but also its change (Creswell, 2009, p. 146; Saunders et al., 2015, p. 200; Thomas, 2017, pp. 176–178).

Vaishnavi and Kuechler (2015, p. 53) propose a longitudinal study for Design Science Research as the iterative process already indicates. Likewise, Baskerville et al. (2018, p. 369) describe the data stream as longitudinal, as the research monitors the gradual changes of the design and gained knowledge. Briggs et al. (2019, p. 5727) add that the studies should take place in various field settings to better achieve generalizable data.

With the act of circumscription in every iteration, Design Science Research can be regarded as a series of studies or research circles, as the newly gathered knowledge leads to altered *Awareness of problem* and *Suggestion,* and with this, to a new perspective in *Development* and *Evaluation* (Vaishnavi et al., 2017, pp. 11–12). So, the data gathering is a sequential study that allows for variants in data gathering as seems fit for the situation at hand (Creswell, 2009, p. 217). As each Design Thinking project lasts for a while and each research circle consists of one or more projects, it is classified as sequential longitudinal research.

### 2.3.6. Data Collection and Analysis

Critical realism research typically uses various data sources and research methods. This is particularly true at the beginning of the research project, when the research field is intrinsically ambiguous, the processes, causes and effects are yet to be determined, and the bandwidth of research provides a decent overview. With time, the data collection gets more selective to investigate the relevant features to answer the research question (Ackroyd & Karlsson, 2014, p. 22).

True to this insight, the research circles start with sophisticated data gathering getting more concise with time but still always make sure that several sources are available to enable rigour through triangulation (see chapter 2.3.3.1).

Data gathering primarily takes place in the evaluation stage of a project. In Design Science Research the first circles can use laboratory settings or realistic conditions. The final artifact must be observed in a real environment (Dresch et al., 2014, p. 123).

It is important to note that the results in Design Science research are based on heuristics. The development of the artifact is accompanied by *construction heuristics*, the evaluation leads to *contingency heuristics* (Dresch et al., 2014, pp. 122, 125; Venable et al., 2016, pp. 83–84). It is difficult if not impossible to measure the performance and state of mind in a Design Thinking project (Schmiedgen et al., 2016, pp. 165–166). Observing the performance in the process, surveying the participants and direct evaluation of the Design Thinking solutions seems to be the best action possible (Dosi et al., 2018; Schmiedgen et al., 2016).

As the objects of investigation are the sessions of Design Thinking projects that are led and modified through the researcher, action research methods can be appropriate. This is formally correct, as Design Science Research agrees with Action Research as a data gathering/evaluation method (Collatto et al., 2018; Sein et al., 2011). Dresch et al. (2014, p. 94) advise the use of Action Research under the paradigm of Design Science in cases where the participants and their (inter-)action play a vital role for the researched subject. Collatto et al. (2018) also see the positive aspects as "the objectives of both research methods converge to a [*sic*] same objective: problem-solving and improving knowledge" (p. 250). They also point to the practical problem-solving attitude that is inherent to both strategies, and deduce: "Action research can be considered as an alternative to or a complementary strategy for design science research" (p. 250). Sein et al. (2011) present a methodology that combines both approaches under the title Action Design Research. The research documented here does not use the Action Design Research Method in full, but employs the data gathering approach of the *Building, Intervention* and *Evaluation* phase (pp. 41-44).

Observing and protocolling the Design Thinking processes is a central task in the given research. Particularly, the changes that arise *in* (learning) and *through* (intervention) the observer, and the alterations this causes *in* (learning) and *through* (reaction) the participants must be closely monitored (McNiff, 2017, p. 169). Reflection of the practice is highly relevant in this task, so the researcher does not only document what she/he observes, but also the thoughts that arise during observation (McNiff, 2017, p. 172). With reflection and learning, the initial concept can gradually develop to a reasonable solution (Briggs et al., 2019, p. 5727).

The author decided to use paper questionnaires when the participants were easy to reach because her experience showed more willingness to fill out paper than electronic forms. Web-based questionnaires were used in cases when the research addressed large group of participants (more than well to reach with paper-based surveys), when fluctuating attendance was the rule, or when the participants were approached via the internet. The kind of questionnaire changed with the demands of the actual stage of the research.

The design of the questionnaires followed the recommendation of Kaur Sidhu et al. (2018), using mainly closed questions with Likert scale for low level and quick answers and additional open questions to leave space for missing aspects.

The here documented research will use a mixed-method strategy that uses as primary data sources:

- Quantitative surveys (mostly numerical with only fields for comments)
- Qualitative surveys / semi-structured interviews
- Project observation (including work results) documented with written protocols, project outcomes (posters, prototypes, presentations) and photography
- Quantitative data from emotion detection in photography

### 2.4. Literature Review

As knowledge development is the work of many people and each new achievement builds on the shoulders of preceding findings, a scientific document without literature review is close to unthinkable (Chalmers, 2013; Saunders et al., 2015; Thomas, 2017). But the domain of literature is not only in building the foundation, it also helps to locate the research subject in its field of expertise, shows the actual state-of-art, supports the research findings, and can be part of the data collection and development process (Saunders et al., 2015, pp. 70–74). Within Design Science DREPT research it has the special function to deliver knowledge from the kernel theories to assess the research findings: "the kernel theories are taken from the most current literature of another field" (Vaishnavi & Kuechler, 2015, p. 81).

Creswell (2009) identifies three ways to use literature:

- The literature is used to frame the problem in the introduction of the study.
- The literature is presented in a separate section as a review of the literature.
- The literature is presented in the study at the end; it becomes a basis for comparing and contrasting findings of the qualitative study. (p. 27)

In the research documented here, the first of the three uses identified by Creswell build the core of the research endeavour. Literature review is firstly used to set the foundation for the whole research endeavour itself. Here, Design Thinking – its foundation, recent directions, variations, and research interests as well as trends and new related movements – are exploited. Additionally, the basics and recent developments in the area of creativity and emotion are investigated to build a basis for the start of the practical research. Secondly, during the course of the research and according to the demands of the ongoing cycle, additional literature review is performed to exploit the fitting kernel theories. The areas are mainly from cognitive psychology and neuropsychology, including affective states, cognitive procedures, perception, system thinking, framing, and leading. Following the DREPT methodology, kernel theories mainly from cognitive psychology should be brought to use in the area of Design Thinking.

The literature review uses textbooks and online resources and puts a focus on scientific articles and research documentations. Academic books, peer reviewed journals with a focus on design, psychology and innovation, and conference papers in these areas are the core source of information for this thesis. Additionally, journals and books with a more business-based attitude like Harvard Business Review and FAST were consulted. With this strategy the author tries to ascertain the latest knowledge in the appointed fields. Following Blaikie & Priest (2017, p. 33) the research will be versatile: "In the Critical Realist paradigm, researchers are likely to adopt a range of stances depending on the nature of the research problem and on which part of the research they are working." This will lead to reverting to a topic and researching more deeply when a new perspective to the subject arises.

To select the academically relevant Design Thinking models, the research followed the search strategy of Waidelich et al. (2018, p. 3) in searching for text books, journal articles, and websites. Searching for "Design Thinking" and variants of the terms *process*, *model* and *application* the following process illustrated in *Figure 12* was applied. Additionally, the terms creativity and emotion in combination with psychology, neuroscience and cognitive science were used for investigation. As the research went deeper, special terms like 'categorical perception', 'mind-wandering' etc. were part of the research.

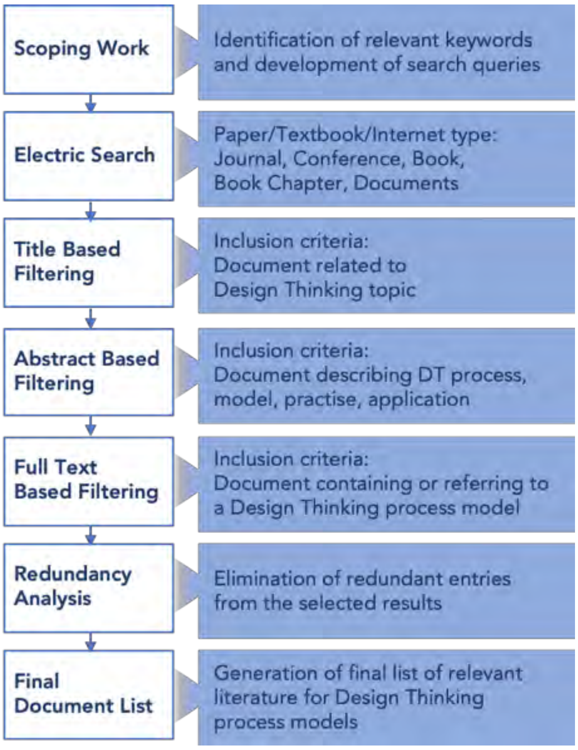



*Figure 12.* Search and Filtering Methods to Identify Descriptions of Design Thinking Models After (Waidelich et al., 2018, p. 3)

As researchers regularly discover, the research process is not as linear as the models prescribe. "In reality some stages will overlap and you will probably revisit each stage more than once" (Saunders et al., 2015, p. 11). This also holds true for this thesis. So, sometimes resources are mentioned that are from a later timeframe than the research phase they structurally belong to. These sources are used because they support the research and bring clarity to a statement, outweighing the notion of matching the source-timeline the research process delineates.

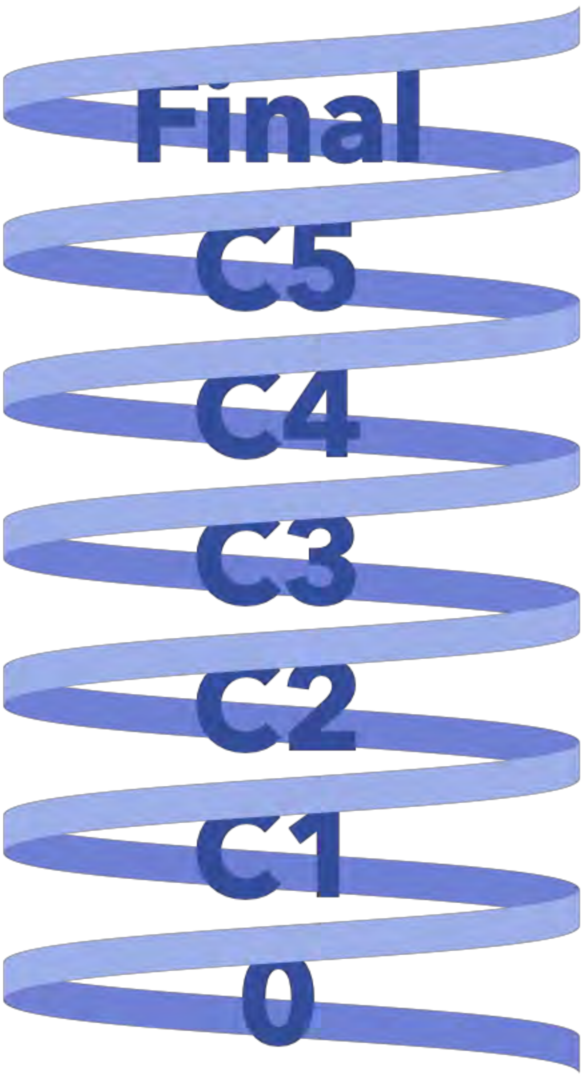
Fitting to the DREPT approach, the research had to investigate into new topics with each research circle. Thus, there are literature review chapters in the empirical part of the thesis with varying volume.

### 2.5. The Research Process

The here documented research process consists of five empirical cycles prepared with a literature research and two final projects to assess the final findings.

Each cycle starts with a hypothetical theory that is tested in the given cycle. The design and execution of the Design Thinking projects in this cycle are the artefacts of the DREPT process.

With the IFS Project the research is evaluated in a non-academic, realistic environment.




**Final Project**
6.1 IFS – Feldkirch
6.2 Antwerp 2019

**5. Team Leading, Creativity**
5.1 Dornbirn 2019

**4. Storytelling, Priming**
4.1 Antwerp 2018
4.2 Dornbirn 2018 / 2

**3. Perception, Neurology, Behavioural Sc.**
3.1 Project FH Dornbirn 2018 / 1
3.2 Three short projects

**2. Mindset**
2.1 Project FH Dornbirn 2017
2.2 Project Porto 2017

**1. Mood, Attitude**
1.1 Project at FH Dornbirn 2016

**Literature Review**
Design Thinking, Emotion, Creativity

*Figure 13.* The Research Process – Created by author

# 3. Fundamental Literature Review

## 3.1. Design Thinking

Goal of this chapter is to provide an overview of Design Thinking and its origins. First, a good understanding is provided of design as the discipline of origin of Design Thinking and its actors. The discussion of the ideal process of design is relevant as it has many parallels to the Design Thinking process.

On this basis, Design Thinking as a method is introduced and the origins of Design Thinking are explored. As this is an ongoing discussion, chapter 3.1.4 is dedicated to the question, if Design Thinking is an effective methodology that deserves the attention it gets today.
As there are various parallel advancements of Design Thinking, the comparison of the development streams shows similarities and differences. Finally, the phases of Design Thinking and various relevant elements are presented in detail as basis for further research.

### 3.1.1. Design in the Context of This Thesis

Design Thinking, as well as several other concepts that are part of modern design are quite ambiguous and call for different definitions. This ambiguity leads to many misinterpretations and faulty adopted competence that can be harmful for design and economy (Wrigley, 2019, pp. 3–4).

Design Thinking in the context of this thesis follows the definition of Tim Brown (n.d., para 1): "Design thinking is a human-centred approach to innovation that draws from the designer's toolkit to integrate the needs of people, the possibilities of technology, and the requirements for business success." [1]

To understand Design Thinking it is relevant to find an understanding to design and the design profession.

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[1] This quote delivers over 550 hits when searched in google (as of July 2020). IDEO and the d.school use it as a standard definition for Design Thinking. It was not possible to Identify the first mention of the text. Whenever Design Thinking under this approach is referred to in this thesis, it is written as a labelling with capital letters.

#### *3.1.1.1. Design*

"Design cannot be explained easily; every complex situation requires tailored, novel approaches. Many ways to seek understanding – but done in a manner inapplicable to future situations" (Spiegeleire et al., 2014, p. 32).

To find a definition for design proves complex, as the perspectives of the writers influence their view and main approach to design. Design has long been seen as “an ineffable, mysterious art” (Cross, 2011, p. 29). “We have done it for centuries and yet for most of that time we have understood very little about how we do it.” (Lawson, 2019, p. 3). This, and the old idea of only giving gestalt had to yield to a demystification through design research, but also to much more complex demands (Dorst, 2019, pp. 118–119). Limitations setting apart the designable and the non-designable are shifting, even vanishing leading to even more complexity to any approach to find a valid definition for design (Janda, 2018, p. 15).

For example, design was defined as:

- a *process* (Bühler et al., 2019, p. 2)
- a *connector* (Cox, 2005, p. 2)
- *everything artificial* (Hunter, 2018)
- an aesthetic form to unlock the world (Feige, 2018, p. 9)
- a *problem-solver* (Simon, 1996, p. 111)[2]
- a *sense-maker* (Margolin, 2002, p. 26)[3].

Manzini (2015, p. 35) – referring to Simon’s and Margolin’s definitions – identifies both as relevant for designing: “making a critical evaluation of the state of things, imagining how we would like them to be, and having the necessary relational system and tools at hand to transform them – and all this in terms of both their practical functioning (problem-solving) and their meaning (sense-making).”

While Kees Dorst sees design gets more complicated and fragmented with every challenge that arises (2019, p. 117), Cross (2018a, p. 372) on the other hand delivers a straightforward definition by saying every time someone thinks about how to achieve something new, he or she designs. Nevertheless, Cross also works with a more narrow definition that dedicates design to professional designers and

---

[2] “Everyone designs who devises courses of action aimed at changing existing situations into preferred ones” (1969, p. 55, 1996, p. 111).
[3] “What does design do? It collaborates actively and proactively in the social construction of meaning” (Margolin, 2002, p. 26 quoted after Manzini, 2015, p. 35).

their cognitive approach to a task that demands creative thinking and planning (Cross, 2011, p. 19, 2018a, p. 373). The very business-oriented approach where "Design is a structured approach to searching, identifying and saving value" (Pijl et al., 2018, p. 11) has its venue, but it deprives the original, innovative character of design. Eric Kessel, for instance, sees exactly this skill for the creative leap as the core of design and the design craft (Ambrose & Harris, 2015, pp. 22–23). Mathers (2015, p. 24), while starting with a definition of design as the linking element between innovation and creativity, defines design as arranging (physical or virtual) elements to fulfil user needs.

Richard Buchanan quotes Walter Gropius who explains the extensive vision of Bauhaus to design: "Our guiding principle was that design is neither an intellectual nor a material affair, but simply an integral part of the stuff of life, necessary for everyone in a civilized society" (Walter Gropius in Buchanan, 1992, p. 6). Gharajedaghi (2011, p. 134) identifies design as one of the three dimensions of human intelligence (see *Figure 14*). "Design, science, and art form an *and* not an *or* relationship to create the incredible human cognitive ability" (Gharajedaghi, 2011, p. 134). With this, he elevates design from an ability to a factor that makes us human.

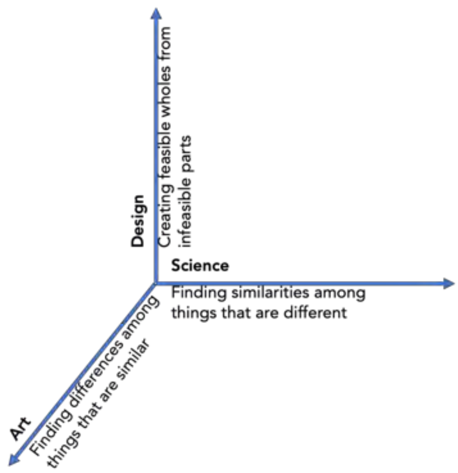


*Figure 14.* The Three Dimensions of Human Intelligence
After (Gharajedaghi, 2011, p. 134)

In 1984, Victor Papanek already claimed: "Design must become an innovative, highly creative, cross-disciplinary tool responsive to the true needs of men" (Papanek, 2005, p. X), defining it as "the conscious and intuitive effort to impose meaningful order" (Papanek, 2005, p. 3). It seems to have worked: "Design is now seen as a pathway for solving complex, nonlinear problems, which can't be solved with technological or scientific approaches alone" (Tomitsch et al., 2018, p. 10). Mathers also recognises this change in design and questions if this new design that should solve the biggest global problems can still be positioned in the same league as the design that many people just see as a discipline dealing with aesthetics (Mathers, 2015, p. 24). Janda (2018, p. 22), referring to Friedrich von Borries, even asks if design is designing the world ("Weltgestalten"). He especially mentions Design Thinking as the initiator of the change from the design that works material, form and function to working on whole systems, processes and even sociologic and economic questions (Janda, 2018, p. 17). But Janda also sees the big discrepancy between the idea of design and the practical (oftentimes very frugal) reality of design (Janda, 2018, pp. 254–255) and the fact that not everything in the world is designable (Janda, 2018, p. 281).

In engineering, design is often seen as just the transformation of requirements with a strict sequence of stages (see *Figure 15*). Miettinen (2018) defines the process as strictly economic and rational, the problems as well structured, and the solution a straight (if difficult) result of deductive reasoning.

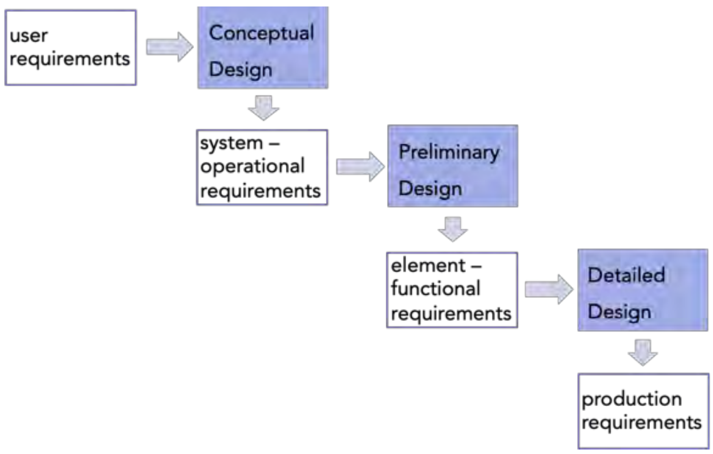


*Figure 15.* Requirement Transformation Stages – After (Miettinen, 2018, p. 1)

Murray et al. (2019, pp. 249, 265) show that this restriction to a logical transformation process does not really fit the tasks of design engineers. The problems they have to deal with are often highly complex and more than just technically challenging. In fact, design engineers also have to deal with ill-structured, wicked problems, that demand for creativity and strategies like switching perspectives and redefining the problem to find solutions.

Manzini (2015) does not look at the outcome or the process of design, but defines design by human qualities (see also *Figure 16*):

> "Design mode means the outcome of combining three human gifts: critical sense (the ability to look at the state of things and recognize what cannot, or should not be, acceptable), creativity (the ability to imagine something that does not yet exist), and practical sense (the ability to recognize feasible ways of getting things to happen)." (Manzini, 2015, p. 31)

With this definition, Manzini is close to Tim Brown's (2019, pp. 23–25) three design constraints: *desirability*, *viability*, and *feasibility,* but adding the ethical factor. In his later book (2019), Manzini supplements the analytical sense to the core design capabilities (p. 38). Thus, Manzini's properties form two dichotomies: The critical sense shows what should not be, creativity imagines what could be; the analytical sense identifies available resources and those missing, and the practical sense, finally, puts these resources to work.

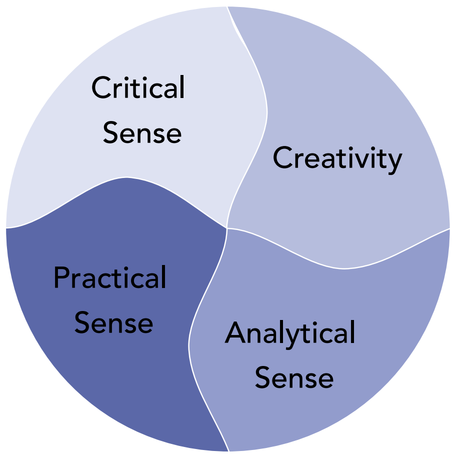


*Figure 16.* Manzini's Human Gifts Used in Design Mode
After (Manzini, 2015, p. 9, 2019, p. 38) visualisation by the author

In summary, design in this thesis is regarded along the lines of Herbert Simon: as a changer of situations towards preferred ones, and in doing so, using not only the creative abilities of the designer but also his or her sensibilities towards human, economic, and ethical demands.

#### *3.1.1.2. Being a Designer*

Who is a designer? What discerns the designer from the non-designer, the expert from the amateur? Why and where does this matter? This chapter tries to outline a designer's role and capabilities within Design Thinking.

> "Everyone designs who devises courses of action aimed at changing existing situations into preferred ones. The intellectual activity that produces material artifacts is no different fundamentally from the one that prescribes remedies for a sick patient or the one that devises a new sales plan for a company or a social welfare policy for a state. Design, so construed, is the core of all professional training, it is the principal mark that distinguishes the professions from the sciences." (Simon, 1969, p. 55, 1996, p. 111)

Papanek (2005, p. 3), Cross (2011, p. 3), as well as Manzini (2015, 2019, p. 128) accede to this, but all discern the amateur from the professional designer (Cross, 2011, p. 4; Manzini, 2015, p. 38, 2019, p. 128; Papanek, 2005, p. 151).

The typical work of a designer is the generation of an exhaustive concept of a new artifact for a producer. But behind this bland description hides the complex and demanding process of finding the right solution in the face of the relevant criteria and establishing a description that is unmistakable and feasible (Cross, 2010, pp. 15–16). John Arnold (2016) as well as Robert McKim (1980, 2016) lay great import in the designer as a comprehensively working and creating person. In their view, the designer's work and responsibility starts with research and need-finding, and ends, at least, with prototyping. McKim links design and human needs extremely closely – design answers to human needs (McKim, 2016, p. 198). "McKim's theory presents the two concepts so intricately connected as though they could not possibly be thought of independently" (Thienen et al., 2019, p. 14). Moholy-Nagy (1947, p. 42) already stressed in 1947 the importance of a holistic, human centred approach in design. He demanded that "The designer must see the periphery as well as the core, the immediate and the ultimate […] He must anchor his special job in the complex whole."

As the main tool of a designer is his or her brain, the *designerly* thoughts processes deserve a deeper investigation (Janda, 2018, p. 21). Thinking about design grew highly important and even was regarded equal to the design product itself (Miller, 2017, p. 169). Don Norman (2013, para 1) argues: "What we call design thinking is practiced in some form or other by all great thinkers, whether in literature or art, music or science, engineering or business". But Norman also gives designers a special attitude to Design Thinking and lists three crucial points: focusing on the affected people, intense experimentation, and scrutinizing the given problem (para 1).

Design Thinking uses induction, deduction and abduction to activate copious ideation with innovative and useful results – but as it happens invisibly, it is difficult to grasp and define (Vossoughi, 2013, p. 197). Cross (2018b, p. 10) claims the complex cognitive abilities of a designer as an intelligence in its own right, comprising of the ability to deal with complex problems while working very focused towards the solution, the aptitude to use various reasoning methods wherever appropriate, and the skill to adopt various media while working on the task. "I don't want to imply that designing is mysterious and obscure; but I do want to show that it is complex. Although everyone can design, designing is one of the highest forms of human intelligence" (Cross, 2010, p. 34).

Manzini (2015, p. 37) distinguishes what design experts can do (expert design) from laypersons' approach to the issue (diffuse design). He thereby acknowledges the natural capability of human beings to design, but stresses the importance of education and practice for a professional designer.

Cross (2011, p. 142) and Lawson (2019, p. 294) stress the fact that there are grades of competences that designers develop with experience and talent. A relevant skill of experienced designers is the ability to approach a problem via a number of variants to find an optimal solution (Lawson, 2019, p. 294).

Tomitsch et al. (2018, pp. 10–11) describe four phases in the evolution of the designer from mere craftsman to a holistic problem solver (see *Figure 17*). This progress does not only happen to the individual designer as he/she develops from novice to designer, but this is also true for the whole discipline of design as it gradually gains importance and value for economy and societal demands.

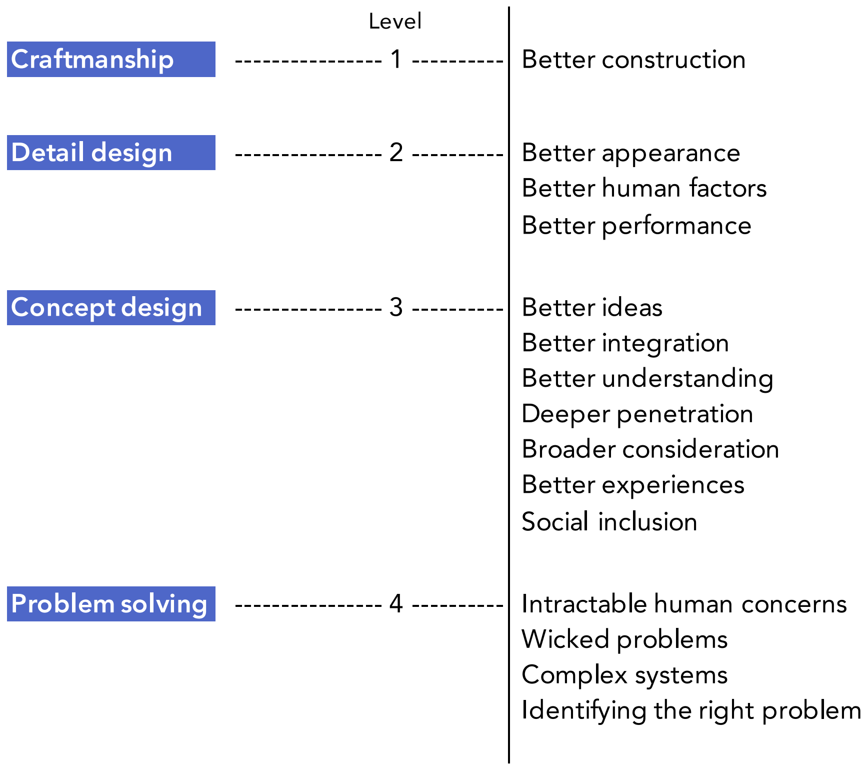


*Figure 17*. Design Evolution – After (Tomitsch et al., 2018, p. 11) layout by author

Daly, Adams & Bodner (2013, pp. 204–205) also found a distinct hierarchy in design tasks deriving from experience, the scope of the task, and the freedom given while solving the problem. They identified 6 stages (see *Table 4*) that went from a very strict evidence based course of action, conformant to the approach of Miettinen (2018) as shown in page 47, to an environment and attitude that is perceived as freedom.

With each stage the scope of the designer extends farther from the given immediate problem to a more holistic view and to more scrutiny towards the given problem (Daly et al., 2013, p. 204). Jackson & Strimel (2018, p. 53) describe the multifaceted connections a design project inevitably has that change the cognition of the given problem. They state "that the situations of design, and designer perceptions and understanding of these spaces, make a great deal of difference in the generated solutions."

*Table 4.* Categories of Experienced Design

| **Category of Description** | **Summary** |
|---|---|
| Category 1: **Evidence-Based Decision-Making** | Design is finding and creating alternatives, then choosing among them through evidence-based decisions that lead to determining the best solution for a specific problem. |
| Category 2: **Organized Translation** | Design is organized translation from an idea to a plan, product, or process that works in a given situation. |
| Category 3: **Personal Synthesis** | Design is personal synthesis of aspects of previous experiences, similar tasks, technical knowledge, and/or others' contributions to achieve a goal. |
| Category 4: **Intentional Progression** | Design is dynamic intentional progression toward something that can be developed and built upon in the future within a context larger than the immediate task. |
| Category 5: **Directed Creative Exploration** | Design is directed creative exploration to develop an outcome with value for others, guided and adapted by discoveries made during exploration. |
| Category 6: **Freedom** | Design is freedom to create any of an endless number of possible outcomes that have never existed with meaning for others and/or oneself within flexible and fluid boundaries. " |

Abridged table after (Daly et al., 2013, p. 199)

An issue designers have to deal with is solution-fixation. As daily duties, time pressure, routine and laxness take their toll; it is easy to stick to once found solutions and designs and not to drop them and to rethink the problem at hand. Working out multiple solutions instead of only one is no waste of time but circumvents impeding fixations and leads to significant improvements that should be the goal designers are striving for (Leifer & Meinel, 2019, pp. 2–3). "Designers have developed a number of techniques to avoid being captured by too facile a solution. They take the original problem as a suggestion, not as a final statement, then think broadly about what the real issues underlying this problem statement might really be" (Norman, 2013, para 1). Cross (2018a, p. 386) therefore claims designers as ill-behaved by profession – never sticking to the task or problem given but questioning it again and again, reframing it to guide the hunt for the best solution as appropriate. He suggests a self-aware approach that balances information-gathering, problem-framing and solution-hunting. Lawson and Dorst (2013, p. 26) describe this as variations in the way a designer regards a given task: "Designers are used to performing this little dance around a problem, taking stabs at it from different sides. This may sound chaotic but if done well it allows one to build up an integrated picture in the end."

A significant distinction of design thinking is the fact that it is universally usable. Design can be applied to every given situation, leaving the designer the task of adapting his or her conception to fit in. This allows dealing with highly complex, wicked problems that are not entirely definable and thus not attributable to one field of experience (Buchanan, 1996, p. 15). The consequences: "Design is branching out, each challenge leading to a new limb on the tree of design disciplines" (Dorst, 2019, p. 118). This trend of using design for more and more complex and pressing problems changes the position of the designer and demands for ever-evolving approaches – even shifting the goal from solving the given problem to working steadily towards a solution, even if the problem might prove unsolvable (Dorst, 2019, p. 124).

Neuroscience studies suggest that the act of designing uses the brain in a very particular way, thus confirming that there is a unique way of "knowing, thinking and acting" dedicated to design (Cross, 2018a, p. 276). The thought process tends more to create new patterns and new insights in given situations than to identify existing patterns in order to draw on given knowledge (Cross, 2018a, p. 381)

Going back to the fact that *everyone* is a designer, this chapter also needs to deal with laypersons. Rittel (2013, p. 123) revokes the claim that design is for professionals only, as well as Moholy-Nagy (1947) who states: "It is desirable that everyone should solve his special task with the wide scope of a true 'designer,' with the new urge to integrated relationships" (p. 42). As every person has the *God-given* urge to design, Chris Pacione (2017, p. 30) claims *design literacy* as an imperative for everyone. So, each person should be given an elementary design education to follow the natural call to create. Pacione urges designers to rise to the occasion, as those literate in design can appreciate the quality of design and will value it more highly than the illiterate. Tomitsch et al. (2018) laud the avowedly simplified models used in Design Thinking as creating easy access for laypeople to the tools of design. Giving non-designers a good approach to design was prerequisite to the evolution of design to a holistic problem-solving method (p. 11).

#### *3.1.1.3. The Design Process*

When asked about the design process Apple manager Tim Brennan drew the following doodle (see *Figure 18*) saying “Someone calls with a project, we do some stuff and money follows” (Makstutis, 2018, para 3).

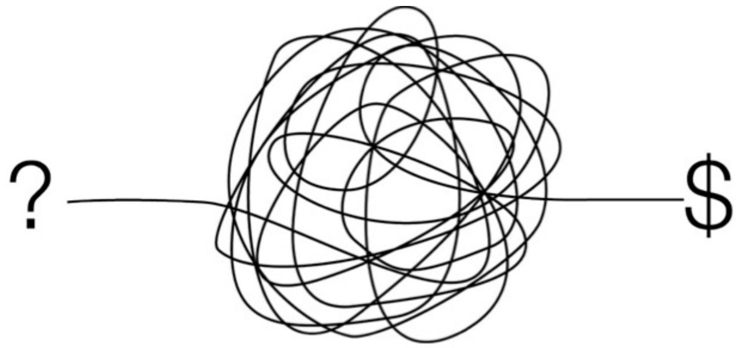


*Figure 18.* The Design Process: Sketch After T. Brennan, Apple Creative Services Group Source: (Makstutis, 2018)

Many professional designers will accede to this delineation because it is how the process feels, typically with even more loops and harsher turnarounds (Spiegeleire et al., 2014, p. 15).

This also concedes that to the perceived ‘process’ in creativity: “The journey that people take to produce creative ideas is often a winding path that involves several twists, turns, detours, and reversals of direction” (Cromwell et al., 2018, p. 53). Even if the drawing seems ridiculous at first glance, it still holds some truths about design: playfulness, (seemingly) randomness, irreducibility and iterations (Dubberly, 2005, p. 10).

Evidently, this is not the only process ever described for design. Hugh Dubberly (2005) collected over 100 design processes "from architecture, industrial design, mechanical engineering, quality management, and software development" (Dubberly, 2005, p. 6) and admitted that there are even more. Processes, in his view, are highly relevant to optimize quality, efficiency, effectiveness and communication.[4]

[4] A deeper look into the advantages and structure of processes is provided in (EABPM, 2014).

One of the best known and most frequently cited models[5] is the Double Diamond of the Design Council (see *Figure 19*).

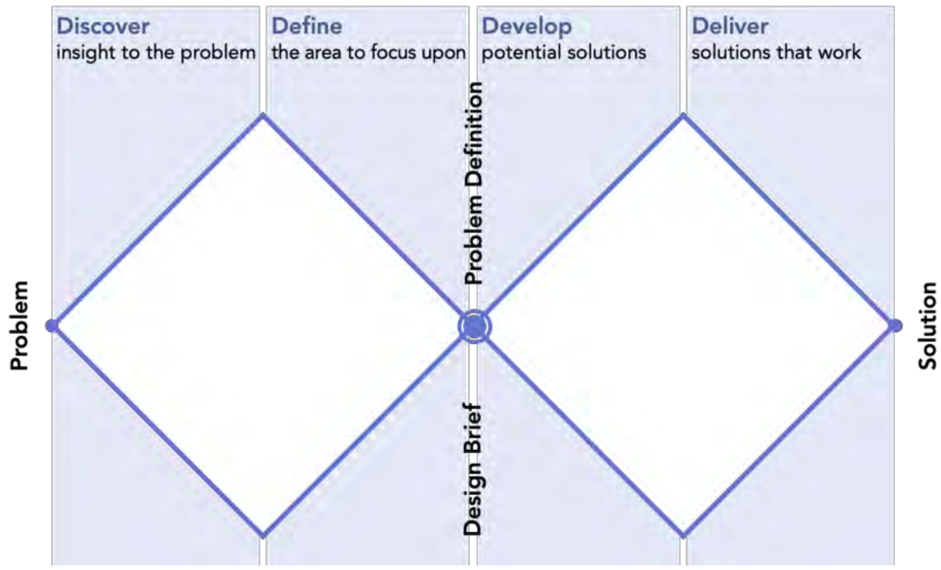


*Figure 19.* The Double Diamond of Design – After (Design Council, 2015)

The form depicts divergence and convergence, as well as the separate phases and the deliverables of the process. The first diamond focuses on finding the right problem definition, and only the second is dedicated to solution development. It is indispensable for a successful design process to identify and work on the right problem. To omit the first diamond and to work on the wrong problem is one of the biggest mistakes a designer can make (Design Council, 2015). The two areas are often called the problem space and the solution space to distinguish the two diamonds and their respective tasks and purposes (Lewrick et al., 2018b, p. 36; Przybilla et al., 2018, p. 17). The update published in September 2019 keeps the basic double diamond but extends it with design principles, a method bank, leadership function and Engagement to illustrate the complexity of the process and provide more tools to the model (Drew, 2019).

Speed is sometimes extremely vital to design projects. So it stands to reason to adapt to the time pressure by using the sprint methodology. Peter Fullagar (2018) describes the sprint process as twin to the Double Diamond but condensed to the absolute time minimum to get results as fast as possible.

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[5] A Google-Scholar search on 6th September 2019 revealed over 1500 hits for the combined terms "double diamond" "design council".

As already stated, design is much about finding solutions for complex – wicked[6] – problems. To do so requires thinking not only about the solution but also about the problem. Lawson defines "design as a negotiation between problem and solution" (Lawson, 2019, p. 146). This negotiation system contains analysis of the problem, synthesis to a solution and evaluation of this solution (see *Figure 20*) and needs communication via verbal and visual media (Lawson, 2019, pp. 146–147).

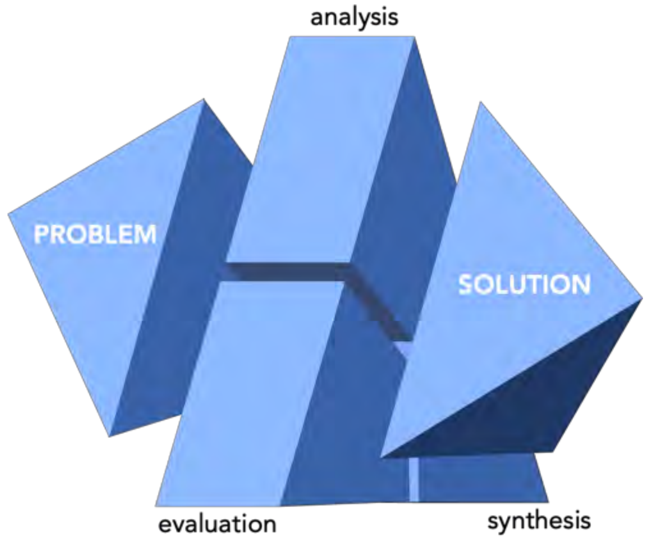


*Figure 20.* The Negotiation Space Between Problem and Solution – After (Lawson, 2019, p. 147)

The task requires questioning even the very questions that need to be answered. Often, this demands for reframing the question over and over again until it seems right and solvable (Dorst, 2017, p. 15). This is the core of the Design Thinking process and the hub for most iterations that lead to a successful solution (Luchs, 2016, pp. 8–9).

Luchs (2016) visualised this vividly in his infinity model (see *Figure 21*). He also pointed out that at the beginning of a project, the design team will not know how many iterations will be needed to find a *satisficing* solution. Iterations are highly relevant as each leads to new thoughts and viewpoints that can lead to better, more original ideas and concepts (Tomitsch et al., 2018, p. 14).

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[6] For details on the term "wicked" see chapter 3.1.3

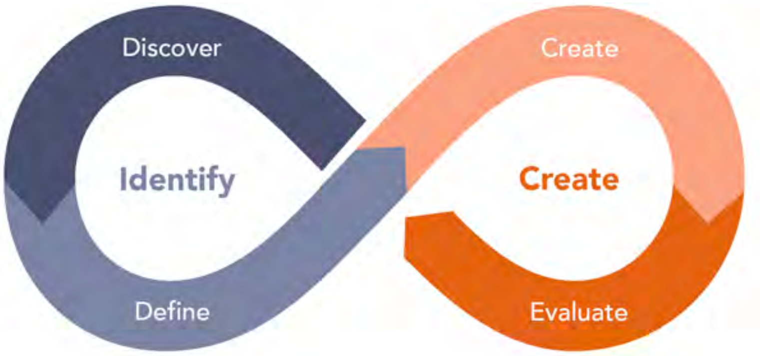


*Figure 21.* Infinity Framework – After (Luchs 2016, p. 4) redrawn by author

To handle a problem differently than other professions is one of the cornerstones of design reasoning. Einstein (2011, p. 25) stated: "For science can only ascertain what *is*, but not what *should be*, and outside of its domain value judgments of all kinds remain necessary."[7] Lawson (2019, p. 65) seized this thought and showed that designers often work precisely contrary to it, with a solution-based approach. By not staying solely focused on the given problem, designers search the "what should be" by trying to find early solutions. Moreover, in failing, they re-discuss and re-work the problem, getting a better grasp for a renewed attempt at a better solution. Don Norman (2016a, p. xv) sees the power of design exactly in this conduct: Not taking the given problem for granted, but questioning it, analysing the situation, discovering the fundamental issues of the problem and redefining it as a working basis in the hunt for solutions.

Rittel (1987) explains: "A design problem keeps changing while it is treated, because the understanding of what ought to be accomplished, and how it might be accomplished is continually shifting" (p. 2). Nigel Cross (2018b, p. 13), together with Kees Dorst, developed a model that shows how solution and problem evolve concurrently (see *Figure 22*), as a partial structure in the problem-space leads to developments in the solution-space that then again leads to the next level in the problem-space. "The co-evolution model fits well with the abductive or appositional nature of design thinking, in that it embodies the building of emergent relationships between problem and solution" (Cross, 2018b, p. 704).

---

[7] This does not mean that scientists don't have to be designers, too. When they deal with a research question, they create new examination methods, procedures of analysis or experiments to tackle the problem. "Design even extends into the core of traditional scientific activities, where it is employed to cultivate the subject matters that are the focus of scientific curiosity" (Buchanan, 1996, p. 6).

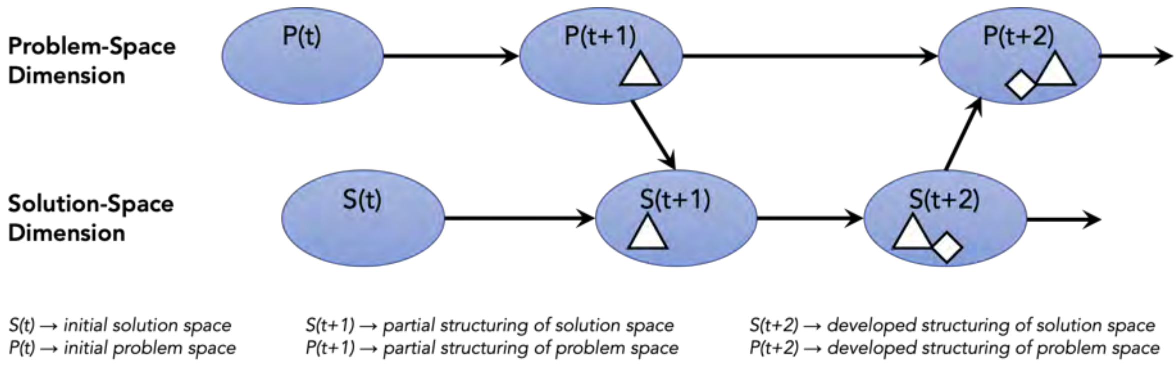


*Figure 22.* A Model of the Co-Evolution of Problem and Solution in Design
After (Cross, 2018b, p. 703)

Tim Brown (2008) also esteems the three-dimensional representation of the process: "The design process is best described metaphorically as a system of spaces rather than a predefined series of orderly steps. The spaces demarcate different sorts of related activities that together form the continuum of innovation" (p. 88). This third dimension not only allows jumps back and forth, but gives great mental flexibility to regard the elements as intrinsically interconnected and reachable far beyond a linear sequence (T. Brown, 2008, p. 89). In the second edition he describes with almost the same words "the continuum of innovation" changing the process to a never ending exertion (T. Brown, 2019, p. 22).

The design process as the endeavour to change an existing situation to a preferred one, is demanding and far more than waiting for inspiration and implementing it. Design demands dedication and empathy, as well as creativity and perfectionism. The fact that, especially with wicked problems, only *satisficing* solutions are achievable can be frustrating, even if the improvement is considerable. Design demands tenacity but also humility because "when addressing issues that are as new as they are complex, design cannot but be an exploratory process."(Manzini, 2015, p. 38)

### 3.1.2. The Design Thinking Method

As indicated in the previous chapter, the term Design Thinking is used (at least) in two different ways in scientific and practise related discussions. This thesis follows the example of Johannson-Sköldberg, Woodilla, and Çetinkaya (2013, p. 123) and distinguishes:

– Design thinking as *designerly thinking*, meaning the way professional designers think and act, as reflective practise (Schön, 1983), and as the theoretical discussion in this area. Highly prominent authors and publications in this area are Simon (1969, 1996), Buchanan (1992), and Cross (2010).

– Design Thinking as a method to solve problems and spurn innovation. “Design thinking is a problem-solving approach with a unique set of qualities: it is human centered, possibility driven, option focused, and iterative” (Liedtka et al., 2017, p. 6).

This thesis started to work primarily on Design Thinking following the second definition, but with commencing research *design cognition*, the mental actions and processes used while designing (Chan, 2015, p. 10), became more and more relevant.

The exact definition of Design Thinking is still in high dispute (Micheli et al., 2019, p. 125), but the above cited version from Jeane Liedtka, in concert with the definition of Tim Brown (see page 45), will serve as a working basis for this thesis. As will be explained in chapter 3.1.3, Design Thinking has a long history and a sound scientific background. There is a close connection to *designerly thinking,* as Design Thinking developed to a high degree from the same practice (Buchanan, 2019, p. 95).

The Design Thinking frameworks serve to give non-designers the possibility to work with methods formally initiated by design practitioners to develop innovative ideas for the product portfolio of companies, to find relief for pressing social problems or to develop solutions for a wide variety of problems (McElheron, 2018, p. 478). Since reaching the public beyond design practitioners and theoreticians, the publicity and relevance of Design Thinking have steadily grown.

"For an increasing number of CEOs, design thinking is at the core of effective strategy development and organisational change" (Naiman, 2019, p. 72). Design Thinking aims to re-think problems in a profoundly new way and thus enable the creation of disruptive innovation (Meinel & Thienen, 2016, p. 310).

Dam and Siang (2019) identified 9 fundamental principles of Design Thinking:

1. *Empathy focused.* Each Design Thinking project starts with an intense engagement in investigating the needs of the people affected by the problem the project tries to solve. An important point is the observation (of those affected) in their natural environment. Isolated interviews and tests in a lab will not work (Butler & Roberto, 2018, p. 45).
2. *Reframing of the proposed problem.* Questioning the assumptions the project started with, challenging the initially set goals, scrutinising the problem statement itself can lead to better understanding and broader perception of both problem and solution space (Buehring & Liedtka, 2018, p. 143).

3. *Collaboration*. Good Design Thinking teams consist of people with various backgrounds, skills, profiles. "Diversity makes teams more creative because the friction that results from multiple opinions drives the team to more original and more complex work"(Sawyer, 2017, p. 83).
4. *Divergent phases*. With various tasks and tools, the Design Thinking team gets stimulated to create a multitude of high-quality ideas. Brainstorming, as developed by Osborne and refined in the Design Thinking frameworks, is an important element in the divergent phases (Sawyer, 2017, p. 60) but other tools that create an open mind and free flow of thought are also important (T. Brown, 2019, pp. 72–73).
5. *Convergent phases*. Often ignored and not deeply researched, the cognitive twin to divergent thinking is just as important to the development of ideas and solutions (Coursey et al., 2019, p. 1). Convergent thinking is the selection and refining process for the abundance of ideas created in convergent thinking. This sorting and combining ensures good solutions that are only possible with the targeted access to a multitude of ideas (T. Brown, 2019, p. 73).
6. *Early prototyping*. Visualisation of the solutions leads to quick evaluation and improvement. Rough prototypes that just show the kernel of an idea are much easier to criticise and to reject in order to leave room for different and better solutions (Liedtka et al., 2017, p. 75). The tangibility gives potential users the possibility to experience the use. In the course of the project, the prototypes gradually get more sophisticated and converge towards the final solution (Lewrick et al., 2018b, p. 45).
7. *Rigorous tests*. "No idea is so good that it can't be improved upon, and we plan on a *series* of improvements"(T. Kelley & Littmann, 2016a, p. 7). Each solution needs to be tested – the more thorough, the better. Testing must be executed not only by the team but also by the prospective users, and they need to be highly critical (T. Kelley & Littmann, 2016a, pp. 106, 114). Failing is an important element in Design Thinking. The term "failing forwards" illustrates that it is a step towards a solution when one fails (Clatworthy, 2016, p. 5).
8. *Iteration*. The fact that Design Thinking is *not* a linear but an iterative approach gives it the power to excellence (Luchs, 2016, pp. 8–9). Most Design Thinking frameworks try to visualise this in their models, e.g. by delicate connection lines (Figure 27, page 72), lots of arrows, or by showing it as an infinity symbol (Figure 21, page 57). Tim Brown even envisions the process as overlapping spaces to show the nonlinearity (T. Brown, 2008, pp. 88–89). Cross (2018b, p. 703) summarizes the requirement of iteration: a refinement in one space changes the other and often requires to recheck there to get better results.
9. *From chaos to clarity*. As wicked problems (Buchanan, 1996) are often the basis of Design Thinking projects, a chaotic starting point is almost inevitable. The structure of the Design Thinking process leads to systematically combing out the chaos and provides an overview – even of highly complex circumstances (Liedtka, 2018, p. 74).

A significant element of all Design Thinking frameworks is a visual representation that depicts the procedure. Chapter 3.1.5 will explain the methodology and frameworks in more detail. Chapter 3.1.3 will before substantiating the history and theoretical basis of Design Thinking, while Chapter 3.1.4 constitutes the relevance of the methodology.

### 3.1.3. The Origins and Scientific Foundation of Design Thinking

In order to understand Design Thinking, it is essential to comprehend its very roots. The task of this chapter is not to tell the story of Design Thinking from its very beginning until now[8], but to investigate the scientific basis upon which it was developed.

Design Thinking has a vivid foundation in diverse disciplines. Its complex structure relies on a scientific background of philosophy, psychology, design, sociology, and other knowledge fields (Barsalou, 2017; T. Brown, 2019; Liedtka, 2018).

Initially, Design Thinking was recognized as a methodology for designers. It describes the designer's way to devise solutions for complex problems. The first official occasion where Design Thinking was discussed as a method to solve problems and to create innovation was a workshop held at the Delft University of Technology in May 1991 (Prud'homme van Reine, 2017, p. 56).

However, the critical features of Design Thinking, namely the work and thought methods, already existed in rudiments in the work methods of early innovative thinkers. Tim Brown sees Thomas Alva Edison as one of the forefathers of Design Thinking. It was not only Edison's inventiveness but even more so his attitude to multifaceted teams, trial-and-error approaches and his focus on human needs and wishes (T. Brown, 2008, pp. 84–85). Bill Gates (2013) characterized: "Edison recognized that inventions rarely come in a single flash of inspiration. You set a goal, measure progress using data, see what's working—and what isn't working—adjust your plan, and try again" (p. 9). In his laboratory at Menlo Park, Edison developed a highly informal working atmosphere, where workers were encouraged to work independently, use self-initiative but still maintain a companionable environment that fostered teamwork. Together with his focus on experimentation and trial-and-error, this made Menlo Park a highly inventive and innovative hotspot for creativity (DeGraaf, 2013, pp. 74–78).

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[8] Curedale provides a detailed timeline for Design Thinking from Plato over Ockham, Hume, and Walt Disney to Jeanne Liedtkas HBR article in 2018 (Curedale, 2019, pp. 16–34)

Kamran (2017, p. 3) documented the beginnings of Design Thinking with the advent of pragmatism with Pierce and James in 1898. The thinking modes induction, deduction and abduction (as described in detail in chapter 2.3.1) are relevant for Design Thinking, especially as a good understanding of abduction helps with modelling ideation tasks.

Richard Buchanan (1992, pp. 6–8) designates John Dewey as the first to describe the current philosophical approach to art, science and technology. However, Dewey's understanding of technology reaches far beyond the classic idea focused on goods. To Dewey, technology is the art of developing products – not only haptic goods but also services and structures. Dewey's definition of technology as the art of experimental thinking sets him in the position of being the spiritual forefather of Design Thinking. Dewey (1989, p. 200) trounces the erroneous split of "what is distinctively human on one side and the science and technology we label merely material on the other side." He believed that only a holistic integration of both could lead to real human and socially beneficial results. Buchanan (1992, p. 8) draws a direct connection from this view to technology and design, and concludes: "There is no area of contemporary life where design - the plan, project, or working hypothesis which constitutes the 'intention' in intentional operations - is not a significant factor in shaping human experience." Van Aken (2018, pp. 37–39) developed a process to solve problems (see *Figure 23*) on the basis of Dewey's 1910 Book "How we think" (Dewey, 2010 reprint), that already suggests a process that can be seen as a first draft towards Design Thinking.


*Figure 23.* The Problem-Solving Cycle – After (Aken & Berends, 2018, p. 13)

Herbert Simon's (1996) thoughts on design are another relevant source for Design Thinking. He described that many systems are hierarchical and thus can easily be decomposed (even complex seeming social systems); that is: simplified (Simon, 1996, pp. 184–186). However, even simplified problems still might not be solvable to the very best solution, but only to satisfactory ones. Design logic studies alternatives, looking for the best solution among the variations (Simon, 1996, pp. 191–121). Simon believes that design action can be operationalized, thus devising universally valid processes that can be taught and empirically underpinned to gain scientific reputation (Rosner, 2018, p. 25).

In the 1960ies, the designers from Scandinavian cooperative design initiated a movement that was based on participative involvement. They saw their role as facilitators to give voice to the public. At this time, they were already focused on more than products, and the cooperative can be seen as the cradle of Service Design and co-design (Szczepanska, 2017).

The holistic view was something that had high importance for the vanguard of Design Thinking. Lazlo Moholy-Nagy already wrote in 1947 that:

> "The idea of design and the profession of the designer has to be transformed from the notion of a specialist function into a generally valid attitude of resourcefulness and inventiveness which allows projects to be seen not in isolation but in relationship with the need of the individual and the community. … Ultimately all problems of design merge into one great problem: 'design for life.'" (Moholy-Nagy, 1947, p. 42)

Buckminster Fuller systematised processes in Design in the mid-fifties. He also engaged team members from different disciplines to confront problems together. At this time, he was already aware of the human responsibility for the world's ecology (Szczepanska, 2017): "the effective application of the principles of science to the conscious design of our total environment in order to help make the Earth's finite resources meet the needs of all humanity without disrupting the ecological processes of the planet" (Fuller after Szczepanska, 2017, para 10).

The scholastic origins of Design Thinking can be traced back to John E. Arnold, Professor of Mechanical Engineering and Professor of Business Administration at Stanford University, who was the first to teach design as a cognitive discipline (Thienen et al., 2018, p. 15). Before achieving this professorship, Arnold worked at MIT (Massachusetts Institute of Technology) where he founded the Creative Engineering Laboratory (*The Stanford Daily*, 1963, p. 1). Besides his keen enthusiasm for engineering and design, he was a dedicated lecturer with an intense interest in didactics. With Arnold's innovative approaches he attained a worldwide standing as educational innovator (Kays et al., 1963). "His courses and summer institutes in Creative Engineering serve as clear landmarks—they were the first substantial efforts at developing the creative potential of engineering designers" (Kays et al., 1963). Arnold's deepest passion belonged always to creativity. He collaborated with highly distinguished experts in creativity like Joy P. Guilford, Buckminster Fuller, Robert Hartman, and the originator of positive psychology, Abraham Maslow (Thienen et al., 2018, p. 15), among many others. Collectively with these authorities, Arnold developed his classes in *Creative Engineering* and *Product Design*. Notably, Alex Osborn's methodology of brainstorming, Carl Rogers' theory of creativity, and Joy Paul Guilford's seminal work on the thoughts processes influenced Arnold's research in methods of creativity (Clancey, 2016, p. 9). Guilfords concept Creative Problem-Solving (CPS) is particularly relevant for Design Thinking.

Design Thinking is classified as a form of CPS and its advancement (Worwood & Plucker, 2017, p. 87). In his lectures, Arnold talked about *Creative Thinking* and described a workflow and factors of creativity that already have close similarity to the modern understanding of Design Thinking. Under Arnold's lead the mechanical engineering department at Stanford started to teach thinking processes. Besides *creative thinking* they also trained their students in *visual thinking,* and *ambidextrous thinking*" (Thienen et al., 2018, p. 14).

Arnold saw the importance of providing an engineering education that combines technical skills with a pronounced focus on the needs and demands of humans. His goal was to train problem solvers. To achieve this, he taught his students how to think differently – combining technical know-how with a human centred approach – in order to come up with creative solutions (Clancey, 2016, p. 5). Arnold stressed the aptitude of problem sensitivity: This skill begins with the capacity to sense a problem, then to conduct a thorough inquiry where the engineer knows how to phrase meaningful questions that help discover the problem space, and then formulate an inspiring problem statement (Arnold, 2016, p. 80). For example, Arnold spurred on the creativity of his students by working with them in fictitious worlds where physical laws were abrogated (Waldron, 2018, p. 45).

Arnold (2016, p. 88) also instituted the rule that a design process needs a tangible result. He frowned upon the idea as the core of the design process: "Ideas can frequently be a dime a dozen. It is only when these ideas are translated into workable prototypes that I believe they have value" (Arnold, 2016, p. 88). Later, McKim carried this method on and deepened its theoretical background (Thienen et al., 2019, p. 14).

When teaching problem sensitivity, creative tools devising problem-statements, and the entire innovation process, "many essential aspects of what people mean today by design thinking can be traced to Arnold's Creative Engineering seminar, and for that reason the depth of our understanding about our past and what we might do tomorrow benefits from reading and reflecting on the 1958–1959 lectures" (Clancey, 2016, p. 52). The teaching attitude developed by Arnold and his co-teachers has been pursued at Stanford University ever since and is still perceptible in today's lectures (Thienen et al., 2018, p. 14).

Robert McKim, a colleague of John Arnold, was particularly influential in three areas that shape Design Thinking: human-centeredness, visual creativity, and interdisciplinarity. McKim was highly influential in strengthening interdisciplinarity. He was one of the initiators of joint projects between diverse programs that led to the d.school (Robbins, 2019, pp. 11–12). In his research and teaching, McKim set a strong focus on human needs beyond the demands of mere sustenance. McKim concatenates design and human needs so intricately that they factually become one (Thienen et al., 2019, pp. 13–14). He defined: "Design is the unique capacity of the human species to manipulate materials and energy in a reasoned or a felt response to human physical, intellectual, and emotional needs—human needs which are partially formed and modified by the natural and cultural environment" (McKim, 2016, p. 200). Visual thinking was McKim's third area of interest. In his books he introduced the theory, and more importantly, the practise of how to think visually (Robbins, 2019, p. 12). McKim was the initiator of the culture of rapid visualisation and the maker movement, enriching Design Thinking with these cornerstones of the methodology (Thienen et al., 2019, p. 14).

Bernhard Roth, the current director of the d.school also has a long history of influence on this institution. Creativity – besides seminal achievements, especially in the robotics area – was always an important element in his work (Waldron, 2018, p. 50). Roth's book "The achievement habit" comprises some of his main concepts of creativity (Roth, 2015). With Roth, the Esalen Institute and its focus on human consciousness influenced the human- centred approach of Design Thinking, as Roth was an early student of this institute. Esalen fostered an approach that the declared "antihumanities" that gave various forms of lectures but never graded the students (Miller, 2017, p. 169).

Rittel and Weber introduced the concept of wicked problems in 1973 (Rittel & Webber, 1973). With Nigel Cross and Donald Schön, wicked problems found their way into Design Thinking in the early 80s. Both asserted that the problems posed to designers are typically too complex, cross-linked and challenging to find a solution with the scientific attitude Herbert Simon represented. They proved that dealing with chaotic problems and sense-making in ambiguous situations needs intuition and artistic approaches, and thus contributed significantly to Design Thinking as it is today (Robbins, 2019, p. 8). Buchanan (1992) discussed the wickedness of problems that designers have to work with in the article "Wicked problems in Design Thinking". This article did not cover the method Design Thinking, but the way designers think.

Robert Curedale (2019, p. 13) names Peter Rowe as the first to publish a book that dealt with Design Thinking as a problem-solving methodology. This book illustrated the approaches used in graphic design, architecture and urban planning and pointed out their similarities (Hernández-Ramírez, 2018, p. 50). Rowe discusses the approaches as procedures, and argues that the way a problem is approached, biases the possible outcomes (Kimbell, 2011, p. 291).

Rolf Faste carried the research on Design Thinking further, solidifying the scientific basis and communicating the idea to a broader public. David Kelley was Faste's colleague and, by joining his brother at IDEO, brought the concept to practise (Curedale, 2019, p. 13). "At IDEO, empathy became 'human-centered design,' shifting the focus from designing products to designing the experience of using the products" (Miller, 2017, p. 169). IDEO acts as a consultant and practitioner in innovation projects, combining the task of lecturers with practical execution, thus testing the process and honing it in daily practise (T. Kelley & Littmann, 2016a, pp. 3–4).

In 2005 Hasso Plattner founded the Stanford d.school of Design Thinking as well as the Hasso-Plattner Institute in Potsdam, and with this, facilitated the scientific and educational advancement of Design Thinking (Hasso-Plattner-Institut, 2019; Miller, 2017). Other highly esteemed academic institutions also advance Design Thinking. Namely the Darden School of Business at the University of Virginia spearheaded by Jeanne Liedtka; Roger Martin at the Rotman School of Management at the University of Toronto; and many others work with and on Design Thinking every day.

Conclusion: Natasha Jen (2017) described it quite clearly (even if this was the only positive thing she had to say): Design Thinking has a long history with a solid scientific foundation (para 10). The basis is widespread as so many disciplines affect the process and the outcomes, but it is stable and deeply researched. Psychology, Sociology, Ethnography and other disciplines create a sound foundation which is systematically integrated and refined in the academic world as well as in business and non-profit organisations (Leifer & Meinel, 2016, p. 3).

### 3.1.4. Why is Design Thinking Relevant?

Design Thinking is often frowned upon, called bullshit (Jen, 2017), absurd (Vinsel, 2018), failing (Ersoy, 2018), or just plain dead (Dreser, 2017; Nair, 2018), typically by graphic or product designers. So why is it worth dealing with it? What makes it valuable? The goal of this chapter is to summarize some points that show the value of Design Thinking.

> Perhaps design thinking will be remembered as our greatest tool for surviving and solving the difficult problems that we will face during the 21st century and beyond. (Curedale, 2019, p. 14)

Former evangelist and then critic (while developing a new method that draws many insights and methods from Design Thinking) Bruce Nussbaum summarizes pointedly (2011, para 11): “Design Thinking broke design out of its specialized, narrow, and limited base and connected it to more important issues and a wider universe of profit and non-profit organizations.”

Design Thinking initiated a movement to more heterogeneous teams with collaboration across multiple disciplines, optimized creative processes and better cognitive approaches that lead to applicable solutions for everyone (Gerber, 2018).

Don Norman is a prominent example of someone who changed his view of Design Thinking. While at first he didn't see anything new in Design Thinking, describing it as "A Useful Myth" that "is a public relations term for good, old-fashioned creative thinking" (Norman, 2010), he later declared it to be "An Essential tool" that "really is special. Alas, it isn't embraced by all designers, but where it exists, it is powerful" (Norman, 2013). "What seems rather obvious though, is the expansion of design into new arenas and target areas, such as strategy, services or organization design, that go beyond the realm of traditional design" (Hassi & Laakso, 2011, p. 2). The methods of Design Thinking give non-designers the possibility to revise their stance to a given situation, to change their perception, and with this to come up with new solutions (Pijl et al., 2018, pp. 10–11). To adopt the designerly way of thinking and working provides a better chance to identify new business opportunities as human-centred approaches, and meeting potential customer's needs can help creating a successful business. Constant rethinking of the solutions in Design Thinking iterations help to stay vigilant and up to date (Pijl et al., 2018, p. 251).

Friedman and Stolterman (2017) identify 10 challenges that apply to all design disciplines:

> Performance challenges
>
> 1. act on the physical world;
> 2. address human needs; and
> 3. generate the built environment.
>
> Substantive challenges:
>
> 1. increasingly ambiguous boundaries between artifacts, structure, and process;
> 2. increasingly large-scale social, economic, and industrial frames;
> 3. an increasingly complex environment of needs, requirements, and constraints; and
> 4. information content that often exceeds the value of physical substance. […]
>
> Contextual challenges:
>
> 1. a complex environment in which many projects or products cross the boundaries of several organizations, stakeholder, producer, and user groups;
> 2. projects or products that must meet the expectations of many organizations, stakeholders, producers, and users; and
> 3. demands at every level of production, distribution, reception, and control. […] (pp. 239-240 abbreviated)

While minor projects might not be hit by the full array of challenges, bigger projects most certainly will and demand far more expertise and a new way of thinking that includes skills beyond former design practice (Friedman & Stolterman, 2017, p. 240). Design Thinking is created and honed to deal with these challenges – especially the contextual ones (T. Brown, 2019; Quackenbush, 2018; Rampersad, 2018).

Being a competent Design Thinker is often seen as a fixed property of a person, unchangeable and unachievable for those who do not have it. This leads to the misconception that Design Thinking is unvaryingly the same whenever it is applied (Leifer & Meinel, 2019, p. 8). Royalty et al. (2019, p. 71) show how incorrect this impression is: Design Thinking changes with the problem, the team, the skill level, and the organisational integration. Being aware of this fact changes the way Design Thinking is implemented. Social design, for instance, proves to be extremely demanding: Not only the complex structure of the people affecting or being affected by the problem and solution, but also the professional knowledge to handle it all calls for more than the typical design approach to avoid being overly simplified (Dorst, 2019, p. 119). Jeroen van Erp (2018) explains how design abilities and the way designers think can be useful for other tasks than classic design. "Design Thinking is more than a process, it's a way of being" (Erp, 2018, #62).

"Human-centered design redescribes the classical aim of education as the care and tending of the soul; its focus on empathy follows directly from Rousseau's stress on compassion as a social virtue" (Miller, 2017, p. 169). The success of design and Design Thinking can be proven by numbers. Design-led companies like Apple, Pepsi, Procter & Gamble and SAP beat the S&P by 211% in 10 years (Naiman, 2019, p. 72). The values were created for the Design Management Institute (DMI) by covering the values of 16 companies that the DMI classified as design-centric with most of them working with Design Thinking (Rae, 2016). As the analysis only covers the data from 2005 until 2015, the author of this thesis collected the data from 2005 to 2019 to verify if the statement is still true today[9]. Figure 24 shows that the outperformance of Design-led companies still holds. The margin on 1st June 2019 is 224%.

[9] The values were drawn from finance.yahoo.com on 22nd July 2019

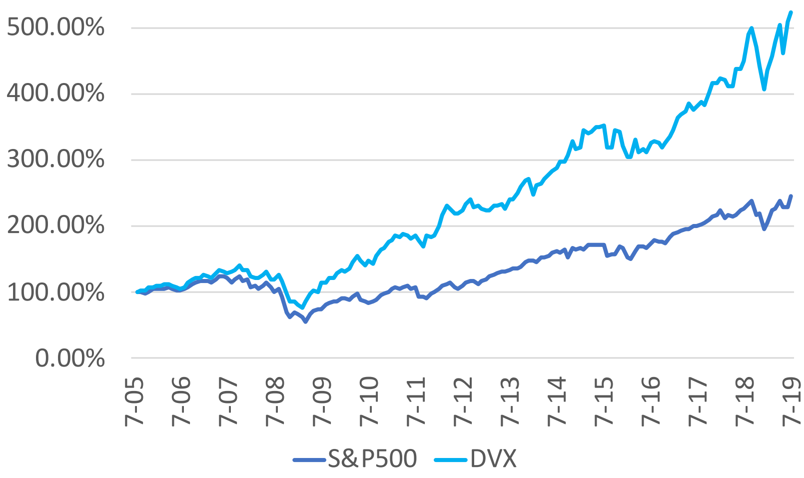


*Figure 24.* Design Value Index from July 2015 to July 2019 – Data analysis and layout by author

Design Thinking has shown its value in projects of social change all over the world (Liedtka et al., 2017). Pressing problems are everywhere and Design Thinking is recognized for its power to find solutions where desperately needed. Tim Brown's biggest concern is the fact that those social problems are overwhelming as "there are ten potential projects for every design thinker with the time and the talent to tackle them, and 95 percent of them are in Africa, Asia, and Latin America" (T. Brown, 2019, p. 222). He sees good leverage in reworking the United Nations' Millennium Development Goals,[10] as they lack the power to spur ideation. Brown gives some examples how Design Thinking's *Define* approach with the 'How might we…' questions could inspire meaningful solutions that lead to real relief (T. Brown, 2019, p. 223).

Liedtka (2018, p. 79) expresses another advantage: Tasks like direct interviews with stakeholders, working with diverse teams as peers, experimenting with failed, and playful approaches change the mindset of managers and give them enhanced empathy, more awareness of their environment, and more willingness to accept failure as part of an innovation process. So, to Liedtka the biggest advantage of some projects is not the solution but the altered team members.

But still, Jen, Ersoy, Dreser and the other critiques should not be ignored. Design Thinking has its flaws and there are reasons why it fails to reach its goals too often:

First Design Thinking is overburdened with some of the expectations people pose on it. Design Thinking does not have the superpower to save the world from each and every problem. The solutions

[10] See https://www.un.org/millenniumgoals/ for details

it provides need support and thorough implementation to really work (Gerber, 2018), "and, moving the organization behind a new solution is where most innovation teams struggle" (Razzetti, 2017, para 7). As the Gartner Hype Cycle for Education shows (see *Figure 25*), Design Thinking is just at the 'Peak of Inflated Expectations' and will be on its way through the 'Trough of Disillusionment'. This is a tough phase, but also helpful, because in this phase, each and every flaw will be lamented by enemies or crestfallen supporters and uncovered so it can be straightened out (Spee & Basaiawmoit, 2016).

The second problem is the fact that Design Thinking is used incorrectly. Wrong team members, incompetent facilitators, too small budgets to leave space for failure and iterations, and companies that squeeze Design Thinking in their narrow, straight and unforgiving culture and cut off what does not fit. Without proper knowledge of how and when to implement Design Thinking, good team structures and solid follow ups, Design Thinking ventures fail and spoil the image of the methodology (T. Brown, 2015; Ersoy, 2018; Gerber, 2018; Nussbaum, 2011).


*Figure 25.* The Gartner Hype Cycle for Education 2018 – Source: (K. C. Williams, 2018)

An innovation does not only have to supply a superior solution – what Design Thinking can do – but it also needs to reduce costs and risks and involve the stakeholders, namely the employees (Liedtka, 2018, p. 74). Without a good change management this is not possible and the solution will fail, no matter how good it was (Bligh et al., 2018). One has to bear in mind that a successful Design Thinking innovation not only needs designerly skills but also technical expertise and managerial proficiency (Micheli et al., 2019, p. 140) to fulfil the required triad of feasibility, desirability, and viability (see *Figure 42*, page 122).

Design Thinking has its flaws and needs to be rethought and optimized, but it has shown its power in business and societal challenges. It is no superpower, but it is effective and worth working with and on.

This chapter answers none of the posed research questions directly, but it is relevant for all of them, because it gives meaning to the results. To optimise an obsolete method would not make any sense at all.

#### 3.1.5. Design Thinking Methodologies and Frameworks

Design Thinking can be viewed and implemented as a mere toolbox where only single elements are utilised, as a process for an isolated problem, a methodology for a repeatedly occurring task, or as an all-encompassing mindset influencing the corporate culture at all levels of the organisation (see *Figure 26*).


*Figure 26.* Perceptions of Design Thinking Along a Spectrum of Two Extreme Poles After (Schmiedgen et al., 2015, p. 47)

The categories are not sharply separated and build a continuum of applicable variations (Schmiedgen et al., 2015, p. 42). The core of the Design Thinking method is the process (Brenner & Uebernickel, 2016). As shown in chapter 3.1.3, the development of this process has a long history. Arnold (2016) already believed, “It seems most plausible to me that there should be something universal about the creative process” (p. 80). It is one of the most important goals for research in Design Thinking to specify, and preferably teach, the process of creativity. This task concerned many researchers in design and Design Thinking, and, interestingly enough, the models derived show many similarities (Meinel & Thienen, 2016, p. 311).

The multiplicity of Design Thinking methodologies - all have their unique details and philosophies - might seem erratic. However, a closer look reveals that the similarities are much more prevalent than the differences. They all evolve from each other – using their predecessors as a developmental basis (Luchs, 2016, p. 3).

The first models developed their structure on the basis of Herbert Simon's design process in "The Sciences of the Artificial" (Dam & Siang, 2019). Today, the number of different frameworks and tools in Design Thinking s in the hundreds (Luchs, 2016, p. 4). It is not the goal of this chapter to present them all, but to illustrate the main features and approaches.

Waidelich et al. (2018, p. 7) conducted an intensive comparison of Design Thinking models and found out that the d.school model and Tim Brown were referenced in most English literature to the subject, while sources in German language mainly referred to the Hasso Plattner Institute of Design Thinking in Potsdam with the main authors Plattner, Meinel and Weinberg. As the American d.school (see Figure 27) and the German HPI model (see Figure 28) are basically the same, one can clearly state that this model is to date the best known and most intensively implemented model in the western world.

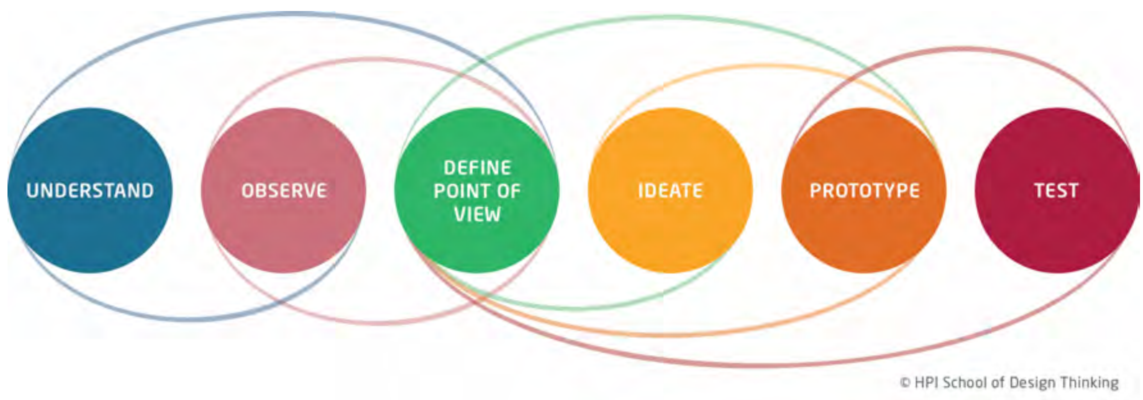


*Figure 27.* The Basic IDEO Process (d.school Model) – (HPI School of Design Thinking, personal communication, 2020) permission granted

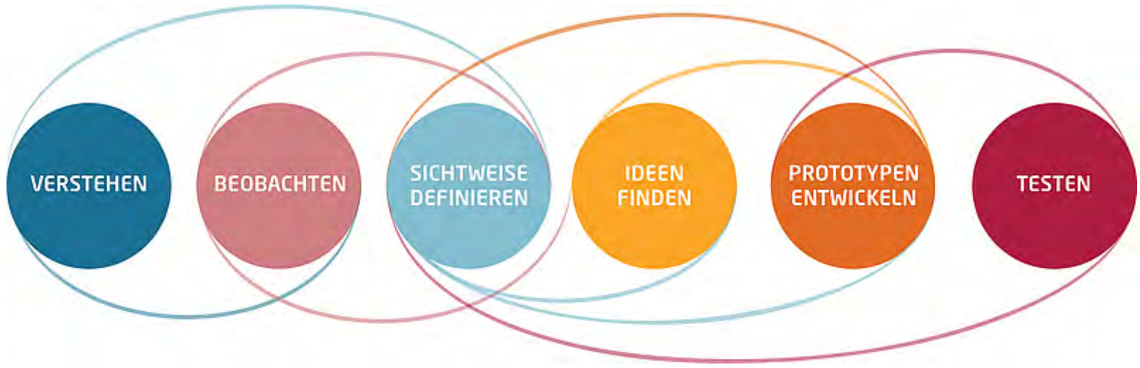


*Figure 28.* The Design Thinking Process ©HPI School of Design Thinking – (HPI School of Design Thinking, 2020) permission granted

The Double Diamond of Design (see *Figure 19*, page 54), a model of designerly thinking, is closely connected to the Design Thinking process and shows similarities with most frameworks (e.g. Curedale, 2019; Design Council, 2015; Lewrick et al., 2018b; Mateus, 2016):

- The separated spaces (problem/solution or inspiration/ideation)
- Within these spaces separate stages with clearly defined tasks
- Divergent and convergent phases
- The decline to and extension from precise points
- The possibility, or even requirement to iterate

All these models follow a problem-first approach as initiated with the creative problem-solving method by Guildford (Darbellay et al., 2017, p. 89). The problem-first approach assumes that the problem space imposes significant restrictions while the possibilities for the solution are fairly abundant. This setting demands for taming the problem first and then proceeding with the solution space, as opposed to the solution-first approach that starts in the solution space and then reaches out to the problem (Cromwell et al., 2018, pp. 69–70).

The solution/problem space or inspiration/ideation space concept is implemented in most Design Thinking models. Some extend it with a third space – namely the implementation space already proposed in Tim Brown's HBR article (2008, pp. 88–89). This model (see *Figure 29*) shows the three spaces and illustrates the iteration and interconnectedness of the tasks. The depiction of or inspiration, ideation, and implementation as intersecting areas matches Brown's concept of Design Thinking as working in a "continuum of innovation" that consists of "overlapping spaces" (T. Brown, 2019, p. 22), which is, again, close to the Double Diamond of Design.

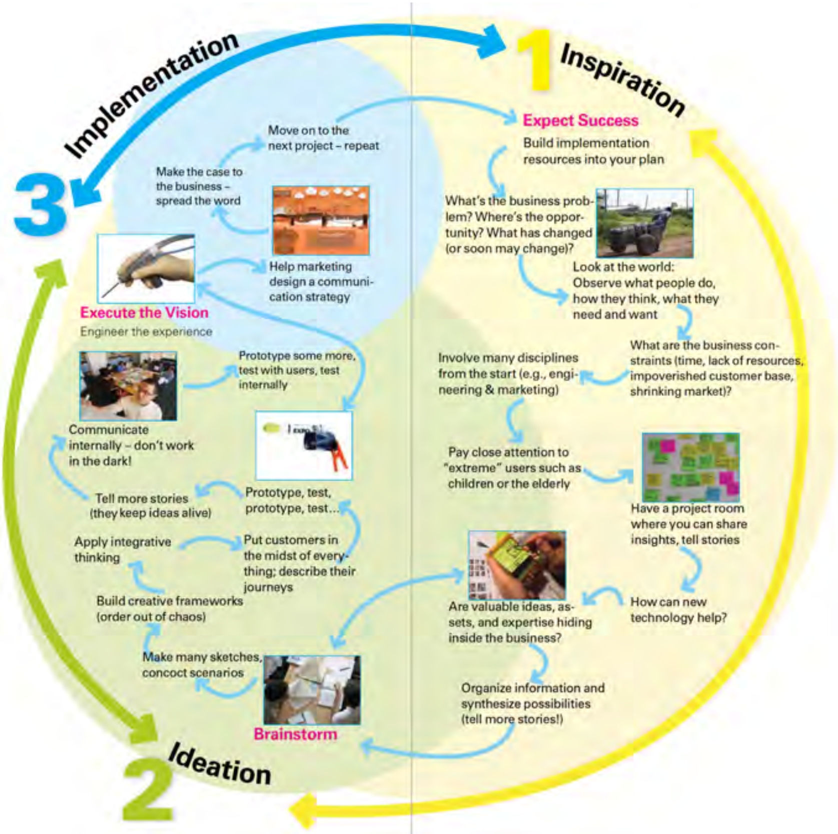


*Figure 29.* The Design Process as a System of Overlapping Spaces
Source: (Brown, 2008, pp. 88–89) edited for better readability, permission granted

Most frameworks, like the Double Diamond of Design, omit the implementation space and work just with the first two spaces. To ignore the implementation space or to demote it, often leads to Design Thinking projects that generate great ideas that never make it to life, and this, in turn, leads to an aspect of the bad reputation Design Thinking suffers from (Schmiedgen et al., 2015, pp. 56, 111–112). As John Adair (2015, p. 203) claims: "Innovation is more than having new ideas: it includes the process of successfully introducing them or making things happen in a new way. It turns ideas into useful, practicable and commercial products or services." So, implementation is essential for Design Thinking. But even Brown marginalizes the third space (see *Figure 29*) at least visually, depicting it as the smallest of the three phases. There are some attempts to extend the Double Diamond with a third diamond (e.g. Casasbuenas, 2018; Norris, 2017). However, the Design Council itself did not implement it into their concept. Most Design Thinking frameworks ignore the implementation space (e.g. Doorley et al., 2018; Liedtka et al., 2017; Luchs, 2016) or reduce it to one phase (e.g. Meinel & Thienen, 2016). If there is good connection and communication, it might be possible to transfer *integration* to another team (Meinel & Thienen, 2016, p. 312), but this prevents iteration back to the other spaces.

Some models even cut out the inspiration or problem space. Brand (2018, p. 91) for instance, defines: "Design thinking is best described as a cyclic process where you iterate various solutions testing them and learning from these tests." As his model only operates in the ideation space (Design-Make-Test-Refine), this definition fits, but the analysis of the task and the observation of the target group is severely missing. Leaving out the first space might lead to solutions for problems that are not there (Design Council, 2015; Lewrick et al., 2018b, pp. 40–41).

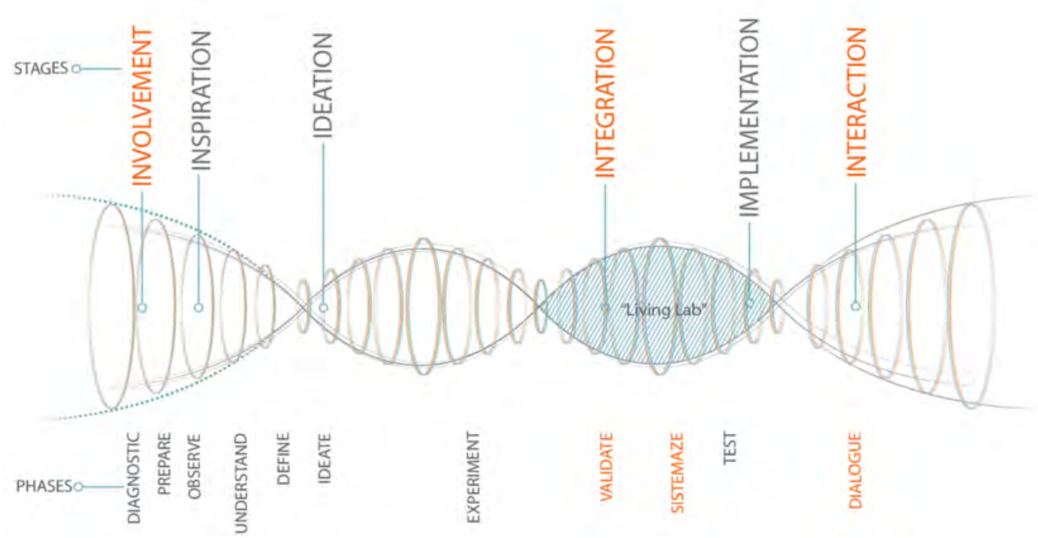


*Figure 30.* Ideas(r)evolution Framework Visualization – Source: (Mateus, 2016, p. 288)

One of the rare methods giving the implementation space more credit is the ideas(r)evolution model (Mateus, 2016). This framework (see *Figure 30*) has two phases to develop a solution towards dissemination:

– The implementation phase: "This stages [*sic*] uses the living lab methodologies focused on proof of concept and technology testing and marketing research techniques and consumer behavior to define the product, service or innovation implementation strategy." (Mateus, 2016, p. 284); and the
– The interaction phase: "it is focused on defining dissemination and dialogue strategies, network creation, information sharing among consumers and interaction measurement." (Mateus, 2016, p. 284)

The Paris-Est d school visualized an extended model of the d.school standard model (see *Figure 31*). Unfortunately, this model finds no resonance in the Design Thinking community. The implementation sequence is typically thoroughly ignored to the detriment of the method.

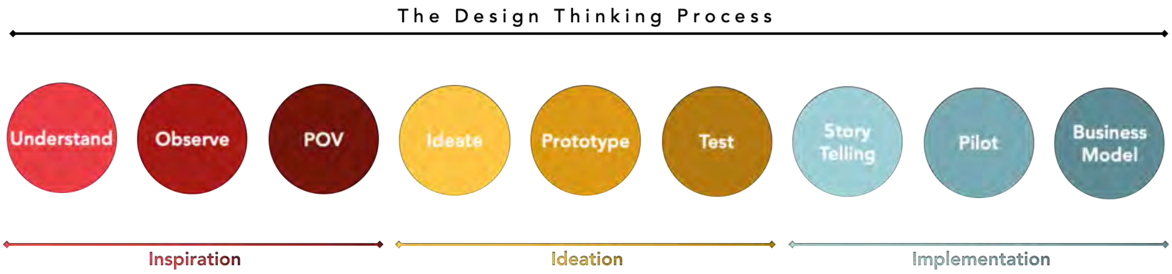


*Figure 31.* The Three Spaces D.School Model – Source (Paris-Est d school at Ecole des Ponts, 2015) layout by author, iteration loops omitted

The implementation phase is the phase that takes care that the *desired future* defined at the starting point of the process will get *current reality* to make way for new ideas and inventions (see *Figure 32*). First of all, this means bringing the ideas to market and checking if they work. Now, the stakeholders that were observed in the first steps of the Design Thinking process take action and decide if they like the concept or not (Liedtka et al., 2019, pp. 36–37).

While some models stick to these three spaces, others split the spaces into smaller phases, varying from four to seven phases (Waidelich et al., 2018, p. 4). Having nine phases, such as the Paris-Est model, tends to be overwhelming for amateurs. This is why it is mainly used by experienced teams (Paris-Est d school at Ecole des Ponts, 2019).

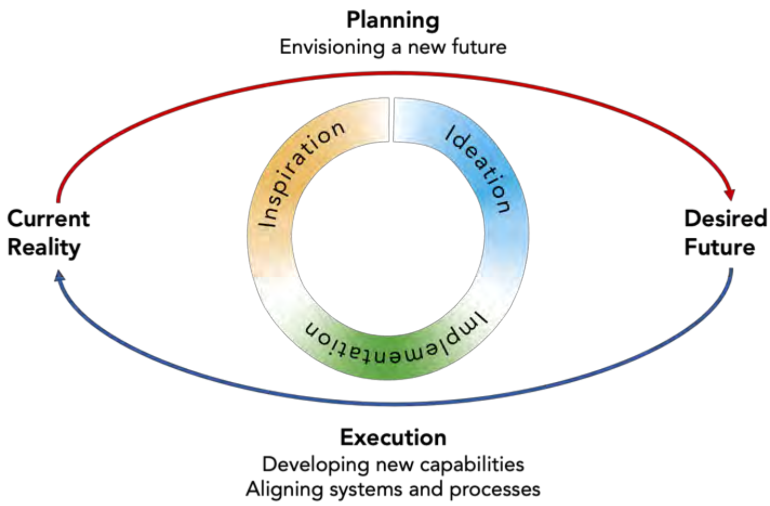


*Figure 32.* The Innovation Loop – After (Liedtka, 2013, p.2) adoption by author

The iterative approach is a core element of Design Thinking. Brown (2019, p. 22), Liedtka (2018, p. 76), as well as Kelly and Littman (2016a, p. 105) stress its importance. In Service Design Thinking the relevance of the iterative approach has become more and more evident during the last years (Stickdorn, Hormess, et al., 2018, pp. 28, 336), and for Design Thinkers, this approach is becoming so natural that it informs all of their work, both inside and outside Design Thinking projects (Rhinow, 2015, p. 30).

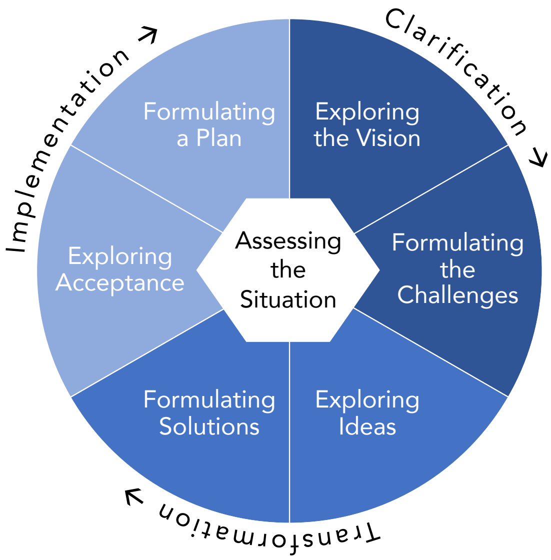


*Figure 33*. Creative Problem-Solving – After: (Rustler, 2019, p. 71) layout by author

It is important to note that the models are relevant and used as aides in practise, mainly needed to teach and represent the method in a fashion that is comprehensible to all team members. Experienced teams work much more flexibly and switch from one task, phase, or even space to another as the state of the project demands (Meinel & Thienen, 2016, p. 311). This is also vivid in the basic CPS (creative problem-solving) model illustrated in *Figure 33*. Here a special phase – *Assessing the situation* – is part of the process where the course of action is checked and it is then decided how to proceed (Puccio et al., 2017, p. 372; Rustler, 2019, p. 72).

The depiction as a circular process is also apparent in many Design Thinking frameworks. Besides the variability of the succession, this is also used to show the iteration and the fact that innovation never stops (Luchs, 2016, pp. 8–9). Still, each model has its default workflow and suggested procedure. To deviate from this sequence demands knowledge, thought, and skill in order not to miss relevant information and tasks on the path to valuable results (Liedtka et al., 2017, p. 315; Pijl et al., 2018, p. 16).

### 3.1.6. The Phases of the Design Thinking Process in Detail

#### *3.1.6.1. Mapping of Other Frameworks to the d.School Framework*

As discussed above (see chapter 3.1.5), the Design Thinking frameworks and concepts essentially follow the same structure (Korhonen, 2018). To be able to discuss the tasks needed, the literature describing the ideation frameworks is analysed and mapped to the stages of the d.school process. This mapping simplifies surveys and discussions as the model is the best known and most cited in Design Thinking (Waidelich et al., 2018, p. 7).

The mapping listed in *Table 5* is based on the tables in Waloszek's "Introduction to Design Thinking" (Waloszek, 2012), and Curedale's "Design Thinking: process and methods" (Curedale, 2016). The entries were updated and extended with the Design Thinking models 4W (Liedtka et al., 2019), ideas(r)evolution (Mateus, 2016), Curedale's Design Thinking Process (2019, pp. 202–203), the TISDD Service Design Framework (Stickdorn, Hormess, et al., 2018, pp. 91–93) and the CPS (creative problem-solving) model (Puccio et al., 2017; Rustler, 2019, pp. 70–73). Some of the old entries were outdated and therefore deleted.

In the following subchapters the stages are explicated and their function in the Design Thinking process is clarified. More importantly, descriptions or instructions to mindsets and mindset changes in these stages are presented, compared and linked. For this, the above-mentioned literature, as well as other sources, are consulted. If not specifically stated, these sources follow one of the listed models and are mapped accordingly.

The project preparation and implementation are left out, as the thesis focuses on the team phases of the basic IDEO Design Thinking process.

*Table 5.* Design Thinking Terminology – Mapping of Different Models

| Prototypical Stages | Understand the problem | Observe users | Interpret the results | Generate ideas (Ideate) | Prototype, Experiment | Test | Implement, Improve |
|---|---|---|---|---|---|---|---|
| **The basic IDEO process / d.school Plattner, Meinel, & Weinberg (2009, p. 114)** | Understand | Observe | Point of View / Define | Ideate | Prototype | Test | |
| **IDEO Tim Brown (2008, pp. 88–89)** | Inspiration | | | Ideation | | | Implementation |
| **Amabile & Pratt (2017, p. 164)** | task presentation | preparation | | idea generation | idea validation outcome assessment | | |
| **Jon Kolko (Kolko, 2018, pp. 71–86)** | | Research | Synthesize | Ideation Story telling | | Refinement | |
| **The Art of Innovation Kelley & Littmann (2016a, pp. 6–7)** | Understand | Observe | | Visualize | | Evaluate and Refine | Implement |
| **d.school Bootleg (Doorley, Holcomb, Klebahn, Segovia, & Utley, 2018)** | | Empathize | Define | Ideate | Prototype | Test | |
| **Design Thinking for Educators ideo.org (2012)** | Discovery | | Interpretation | Ideation | Experimen-tation | Evolution | |
| **Mark Dziersk (2008)** | Define the problem | | | Create and consider many options | Refine selected directions | Pick the winner, execute | |

Table 5 **continued**

| Prototypical Stages | Understand the problem | Observe users | Interpret the results | Generate ideas (Ideate) | Prototype, Experiment | Test | Implement, Improve |
|---|---|---|---|---|---|---|---|
| **Baeck & Gremett (2011) quoted after (Waloszek, 2012)** | Define the problem to solve | Look for inspiration | | Ideate multiple ideas | Generate prototypes | Solicit user feedback | |
| **Liedtka, Ogilvie, Brozenske (2019) Liedtka, Salzman, & Azer (2017)** | What is? | | | What if? | What wows? | What works? | |
| **Ideas(r)evolution Mateus (2016)** | Involvement | Inspiration | | Ideation | Integration | Implementation | Interaction |
| **Curedale (Curedale, 2019, pp. 202–203)** | Plan<br>Warm up | Discover/<br>Research/<br>Empathize | Synthesis/<br>Point of View | Ideation/<br>Concept<br>Generation | Prototype | Test and<br>Validate<br>Implement | |
| **Creative Problem-Solving (Puccio et al., 2017, pp. 371–372; Rustler, 2019, pp. 70–73),** | Clarification | | Transformation | | Implementation | | |
| | Exploring the vision | | Formulating the challenges | Exploring ideas | Formulating solutions | Exploring acceptance<br>Formulating a plan | |
| | Assessing the situation | | | | | | |
| **TISDD Service Design Framework (Stickdorn, Hormess, et al., 2018, pp. 92–39)(2011)** | Research | | Ideation | | Prototyping | Implementation | |

Based on (Curedale, 2016; Waidelich et al., 2018; and Waloszek, 2012), layout and extension by the author

#### *3.1.6.2. Understand*

As discussed above (see 3.1.2), Design Thinking as a process is a methodology for problem-solving and innovation. It is crucial to carry out this phase with utmost care and dedication, as faults made here influence the whole process (Schallmo et al., 2018, p. 7). A Design Thinking project must begin with a deep understanding of the problem or challenge the team will face (Sosa et al., 2017). A problem is an initial state that is dissatisfactory – at least for the people initiating the Design Thinking project. These people trust that there is a solution, a goal state that can be reached (van Aken & Berends, 2018, pp. 52–53), but the obstructions to reach the goal can't be overcome with known procedures.

So, the solution is not readily at hand but instead must be developed. Purposeful thinking and doing, including processing and analysing information, are indispensable to solve the problem (Fleischer et al., 2017, p. 34). This fits with Herbert Simon's statement, that the goal of designers is "changing existing situations into preferred ones" (Simon, 1996, p. 111). Sosa et al. also stress this preference: they say that contrary to the common understanding of problems as a situation that is problematic in itself, problems that need to be solved by design "only exist when they are identified as such *by someone*" (Sosa et al., 2017, p. 473). Tim Brown advises to change the problem to a project, to identify and embrace the constraints and to set a goal. Handled properly, the constraints deliver grip for the development of the solution, not hindering but bracing the team, giving it a framework to progress in (T. Brown, 2019, pp. 27–29).

Problems that can be handled with Design Thinking can be well-defined, ill-defined or wicked (Lewrick et al., 2018b, p. 51). As discussed in chapter 3.1.3, Design Thinking is best suited for solving wicked problems. Liedtka et al. (2017, p. 257) name human-centeredness, unclear problem, numerous unknown factors, high complexity, nebulous information and a high demand for the solution as relevant factors for a fruitful Design Thinking project. "…we recognize that problems to be solved are often not even clear, let alone clearly formulated. In such cases the role of design becomes strategic: before anything else it must identify the problems to be dealt with (*problem finding*) and portray them in such a way as to make them easy to understand (*problem shaping*)" (Manzini, 2015, p. 210).

It is important to note that the *Understand* phase not consists only of introducing the problem. Kelley and Littman (2016a, p. 6) stress the holistic view needed at the beginning of the Design Thinking project: "Design thinking identifies and investigates both known and ambiguous aspects of the current situation in an effort to discover parameters and alternative solution sets which may lead to one or more satisfactory goals." (Weiss, 2018, para 4). Rittel & Webber (1973, p. 161) point out that there must be at least a preliminary idea of how to solve a wicked problem to be able to plan which information will be needed to get to a proper understanding of the problem.

As Design Thinking is human centred, the people that are affected by the problem or that might be part of the solution are highly relevant for the project. So, one of the first tasks is to identify the target groups and how they can be observed (Liedtka et al., 2019, p. 11).

To activate their motivation the team members must be made aware of the value of the project at hand (Curedale, 2019, p. 202). Amabile and Pratt (2017, p. 163) emphasize that the right motivation is essential for the smooth workflow of the creative project and advise creating a positive starting mood that ensures the team members are intensely encouraged to tackle the given problem.

Closely linked to motivation, the team members must get to know each other, to harmonise and to build a team spirit (Gerstbach, 2017, pp. 49–50). Some warm-up exercises help with this (Curedale, 2019, p. 238), but most important is the possibility to talk and play and to build a hierarchy free environment (T. Kelley & Littmann, 2016a, p. 70).

In summary, the *Understand* phase is relevant to build a team spirit, to understand the challenge and its environment. Ideally, the output of this phase is – besides a highly dedicated team – a design brief, a project plan and a task list for the research team (Liedtka et al., 2019, p. 13; Schallmo & Lang, 2020, pp. 53–54).

#### ***3.1.6.3. Observe***

The typical procedure in customer research is very impersonal. The observation is done by people not interested and not affected by the outcome, and the analysis of the data obtained by the observers is made by other people - analysts. The connection from the customers to the designers happens only over impersonal, pre-filtered data. Furthermore, only problems that are named by the people the observation team has selected for their research will be recognized, and many nonverbal clues are lost (Liedtka, 2018, p. 76). Observation in Design Thinking means to find out “what is really going on inside our heads (and hearts)” (Liedtka & Ogilvie, 2011, p. 62). Kelley and Littmann (2016a) advise: “Observe real people in real-life situations to find out what makes them tick: what confuses them, what they like, what they hate, where they have latent needs not addressed by current products and services” (T. Kelley & Littmann, 2016a, pp. 6–7).

This task seems easy at first (T. Kelley & Littmann, 2016b, p. 16), but it demands a lot. It demands an attitude that allows regarding things and processes as if they are seen the very first time. Kelley and Littman (2016b, pp. 17–18) call this “Vuja de” in opposition to “Deja vu”. “Vuja de” means seeing the observables as if it was the first time even if one saw them multiple times before.

In an extensive study, a scientific team (Meinhardt-Injac et al., 2018) examined the ability of human beings to comprehend the behaviour of other people. This ability is fundamental to social interaction but still not explored in depth. Implicit as well as explicit processes are utilized to fulfil the task of recognizing the mental states of others. Not only deliberate acts and language are observed, but also facial expression and body language. And even if language has an important role, only when the observer has also perceived the nonverbal expressions of the observed person he/she can draw relevant clues about them (Meinhardt-Injac et al., 2018, p. 7).

The d.school bootleg model names this phase *emphasize*, because creating a connection with the people affected by the project's problem is mandatory for the human-centred design process. Empathy is developed not only by observation but also by engagement and immersion. So, the focused attention on the observable is mandatory in this phase (Both & Baggereor, 2010; Doorley et al., 2018, p. 3 card i). The d.school also demands a 'beginner's mindset' that observes without judging, questions without rejecting and absorbs without filtering (Doorley et al., 2018, p. 14 card 1). With this they set the core mindsets needed for a fruitful and empathic research phase.

“Several techniques used to develop an empathic mindset were highlighted. For instance, one interviewee told us how the company encouraged its employees to informally engage users in different settings” (Carlgren et al., 2016, p. 46). In his iconic model (see *Figure 29*, page 74) Brown (2008) depicts the zoom in – zoom out (from global to specific view) attitude with the switch from “Look at the world” (p. 89) to “Pay close attention to …” (p. 89).

The human-centred orientation is extremely important in the *Observe* phase. Tim Brown (2019, p. 11) mentioned the engineers Edison, Porsche and Brunel as a source for his inspiration because they tended to be more interested in human needs than in technological details. The observation must follow ethnological methods to emerge deeply into the world of the affected people (Meinel & Thienen, 2016, p. 312). Kolko (2018, p. 75) advises to create a full transcript of the observed session because in doing so the observer-then-writer starts to adopt the viewpoint of the observed people. The transcript should consist of separate snippets that can be manipulated and sorted as the next phase demands.

Not only primary but also secondary research can reveal valuable information for the given challenge. An analysis of the environment, for instance the market competition, and a trend analysis help in understanding the underlying conditions of the project (Böhle et al., 2017, pp. 9–14). Today, the contracting organisation is often able to provide a massive amount of data connected to the project. To make sense of these data, technologies like Business Intelligence and Data Mining must be implemented to acquire real and helpful information (Lewrick et al., 2018b, p. 302).

#### *3.1.6.4. Define / Point of View*

This phase is special within the Design Thinking process. It is the pivot point that centres the project (Pijl et al., 2018, p. 48). Most iterative loops start or end at this phase (see *Figure 27*, page 72). A well-executed *Define* phase gives the team a foundation to venture into the future. With a "what if anything were possible" stance and a deep understanding of the proposed problem the team has an ideal starting point to find innovative solutions (Buehring & Liedtka, 2018, pp. 138, 142). It is the connection point between the problem space and solution space; the interface that allows optimization on both sides. "Such a 'creative bridge' creates a resolution between the unfolding design requirements and the emerging design structure of a potential new product" (Cross, 2018b, p. 703).

The goal of the *Define* phase is the synthesis of the problem statement, also called the Point of View, the creative or trigger question (Curedale, 2019, p. 202; Doorley et al., 2018; Stickdorn, Hormess, et al., 2018, p. 179). John E. Arnold (2016, pp. 80–83) was resolute in stressing the importance of a good problem statement. He amplified the way a question could curtail one's creativity or spark new ways of thinking and imagining solutions. His down to earth example was the comparison of a problem statement that asked for a better toaster in relation to one that asked for a better way to get warm bread with a brown, crispy surface. Einstein had a similar attitude:

> The formulation of a problem is often more essential than its solution, which may be merely a matter of mathematical or experimental skill. To raise new questions, new possibilities, to regard old problems from a new angle, requires creative imagination and marks real advance in science.
> (Einstein & Infeld, 1938/2018, p. 95)

Referring to the quote of Herbert Simon's 'Everyone designs…', Jerry Diethelm (2016, pp. 168–169) states that design problems deal with *situations* and interrelations between situations. So, a design-problem is the difference between a given situation and its preferred counterpart. "It refers to the qualitative difference between an existing and preferred state of *being*, rather than a difference in the quantitative condition of *knowing*. The difference that makes a difference in designing—and is the driver of design thinking—is the social perception of a significant qualitative difference" (Diethelm, 2016, p. 169). Don Norman (2013) values the practise of Design Thinking to use the original problem as a first approach and then to deeply investigate to detect the problem that really matters and that is often hidden beyond the obvious preliminary given task.

The expression of the problem statement is the last step of the *Define* phase. The statement is the result of a systematic condensation process, starting with all the information gathered in the previous phases (Osann et al., 2018, p. 52). To avoid being overwhelmed by the information and the task, it is sensible to divide this phase into several sub-phases, as shown in *Figure 34* (Lewrick et al., 2018b, p. 80). At the beginning of the *Define* phase, the findings of the previous phase have to be sighted, sorted and analysed (Kolko, 2018, pp. 75–80). A tool recommended for the very start of this task is 'What? How? Why?'. The first step is the documentation of the observed situation (What is happening?), then one analyses how this happened and the last step is trying to understand the reasons for the action. So, one develops from the obvious situation to its emotional and motivational basis. This practice demands deep reflection on the arisen observations (Curedale, 2019, p. 318; Doorley et al., 2018, pp. 15–16).

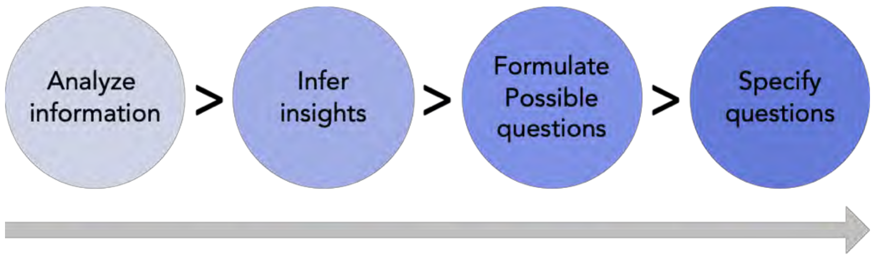


*Figure 34.* Sub-tasks of the Define Phase
After (Lewrick et al., 2018b, p. 80) layout by author

Liedtka (2018, p. 76) calls this stage *sense-making*. She stresses the difficulty of this phase, as many team members feel overwhelmed by the sheer mass of data gathered in the former tasks, and she points out that it is highly essential to avoid personal biases in this analytic process. She recommends involving stakeholders to find the truly relevant points, making sure that uncomfortable facts don't get ignored and that the problem gets another boost in human-centeredness and actuality. Kolko (2018, p. 76) calls this phase arduous but highly important: A group of people working through the amassed information from the observation phase, sorting the data by gut feeling until a shape begins to build.

Tim Brown (2019, p. 222) regards the question developed here as a condensed design brief, taking constraints into account and giving metrics to evaluate the success. The creative person should recognize the constraints as guidance that assist in finding the best solution (Dobson, 2018, p. 304). Jeanne Liedtka (2018, p. 77) in contrast asks "If anything were possible, what job would the design do well?" It is important for her to open up and to leave constraints aside in this stage to activate the determination to change the given situation into a better one.

As described above, the *Define* phase demands a reframing of the problem given at the beginning of the Design Thinking project. Sosa, Connor, and Corson (2017, p. 476) don't see this point and rebuke the Design Thinking method. They perceive a distinct weakness in providing attitude and means for iteration. In their view Design Thinkers often ignore the highly important task of keeping an eye on the problem and scrutinising it continually. Moreover, with reference to “Design Thinking for Educators” (ideo.org, 2012)

Sosa, Connor, and Corson allot Design Thinking to only being able to solve *tame* problems because the text advises to precisely define the output of the Design Thinking process: “What will you work to produce? Where do you expect to get at the end of this process?” (ideo.org, 2012, p. 19). Because of this, they render Design Thinking qualities moot (Sosa et al., 2017, p. 476). The reproach seems unfounded since this advice does not aim for the precise outcome, but for the limitations of the project, for instance in skillsets or finance. The task is to seek for methods to still deliver a feasible result (ideo.org, 2012, p. 19). This resonates with Tim Brown’s demand to embrace constraints and work with them (T. Brown, 2019, p. 24).

It is important to see the *Define* phase not only as a convergent phase that reduces the information to a narrow point, the problem statement for the next phase, but also as a gateway to new opportunities. Tim Brown (2008) calls this step “Organize information and synthesize possibilities” (p. 89). Gregersen (2018, p. 67) also sees a good inquiry session as a key to finding surprising new ways to think about the problem. “Brainstorming for questions rather than answers makes it easier to push past cognitive biases and venture into uncharted territory” (Gregersen, 2018, p. 67).

The d.school demands activating the imaginativeness of the team members to create a real “design vision” from the collected and analysed information (Doorley et al., 2018, p. 5). It is highly important to strengthen the empathy for the observed group again. For this empathy building, Meinel and von Thienen (2016, p. 312) advise the use of personas to bundle the important aspects and to give them a palpable shape.

This chapter is considerably bigger than the others in this section to meet the high importance of its role in Design Thinking. The constant scrutiny of the problem at hand and the iterative character gives Design Thinking teams the chance to make sure to solve the right problems and to optimize the solutions. The need to emphasise this relevant hub function must not only be visualized (like in the infinity framework see *Figure 21*, page 57) but also practised and taught.

> “Perhaps the most important contribution granted by design thinking to those outside the design profession is the ability to step back and reconceptualize issues, and, sometimes, to take a very different perspective upon them.” (Norman, 2016b, p. 345)

#### *3.1.6.5. Ideate*

To ideate means to find solutions for the whole or at least parts of the problem (Cromwell et al., 2018, p. 57). The standard tool in ideation is brainstorming, but the way brainstorming is conducted is specially tailored for Design Thinking and includes various rules to make it effective (T. Kelley & Littmann, 2016a, pp. 53–66). “Brainstorming is practically a religion at IDEO” (T. Kelley & Littmann, 2016a, p. 55). However, brainstorming is not easily done and needs exercise. A person cannot do it once in a while and be good at it. And without team members that are trained and fit brainstormers, the outcomes will be low in quantity and quality (T. Brown, 2019, p. 84). The different Design Thinking frameworks offer numerous variations and supportive tools to activate the idea generation even for Design Thinking newcomers. Thinking hats, 635, lotus method or AOKI are some of the provided methods that derive from creativity researchers outside and apart from Design Thinking but are often (slightly) modified to share the spirit of Design Thinking (Curedale, 2019, pp. 451–452; Lewrick, Link, et al., 2020, pp. 151–184; Stickdorn, Hormess, et al., 2018, pp. 177–182).

Many sources recommend producing as many ideas as possible (e.g. Doorley et al., 2018; T. Kelley & Littmann, 2016b, p. 161; Siang & Dam, 2018). Dev Patnaik underscores this:

> “Out of a hundred ideas, the first sixty ideas produced five that were actually new or different, the next twenty produced nothing but laughter, and ideas eighty to a hundred produced another ten that were amazing. Thankfully, we didn’t give up when the well ran dry around idea number sixty.” (D. Patnaik cited after Curedale, 2019, p. 454)

Glǎveanu and Clapp (2018) stress the importance of “openness to participation” (p.58) in the context of creativity. They propose a change from the focus on new experiences that is highly individualistic over the attention on differences in a group to the creative process as a product of intricately interacting and interwoven systems. Finding ways to changing systems – or even the world – is a cooperative process; creativity in this context is co-creation (Clapp et al., 2016, pp. 122–128).

Teresa Amabile (1996, pp. 237–238) showed that creative pre-tasks enhance creativity. After engaging test participants in a creative task, they performed much better in evaluations of creativity – even after several days. This approach also fostered the motivation of the participants, thus making them more engaged participants in the task ahead. Another successful approach are playful tasks to support a fruitful mood (Amabile, 1996, p. 238). Together with Pratt (Amabile & Pratt, 2017, p. 164), Amabile researched the relevance of motivation for the outcome of the ideation phase and stressed the high correlation of these two factors. “Play becomes an integrative concept, the ‘glue’ holding together different antenarrative elements, building on ideas but also often refusing to have the (final) idea.

Thus, play, whether practiced in an engaging or diverging manner, can relieve from the coercive rules and norms of behaving and thinking" (Stierand et al., 2019, p. 169). Focusing on the defined task is highly important. For example, the team developing the Coasting bike riding experience deliberately did not design a whole bike (in this phase) to avoid losing the focus on the experience itself (T. Brown, 2008, p. 90). But within the task, "the goal of creativity is not to find the right answer, but to explore the range of possibilities. The broader the range of ideas that are explored, the more likely it is that one can discover breakthrough concepts" (Canaan, 2004, p. 238).

There are more possibilities than the classical brainstorming once developed by Alex Osborne to ideate in a Design Thinking project. Dam and Siang (2018), for instance, propose Braindumping, Brainwriting, and Brainwalking. Furthermore, the original form of Osborne's brainstorming should not be used, as it has flaws that weaken ideation (Rustler, 2019, p. 170).

To work properly, brainstorming in Design Thinking needs to follow some rules:

- No brainstorming without a focus – typically a challenge in the form of a question or Point of view (POV) statement
- There are various methods with which to conduct a brainstorming session, sometimes it is good to seek diversity
- Each session has a time limit (length depending on the method)
- Ideas need to be fixated but only with keywords or scribbles
- Each idea needs its own piece of paper
- Mix individual and group work phases
- Keep a positive, playful atmosphere
- No critique
- Number your ideas
- Go for many ideas, go for crazy, go for quality
- Build on existing ideas – there is no ownership
- Get visual (draw) – get physical (enact, prototype)
- Low-tech and being together work best
  (T. Brown, 2019, pp. 77–79; T. Kelley & Littmann, 2016a, pp. 56–62; Liedtka et al., 2019, pp. 68–71; Rustler, 2019, pp. 168–169)

The length of this list alone shows the importance of having a facilitator whose role is to keep the team focused, energized and feeling secure. This subject will be discussed in more detail in chapter 3.1.10.

Liedtka (2018, p. 78) names *Articulation* as an important Ideation task. After generating ideas, Liedtka demands questioning assumptions, and challenging seemingly given facts. This strategy gives freedom to fresh ideas and prevents getting stuck because of nonsensical constraints. Canaan (2004, p. 238) agrees: “Comparisons, analogies, objectives, scenarios and business plans are the vocabulary to describe a project while the outcome evolves through the creative process.”

#### *3.1.6.6. Prototype*

Prototyping gives the team the chance to discover the interaction of user and solution at a very early stage of the development process: flaws can be identified and weeded out before they can do real harm (Meier & Miller, 2016). “Prototyping is problem solving”, “A playful, iterative approach to problems is one of the foundations of our culture of prototyping” (T. Kelley & Littmann, 2016a, pp. 103, 105).

Nevertheless, prototyping can also be part of the idea generation. With this in mind, Juelsbo et al. (2017) characterise prototyping – or design doing – as “making a creative dent in the universe through action” (p.150). They claim that ideas are crafted by using and moulding what is already there instead of being inspired out of a void. So while shaping the material, a feedback loop from the material back to the idea gets invoked that alters the idea itself (Juelsbo et al., 2017). This concept is supported by Prud’homme van Reine (2017, pp. 66–67) who sees a different way to think about solutions when using intensive prototyping. The consequential iteration process, repeating (at least) prototyping and testing, demands non-linear thinking – a cognitive process that allows different stages to happen simultaneously and cross-pollinate for better results.

Keeping the prototypes as minimal as possible is also highly important, because critique on an elaborately created prototype or a beloved idea leads to negative emotions and disturbs the creative process (Agnoli & Corazza, 2019, p. 62).

> Prototypes should command only as much time, effort, and investment as are needed to generate useful feedback and evolve an idea. The more “finished” a prototype seems, the less likely its creators will be to pay attention to and profit from feedback. The goal of prototyping isn’t to finish. It is to learn about the strengths and weaknesses of the idea and to identify new directions that further prototypes might take. (T. Brown, 2008, p. 87)

Furthermore, inexpensive prototypes give the possibility to test a number of ideas without a lot of effort (Meier & Miller, 2016). Liedtka (2018, p. 78) also advices for minimal prototypes that only grasp the essence of the given concept. “But what these artifacts lose in fidelity, they gain in flexibility, because they can easily be altered in response to what’s learned by exposing users to them. And their incompleteness invites interaction” (Liedtka, 2018, p. 78).

Prototypes must be palpable. For service design they typically can't be objects, but rather scenarios. Brought to life as scribbled storyboards or performances that are recorded as still or moving images help to conserve them for further analysis and also to preserve the findings. Moreover, scenarios help the Design Thinking team focus on the user and his/her interaction with our solution (T. Brown, 2019, pp. 98–101). Generally, there are two types of prototypes: embodied and disembodied prototypes. The embodied prototype gives form to the solution in a reduced but similar form that is so close to the final solution that the user can interact with it as if with the finished product. The disembodied prototype needs more imagination, as the relevant features of the solution can't be modelled as needed and the user needs to use his/her fantasy to grasp the idea (Stickdorn, Hormess, et al., 2018, p. 227).

Worwood and Plucker (2017, p. 93) suggest prototyping and testing the combination of analytical and lateral thinking, as this allows one to regard various perspectives and to detect what is genuinely relevant for the optimization of the concept. The concept of lateral thinking, which demands being right at the end but allows error during the process, gives the freedom to experiment and to fail, and with this, to gather new information and to learn (de Bono, 2016b, pp. 95–96). Thienen et al. (2017, p. 1) advise to celebrate failure, to teach participants that mistakes are part of the process and nothing to be ashamed of.

Storytelling helps to *shape* a prototype. To narrate how the product (or service) will be used helps to identify its core features and thus what needs to be modelled and what can be left out (Kolko, 2018, p. 82). However, one has to be careful with this strategy, as it is mandatory to let go of the prototype – physically and mentally – to show not to tell in order to get good results from testing. So, storytelling can be a good element of the prototype, but should not be overstressed while testing (Lewrick et al., 2018b, pp. 129, 178).

Prototyping is not only preparation for the test phase, but the act itself shapes the given ideas and enriches the process. With quickly drafted variants, willingness to err and iterate and mindful observation of the phase, prototyping is extremely valuable for the outcome of the process.

#### *3.1.6.7. Test*

The task in the *Test* phase is "checking ideas against criteria for the task and criteria in the domain more generally, to ensure the usefulness or appropriateness of the novel ideas emerging from the third [ideation] stage" (Amabile & Pratt, 2017, p. 164). It is also a phase where more information about the affected persons is gathered that can be used in further iterations (Worwood & Plucker, 2017, p. 91). Still *Test* is hard, as the presented solution is under assessment and failure is foreseeable (Liedtka &

Ogilvie, 2011, pp. 149–150). However, failure is a possibility to learn and to optimize (Liedtka et al., 2019, p. 38). But this does not permit laziness. The team must strive to achieve the best solution, and conduct successful iterations, the failures must boost the project: “Failures must be ‘above the waterline’” (Dobson, 2018, p. 303).

In his Nobel Memorial Lecture, Herbert Simon (1978) declared that most situations only allow for “satisficing” (p. 350) solutions under real circumstances, or that decisions have to be made on the basis of models that simplify reality until it can be properly managed. “By giving up optimization, a richer set of properties of the real world can be retained in the models” (1978, p. 350).

This definition fits one of the attributes of wicked problems as they were described by Horst Rittel and Melvin Webber (1973). Wicked problems don’t have solutions that can be classified as right or wrong. The typically manifold stakeholders have varied criteria to judge a solution: “Their assessments of proposed solutions are expressed as ‘good’ or “bad” or, more likely, as ‘better or worse’ or ‘satisfying’ or ‘good enough’” (p. 163). This is also a long standing design issue: “Practice proves that there is always a possibility of alternative design solutions with greater or lesser ‘objective’ quality” (Moholy-Nagy, 1947, p. 56). Baskerville et al. (2019, p. 4) also point out that given constraints lead to decisions that might not be optimal, but (just) fulfil the demands of the problem.

To a dedicated Design Thinker this is far from rewarding. “There is just no comparison between this resolution of despond and the thrill at the end of a designerly voyage of innovation, creation, or discovery that ends in some far better than expected, unimagined ending” (Diethelm, 2016, p. 170). It is important that the team is willing to throw away their most favourite ideas or modify them profoundly if the *Test* phase shows they are flawed (Meinel & Thienen, 2016, p. 312). "The ability to pursue an idea you know you'll ultimately reject is counterintuitive to efficiency, but it's essential to breakthrough ideas” (Canaan, 2004, p. 239).

Eric Kessel explained the importance of play and trying alternatives in an interview (Ambrose & Harris, 2015, p. 21):

> When you see young students, you`ll notice that their front garden is beautiful, but their back garden is a total mess. That is to say that they haven’t spent enough time in the back, experimenting, which would then allow them to inform what happens in the front, in the public area.

The *Test* phase needs people that are highly competent in the problem/solution domain to really evaluate the results, to assess the reasons for an identified failure and to point to the flaw that needs to be ironed out (Amabile & Pratt, 2017, pp. 164, 166).

Liedtka et al. (2019, pp. 32–35) propose two steps for testing: First, “Feedback from Stakeholders” (Liedtka et al., 2019, p. 32) with very rough prototypes and test persons that are attached to the problem and willing to help. They test variations of the solution and give critical but engaged feedback to the design team. Later, with a much more elaborated prototype “Learning Launches” (Liedtka et al., 2019, p. 32) are conducted that test the solution in an environment that is as close to the later real rollout as possible. Tim Brown calls this “Prototyping in the wild” (T. Brown, 2019, pp. 103–104) and emphasises the importance of assessing the survivability and effectivity of the solution.

Amabile and Pratt (2017) differentiate between three results of the *outcome assessment* phase: “success, failure, or progress (partial success)” (p. 163). Each result needs to be reflected as each result includes the chance to optimize and with this the need to iterate.

The important point in testing is the learning outcome. Testing is only reasonable when the Design Thinking team is willing to fail, to learn and to iterate. Even after launching a solution this should not stop, but continue in order to optimize the solution even when it is alive and running (Pijl et al., 2018, pp. 184–185).

### 3.1.7. Thinking Styles in Design Thinking

Thinking styles are cognitive strategies to collect, decode, manipulate, and remember information (Bendall et al., 2019, p. 68).

A particular character of Design Thinking is the variation of thinking styles, the demand to switch between contradictory methods or even to handle both at the same time. Curedale (2016, p. 114) lists 29 categories of thinking comparing business style on the one hand with creative style on the other. Design Thinking is positioned at the very centre of both, typically embracing both sides (see *Table 6*).

*Table 6.* Thinking Styles

| Business Thinking | Design Thinking | Creative Thinking |
|---|---|---|
| Left brain | Uses whole brain | Right brain |
| Rational | Both rational and emotional | Emotional |
| Analytical | Analytical and creative | Creative |
| Likes well defined problems | Works with defined and ill defined problems | Works with ill defined complex problems |
| Does not tolerate mistakes | Mistakes are inexpensive and a learning opportunity | Tolerates mistakes during exploration |
| Analyse then decide | Prototype test decide | Ideate then decide |
| Focuses on parts of a problem | Focuses on parts and on whole iteratively | Holistic diffuse focus |

After (Curedale, 2016, p. 114) – excerpt: first to seventh of 29 listed styles

Other authors also discuss this special feature of Design Thinking. As discussed in chapter 3.1.1.3, divergent and convergent thinking that are both crucial for ideation. To be efficient while perfecting a problem statement or a solution, a Design Thinker needs "the capacity to spontaneously shift between convergent and divergent thought as needed, in response to the situation one is in" (Gabora, 2019, p. 1798).

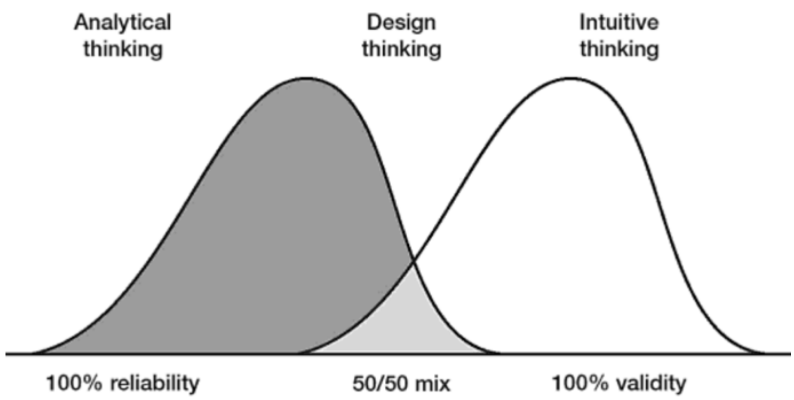


*Figure 35.* The Predilection Gap – Source (Martin, 2009, p.54)

Roger Martin (2009, p. 54) positions Design Thinking between analytical and intuitive thinking (see *Figure 35*). Today, keeping the equilibrium between those two modes is a notable feature of Design Thinking (Micheli et al., 2019, p. 136). Tim Brown (2008, p. 87) names integrative thinking as an essential skill of Design Thinkers and praises the holistic approach of the method (T. Brown, 2019, pp. 229, 234).

### 3.1.8. Experts and Amateurs in Design Thinking

Design Thinking as a method typically works with a cross disciplinary team consisting of professional designers and non-designers (T. Brown, 2008, p. 87). The question is, if and how untrained non-designers can be effectively included in Design Thinking projects. Tomitsch et al. (2018) hail the fact that the design methods have become accomplishable for non-designers (p.10). Non-designers are usually overwhelmed when beginning the work, as the tasks are unaccustomed and far outside their comfort zone but Design Thinking's clear structure helps to integrate amateurs (Liedtka, 2018, p. 74). "Anytime you're trying to change people's behaviour, you need to start them off with a lot of structure, so they don't have to think. A lot of what we do is habit, and it's hard to change those habits, but having very clear guardrails can help us" (Kareen Hanson in Liedtka, 2018, pp. 74–75).
Yet, Tim Brown (2019, p. 3) believes that trained Design Thinkers – that is people not necessarily with a formal design education but with extensive experience in Design Thinking – are much more efficient and effective than novices. He purports that *design sensibilities* are mandatory for an effective process. Apparently, it needs experience to accomplish this. On the other hand, Brown argues that today's vast ant threatening changes in economy, society, technology, in short, our whole environment requires from everyone to think and act like a designer and work on pressing problems of our world (T. Brown, 2019, p. 43)

Designers are (or at least should be) continually taking care of their target groups, so they are used to observing, analysing and taking into account the wishes and needs of the affected people. They know that statistics and mere data is not enough, but that they need emphatic access to the needs and wishes of their customers. It is not always possible to do in-depth research, but the designers are aware of the humans they are working for. Ideally, they try to create their solutions in a way that makes it easy for the user to look cool – making them heroes while using what the designer created (T. Kelley & Littmann, 2016a, pp. 30, 41–42, 51).Roger Martin (2009, p. 56) calls designers "first-rate noticers" as they do more than watch and listen: By observing intensely, they discover what *really* matters concerning their task.

But, as designers mostly achieved these skills through training, it is evident that these abilities are learnable: "As people become expert at design thinking, they change their understanding of it: from perceiving it as a prescribed process to a mindset and finally to a dynamic toolkit appropriate for approaching a wide variety of problems" (Gibbons, 2018, para 15). Jeanne Liedtka (2018, p. 75) similarly points out that each project changes the project members. She provides a list of improvements that shows how the innovators themselves are changed through Design Thinking (see *Table 7*).

*Table 7.* Shaping the Innovator's Journey

| **PROBLEM** **Innovators are:** | **DESIGN THINKING** | **IMPROVED OUTCOME** |
|---|---|---|
| Trapped in their own expertise and experience | Provides immersion in the user's experience, shifting an innovator's mindset toward… | A better understanding of those being designed for |
| Overwhelmed by the volume and messiness of qualitative data | Makes sense of data by organizing it into themes and patterns, pointing the innovator toward… | New insights and possibilities |
| Divided by differences in team members' perspectives | Builds alignment as insights are translated into design criteria, moving an innovation team toward… | Convergence around what really matters to users |
| Confronted by too many disparate but familiar ideas | Encourages the emergence of fresh ideas through a focused inquiry, shifting team members toward… | A limited but diverse set of potential new solutions |
| Constrained by existing biases about what does or doesn't work | Fosters articulation of the conditions necessary to each idea's success and transitions a team toward… | Clarity on make-or-break assumptions that enables the design of meaningful experiments |
| Lacking a shared understanding of new ideas and often unable to get good feedback from users | Offers pre-experiences to users through very rough prototypes that help innovators get… | Accurate feedback at low cost and an understanding of potential solutions' true value |
| Afraid of change and ambiguity surrounding the new future | Delivers learning in action as experiments engage staff and users, helping them build… | A shared commitment and confidence in the new product or strategy |

Source (Liedtka, 2018, p. 76)

Rhinow (2015, p. 29) also appreciates the substantial change in people that work in a Design Thinking informed environment. They even get irritated when appreciation, learning and thinking in possibilities are missing from their work environment.

Victor Margolin (2007) sees a significant change in the role of designers. Historically, "Providing decoration for or giving form to products was the primary task." But today, "designers have to think more profoundly about the future and their role in making it into the present" (p. 14). Margolin also describes a change in design ethics that today has to challenge the fashion in which we conduct our lives. The designer is at least partly responsible if products and services do not serve both humans and the environment (2007, p. 15).

"Therefore, the novelty that survives to change a domain is usually the work of someone who can operate at both ends of these polarities – and that is the kind of person we call 'creative'" (Csikszentmihalyi, 2013, p. 76). While children are highly creative, for most people this skill fades with age and is hard if not impossible to achieve. Creative people often shun 'normality' to stick to a creative mindset, hunting down inspiration and playing mind games with reality (Ambrose & Harris, 2015, p. 33).

Still, it is important to include amateurs in the Design Thinking teams. Warm-up games help them immerse themselves into the given tasks, as the playful approach eases them and shifts them toward the right mood for creativity (T. Kelley & Littmann, 2016a, p. 60).

Design teams must be as multifaceted as they problem demands. Complex problems demand teams with various skills and perspectives to the world to challenge them in various (Papanek, 2005, pp. 323–324). A mix of design professionals and experts in other areas is the natural consequence.

### 3.1.9. Personality Profile

In the chapter "A Design Thinker's Personality Profile" from his seminal article ,Tim Brown (2008, p. 87) describes the characteristics he sees as essential for a Design Thinker. Subsequent authors build upon this article, but typically talk about the *mindset* when describing the aptitude desired for Design Thinking. (e.g. Dosi et al., 2018; Groeger et al., 2019; the metastudy J. Schweitzer et al., 2016; Sobel et al., 2019).

Some knowledge, skill or experience in the area of the problem/solution space is indispensable for the creative process (Amabile, 2019, p. 25), but does not have to be simple-mindedly in the core subject of the area. The capability can also derive from adjacent areas or just from being affected by the problem (Gerstbach, 2016, p. 130). Indisputably, at least some of the team members need deep knowledge in the field of the problem space, because the research session becomes better focused and the results richer based on a good amount of already existing knowledge (Agnoli & Corazza, 2019, p. 55).

Very often, Design Thinking literature demands for t-shaped people (e.g. T. Brown, 2019, p. 38; Curedale, 2019, p. 159; Prud'homme van Reine, 2017, p. 68), that is people that have a deep competence in one speciality but have a broad general knowledge with an intrinsic openness for foreign subjects. Newer developments demand for π-shaped personalities, that extend the T with an additional - often leadership-based – skill (S. Brown, 2020, p. 159), or even a "Drippy-T" (Lewrick et al., 2018a, p. 31) structure, that stands for people with a variety of more or less deep capabilities. This structure, also coined key-shaped, is an ideal basis for creativity as it provides knowledge in various areas that might work in a synergistic way on challenging a problem (Diodati, 2017).

Today, a new concept arises: the x-shaped learner. A person not only identified by its skills, but by a wide portfolio of strengths, stances and abilities that are centred in humanity and allow real transdisciplinary work. These people are constant learners and might be the key to solving our life-threatening problems in the future (Doig, 2019).

High diversity is decidedly fruitful for Design Thinking teams. Not only the skills but factors like age, gender, personality type, employment type and duration should show as much variability as possible. These mixed teams help to acquire multiple perspectives on a problem and to generate trans-disciplinary solutions that are only possible in co-creation (Gerstbach, 2016, p. 131).
To Arnold, the interchange between heterogeneous persons is indispensable in a creative process; the touch point between these people being created through the shared experience with the *process of innovation* (Arnold, 2016, p. 80). The variation makes sure there are always people that look at a situation with a fresh view. These people might dispute what is challenging for those who are too used to the situation. "It is by questioning the obvious that we make great progress" (Norman, 2013).

#### 3.1.10. Team Leaders, Facilitators

Design Thinking is far from simple. The demanding problems tackled and the intricate structure of a Design Thinking team calls for a team leader with outstanding skills (Mosely et al., 2018, p. 177). Manzini (2015, p. 1) calls for design experts as leaders of the Design Thinking teams as they have access to tools that enable a fruitful design process by integrating people of various skill levels.

> Design experts are therefore subject endowed with specific knowledge permitting them to operate professionally in the design processes. In turn, this design knowledge can be defined from different points of view: from that of its content, its form and its modality. (Manzini, 2015, p. 38)

Team leaders in Design Thinking are facilitators. As their role-title demands, facilitators ease the way through the design process from introduction to the problem to the implementation of the solution. A good facilitator is crucial for the success of the Design Thinking endeavour as he or she provides the structure of the process, upholds a fruitful culture of interaction and maintains a mindset of creativity (Lewrick et al., 2018b, pp. 180–182). A team consisting of many disciplines is typically the ideal basis for Design Thinking. It is one of the most difficult but also most rewarding tasks of a facilitator to unite these individuals to a transdisciplinary team that thrives in synergetic effects. Additionally, the facilitator must make sure that the user and its needs, as well as the problem statement, are always prevalent in the teams development process (Siang & Dam, 2018).

Team leaders must be aware that their emotions are highly infectious. They can use this to lead the mood of the team, but need self-management and sensibility (McKee, 2018, pp. 47–48). The most important task of facilitators is to guide the creative process of the team. They must be aware of the process itself and make sure that the team is in the right cognitive. They motivate the team to stay in a divergent process if there might be more to uncover but also lead timely to the next step. In general they always observe the team and try to guide it to maximum performance (Sosa et al., 2017, p. 487). It is not enough for the facilitator to request people to be creative, as they typically do not know what to do or think. Facilitators must possess a wide portfolio of tools and tasks to be able to provide the optimum of activities for the given task and team (Sassenberg et al., 2017, p. 129).

Ness and Glâveanu (2019) establish that creativity evolves from the interaction within the team on the basis of the task and their environment (p. 190). Facilitators must be able to distinct between a creative expert and an amateur and lead both differently. They must be aware of various types of personalities that might impede or foster the team's progress. Moreover, facilitators must assess the mood of team members and possible interpersonal conflicts and take them into account mode (Mosely et al., 2018, p. 188).

Ness and Glâveanu (2019, p. 204) propose for creative processes a leader practise the call Polyphonic Orchestration that is based on dialogue and openness. To the author, this approach seems to be the ideal strategy for Design Thinking facilitation.

#### 3.1.11. Conclusion

Goal of this chapter was to provide an answer to the research question: "Sub-Question I.1: What is Design Thinking and is it based on scientific methods or is it just something IDEO invented (Seitz, 2018, para 1)?".

To do this, first the concept of design itself needed to be clarified as it builds the fundament of Design Thinking. Designing is, in this thesis, the endeavour of changing a given situation towards a preferred one while being sensible towards human, ethical, and economic demands. Thinking and acting in that fashion has been done by exceptional people ever since. But with Design Thinking a method arose to create innovations in a defined, structured and teachable way (Norman, 2013).

Design Thinking draws on the potential of interdisciplinary teams to create solutions for pressing problems that are desirable, viable and feasible, particularly exploiting the skills of designers, engineers and management (Micheli et al., 2019, pp. 139–140). "This interdisciplinary design thinking is especially valuable for deciding what to do in the first place, so that the power of intuitive creative processes can be harnessed to stimulate innovation, solve difficult problems and develop new opportunities." (Moggridge, 2010)

The scientific foundation of Design Thinking can be traced back to C.S. Pierce's and W. James' Pragmatism (Kamran, 2017, p. 3), and J. Dewey's view to technology as art of experimental thinking (Buchanan, 1992, pp. 6–8). Design Thinking as a method was first devised and taught by J. E. Arnold at Stanford University. He and a team of outstanding designers drew on the knowledge of great thinkers and scientists like J. P. Guilford, Buckminster Fuller, Robert Hartman, Abraham Maslow and to develop a method that is deeply founded in psychology, technology and design (Thienen et al., 2018, 2019).

In sum, the research question I.1 can be considered as answered.

### 3.2. Creativity

Design Thinking is inseparably linked to creativity. So, in order to optimise Design Thinking, one needs to understand what creativity is, how it arises, and what hinders it. With this basis, strategies can be developed for how to foster and support an optimal creative process.

Creativity is a highly complex concept. The ability to be creative is comprised of many aspects and parameters like personality, task, and environment, which will be discussed in this chapter. Research in creativity does not have a very long history. Some people may point to the nineteenth century and Francis Galton's search for genius (Vlad Petre Glăveanu & Kaufman, 2019a, p. 13) or the American pragmatists (Vlad Petre Glăveanu & Kaufman, 2019a, p. 17), but there is a general consensus that Guilford created a turning point in 1950 as he demanded intense creativity research to discover creative talent and support the development of promising children (Vlad Petre Glăveanu & Kaufman, 2019a, p. 12; Plucker et al., 2019, p. 44). Since then, research efforts were intense and widespread, as the importance of creativity became recognized, even identified as an essential ability to thrive in this century (Vlad Petre Glăveanu & Clapp, 2018, p. 51). Still, some researchers allege that the knowledge in cognition and neuroscience of creativity is negligible (Dietrich, 2019, p. 1). On the other hand, many aspects are already identified: "Creativity can mean so many different things and simply cataloguing the most cited theories would be as coherent as learning modern cinema by seeing a minute-long clip of every Oskar-winning movie" (J. C. Kaufman & Glăveanu, 2019, p. 27). So, the following chapters will concentrate on the aspects of creativity that are deemed to be the most important for the given research question.

#### 3.2.1. Understanding Creativity

> Creativity is an instinctive urge; a powerful drive that fights logic; an activity that gives creators an unusual euphoria and generates an unmatched sense of satisfaction. Creativity is the core of new ideas. It's the source for new products, new designs, and vision to see the world in a renewed way. (Canaan, 2004, p. 236)

Creativity is the ability to bear something new, that generates value (Rustler, 2019, p. 18). Corazza (2016) starts with a similar definition: "Creativity requires both originality and effectiveness" (p. 259) which he develops to "Creativity requires potential originality and effectiveness" (p. 262). The main reasons are that judging creativity only by a successful artefact ignores the creative actions needed to get to that point (or even failing to get there) that might need a multitude of various approaches, reframings, and prototypes. So, Corazza educed a definition that includes the pursuit of novel and valuable results (Corazza, 2016, pp. 259–262).

Furthermore, the newness of a thought can only be determined if there is a reference point – the value needs evaluation in social or economic context. "Therefore, creativity does not happen inside people's heads, but in the interaction between a person's thoughts and a sociocultural context" (Csikszentmihalyi, 2013, p. 23). Amabile and Pratt (2017) comparably define creativity as the act of ideation as a single person or in a team, demanding for novel and useful ideas. Additionally, they define innovation as "the successful implementation of creative ideas within an organization." (p. 158). What *is* novel and useful depends on the environment in which the thoughts are created, therefore, judging creativity is always subjective and domain specific (Amabile & Pratt, 2017, p. 158).

Against the commonly accepted belief that creativity is an elusive incident of reaching an idea (Reiter-Palmon & Leone, 2018, p. 387) or something god-sent without any mundane causation (A. Cropley, 2018, p. 47), Vannucci and Agnoli (2019, p. 250) outline: "Reality and empirical evidence depicted creative thinking as a complex dynamical phenomenon where idea generation is only a phase of the process, which furthermore involves inter-relations between lower-order cognitive, emotional, and attitudinal components."

The complexity of creativity becomes apparent in the list of 111 keywords John Arnold compiled that he regarded as essential factors of creativity (see *Table 8*). He even recommended using them as a checklist (Arnold, 2016, p. 93).

*Table 8.* John Arnold's Creativity Keywords

| | |
|---|---|
| **A** | associate - attributes - attitudes - altruism - anthropology - analogy - anxiety - analysts |
| **B** | blocks - brain - "brain storm" |
| **C** | consciousness - culture - concepts - create- comprehensive - confidence - curiosity - craftsmanship |
| **D** | daringness - determination - design – drive - decision - deduction - difference |
| **E** | energy - enthusiasm - environment - extrapolation - encouragement - experience - empathy - emotion - exercise - evaluation |
| **F** | fear - finish - freedom - faith - fantasy - foresight - fluency - flexibility |
| **G** | gamble - game theory - group dynamics – generosity - gestalt |
| **H** | human relations - humor |
| **I** | information theory - imagination - induction - insight - individualism - innovation - interests - independence – introspect |
| **J** | jokes - judicial thinking |
| **K** | knowledge - know thyself |
| **L** | logic - learning theory - liaison |
| **M** | motivation - management |
| **N** | newness - nonconformity |
| **O** | observe - operational definitions - operations research - originality |

Table 8 continued

| | |
|---|---|
| **P** | prediction – perception - personality – projection - probability – presentation - practice penetration - philosophy - psychology - physiology - problem statement |
| **Q** | question |
| **R** | resistance to innovation - relationships - retrospection - rationalization - reverie |
| **S** | skills - semantics - synthesis - subconscious -safety - sensitivity - symbolic logic - sympathy - statistics - sets |
| **T** | tricks - traits - therapy - thinking |
| **U** | uniqueness - universality - understanding |
| **V** | value theory - vision |
| **W** | work - working backwards - writing |
| **X-Y-Z** | yourself |

After (Arnold, 2016, p. 93)

Baskerville et al. (2019, p. 5) differ between idea and artifact: While the creative process in itself is assigned to the individual and his/her cognitive performance, the generation of a novel artifact is dependent on a structured creation-process.

According to the multivariate approach of creativity, an individual has the possibility to be creative when his/her creative potential and the given environment allow for it. The creative potential of a person consists of cognition – the individual's abilities and knowledge, conation – his/her personality traits and motivation, as well as emotion – coined as affect and mood (Mastria et al., 2018, pp. 4–5). This potential is affected by the given task and the stimulation the environment provides. "The creative potential of an individual in various fields of activity results from the interactive combination of the different factors related to the characteristics needed for creative work in that field or specific activity" (Mastria et al., 2018, p. 6). As Hess (2014b) points out: "A positive work environment with positive relationships enables creativity" (p. 57).

The majority of people do not perceive themselves as creative (Adobe Systems, 2016, p. 10). It is a trait that seems alien to many people, and that they relate with persons who behave a bit strangely and who fail in areas like being organized or acting professionally (Canaan, 2004, p. 236). People often do not understand creativity – they even fear it. Even if their personal accomplishments are highly creative (like creating a new jet engine or devising an innovative app), they will not associate themselves with creativity. "We don't think of ourselves as creative because we don't know how to identify creativity. We don't even know how to define it properly" (Nussbaum, 2013, p. 7). Ambrose and Harris (2015, p. 9) also point out that creativity is often considered as something that just happens without any means of control. They, in contrast to this belief, describe creativity as a professional process with specific phases and instruments that support ideation and creation. To them inspiration is "a tool that needs to be facilitated and supported by others as part of an overall design process, rather than being the only element that produces results"(Ambrose & Harris, 2015, p. 9). Bestley and Noble (2018, p. 192) even accuse creatives of indolence when they retreat to intuition, neglecting or concealing the analytical steps and the evaluation of their task and accomplishment, withdrawing to the inexplicable flash of genius.

Kolko (2010) also sees the discrepancy between reputation and reality. While many clients like to have a magical seeming design process as it appears more valuable than a logical process, "it is only the lack of understandable documentation, or the decision to not share that documentation, that creates the sense of magic" (Kolko, 2010, p. 16). Even if it seems to get harder to recognize the process parallel to the innovation level of the solution, there is a clear structure that leads to a repeatable and transparent design process (Kolko, 2010).

Fox and Beaty (2019) sum it up:

> "A truly creative individual is able to repeatedly generate such highly novel and useful thoughts: someone who has harnessed the default generative capacity of the mind for their own particular purposes—or alternatively, someone simply born with their distribution skewed toward the more novel and useful end of the cognitive spectrum." (p. 128)

So, creativity is the potential to create artifacts that are novel and useful to certain people and in specific contexts. It is not only the incident of achieving an idea but an intricate process that can be taught and trained. Being creative is not reserved to a small group of gifted people but a trait that is inherent in everybody. Still, its complexity affords and receives intensive research. The following chapters demonstrate some aspects that help to address the research of this thesis.

### 3.2.2. Creativity in Positive Psychology

The idea of Positive Psychology was to investigate the positive qualities of the human mind and not to only regard the defective aspects (Seligman & Csikszentmihalyi, 2014, p. 280). The research in Positive Psychology focuses on individual and environmental influences with positive aspects (Ackerman, 2018). "As a field, positive psychology spends much of its time thinking about topics like character strengths, optimism, life satisfaction, happiness, well-being, gratitude, compassion (as well as self-compassion), self-esteem and self-confidence, hope, and elevation" (Ackerman, 2018 para 7). When it comes to the characteristics of the individual, creativity builds an essential field of research for positive psychologists (Seligman & Csikszentmihalyi, 2014, p. 287).

Creativity is a highly complex field that requires interdisciplinary investigation. Hennessey and Amabile (2010) stated that, "creativity arises through a system of interrelated forces operating at multiple levels, often requiring interdisciplinary investigation" (p. 571), thus stressing the importance of a holistic view and transdisciplinary approaches. Their visualisation shown in *Figure 36* depicts the broad field of forces that influence creativity. They accentuate that the figure is simplified, as the depicted fields amalgamate and the synergetic effects outreach the effect of the single elements in both creative process and individual (Hennessey & Amabile, 2010, pp. 571–572).

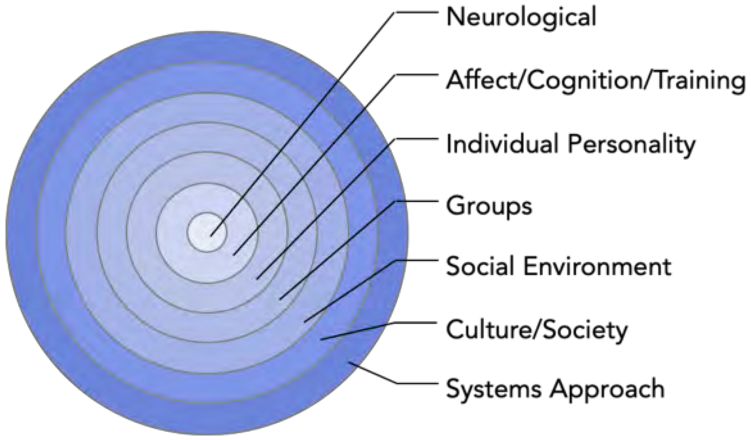


*Figure 36.* Schematic Representation of the Forces that Shape Creativity
After (Hennessey & Amabile, 2010, p. 571)

Manzini (2015, p. 31) states that creativity is a talent every human being possesses, but that it must be encouraged and nurtured to thrive. The framework and stimuli surrounding a task can influence the creative output greatly – they either suppress or promote it. Agnoli and Corazza (2019, p. 48) also see a multitude of relevant components: "Human creativity cannot emerge without access to knowledge, without interactions with social norms, without the use of some forms of intelligence, without divergent movement in the thinker's mind space, or without evaluation abilities." They further stress the importance of emotions for the creative process. This subject will be discussed in detail in chapter 3.3.2.

Arthur Cropley (2018, p. 48) and other researchers lay great import in demystifying creativity. He argued in great detail that creativity can be understood, explained and controlled, still acknowledging that there are few highly gifted individuals who excel when it comes to revolutionary new ideas. This is a predictable effect, as creativity is a human ability with the typical bell curve of a Gaussian distribution.

Glăveanu (2013) developed a theoretical framework to structure and describe creativity research. Creativity is a highly interactive process, impacted by social and economic conditions and evolving from given resources, skills and competences that all have to be taken into account when researching (Elisondo, 2016, p. 196). The Five-A Framework provides the subsystems actor, action, artifact, audience, and affordances. The fundamental cross-interference of these elements always demands a holistic view, so the elements provide a focus on only certain factors (see *Table 9*) (Vlad Petre Glăveanu, 2013, pp. 71–72).

*Table 9.* The Focus Points of the Five-A Framework

| The Five A's of Creativity | Focus on |
|---|---|
| Actor | Personal attributes in relation to a societal context |
| Action | Coordinated psychological and behavioural manifestation |
| Artifact | Cultural context of artifact production and evaluation |
| Audience Affordances | The interdependence between creators and a social and material world |

After (Vlad Petre Glăveanu, 2013, p. 71) excerpt

Creativity itself needs structuring as the specificity varies greatly (J. C. Kaufman & Glăveanu, 2019, p. 28). There must be a way to distinguish between creating great art or disruptive innovations and deciding how to place the pillows on a sofa (Cotter et al., 2019, p. 641). It was already quite common to distinguish between everyday creative capability and genius creations (Vlad Petre Glăveanu & Kaufman, 2019a, p. 20), but this still blurred lines between very discriminative aspects.

Kaufman and Beghetto (2009, pp. 2–4) developed the Four C Model of creativity, distinguishing:

– Little-C: everyday innovation. Typically, small changes in daily life that every layperson creates and that are new and useful to them
– Mini-C: transformative learning. A very personal kind of creativity. A person achieves a novel insight through experiences or information
– Pro-C: professional expertise. The result of education, personal development and talent. The work of professional creatives like designers or chefs
– Big-C: outstanding creative accomplishments. Revolutionizing achievements of artists and the great thinkers of their time. (pp. 2-4)

Glăveanu and Kaufman (2019b, p. 6) state that the level of creativity and the elements of the creative system need to be combined for systematic research as every combination of the given substructures demands for specific examination. They propose a matrix – coined The Creativity Matrix – that combines the Four C Model and the Five A Framework (see *Figure 37*).

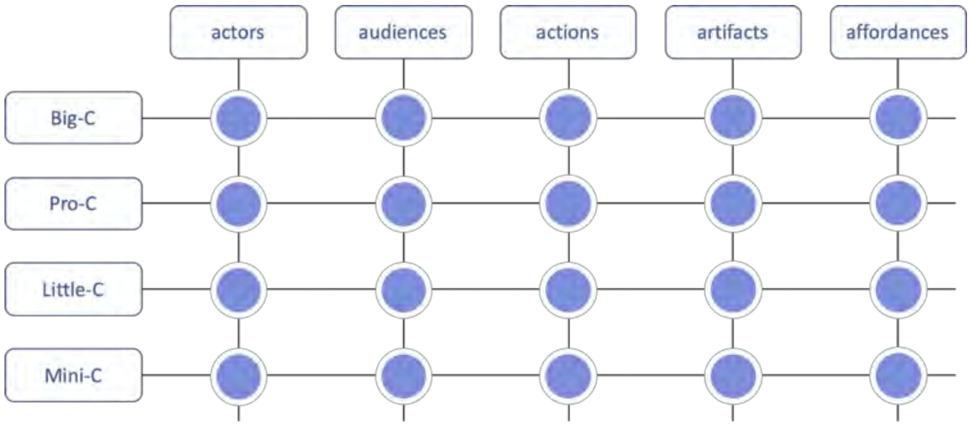


*Figure 37*. The Creativity Matrix – After (Glăveanu & Kaufman, 2019)

The idea of the matrix is to present interesting fields of investigation that easily get overlooked and that eye-catching within this tool. An example is research concerning the social environment affordances along all levels of creativity (Vlad Petre Glăveanu & Kaufman, 2019b, p. 8).

The creativity levels pursued with Design Thinking are quite diverse. Often, the support of mini-C and little-C is intended, but projects seeking innovations in organizations or working on the development of new products or services pursue pro-C or even big-C achievements instead. So, Design Thinking teaches respect and sensitivity for mundane creative traits but also fosters sparks for life changing disruptions (Royalty et al., 2020, p. 51).

John Arnold (2016, pp. 71–77) illustrated and explained a "spectrum of thinking" (see *Figure 38*) that gave examples to thinking modes he found important for engineering. He distinguished between organized and inspired creative thinking. The effects of both modes are discretely very different: "Organized creativity approaches bring about incremental change. […] Inspired creativity approaches bring about disruptive change" (Thienen et al., 2019, p. 3). Arnold (2016, p. 76) gave high import to the combination of inspirational and organized approaches, namely the "Scientific Hunch" – reaching innovation through big goals and systematic development processes and "Serendipity" – combining insights and empirical methods. "While the combined approaches mentioned by Arnold merge only one approach from the inspired and organized category each, design thinking appears to systematically combine all of the discussed approaches. It also iterates and advances them" (Thienen et al., 2019, p. 31).

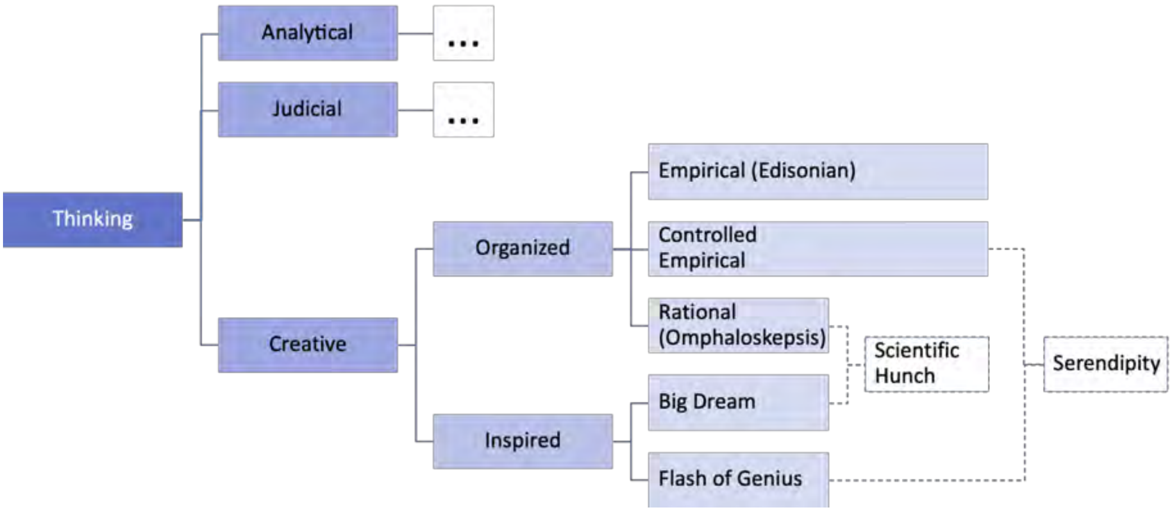


*Figure 38.* The Spectrum of Thinking
After (Arnold, 2016, p. 74) – Analytical and Judicial branches are collapsed

Manzini (2015, pp. 30–31, 2019, pp. 41–42) distinguishes between the conventional mode and the design mode. The conventional mode describes an approach to tasks that relies fully on proven and tested ways of working. “We do it like this because we have always done so” (Manzini, 2015, p. 30). This mode demands methods that already have shown their success and practicability. Manzini’s design mode on the other hand demands fresh and imaginative approaches to the challenges at hand and it implies ethical choices every designer must be aware of and must build her or his own standpoint (Manzini, 2019, p. 52). Tina Seelig (2017) sees imaginative approaches at the centre of creative work, claiming: “Creativity is applying imagination to address a challenge” (p. 9).

As seen in chapter 3.1.1.3 and 3.1.2 creative work is often represented and executed with the help of a process model. This is not only true for design but also for creative projects in general (Mumford & McIntosh, 2017). Trying to provide a comprehensive overview, Dubberly (2005) collected and described over 100 processes from the inscrutable squiggle of T. Brennan (*Figure 18*, page 54) to an intricate process for product design with 229 steps (Dubberly, 2005, pp. 99–113). Agnoli & Corazza (2016, p. 5) assert three basic steps, “(a) gathering and structuring of information elements; (b) ideation; (c) verification” that must be existent to perform a creative process. They conclude that a further reduction is not possible, as only the triad performs every task indispensable to create novel and useful solutions. Creativity model pursuing an optimised workflow, split these 3 phases in smaller steps and create transitional phases but fundamentally keep the basic structure (Corazza & Agnoli, 2016, pp. 5–7).

Creative outcomes can be evaluated by three factors: a) creative fluency, regarding the number of ideas created, and b) cognitive flexibility, the ability to shed mental constraints and to think in an unanticipated way, and c) originality (Sassenberg et al., 2017, p. 129). Flexibly thinking people access out-of-the-way information, dismiss constraints, and connect concepts that superficially have no relation (To & Fisher, 2019, p. 105).

### 3.2.3. Convergent and Divergent Thinking

Customarily, creativity is often linked with divergent thinking. Creative people often call themselves divergent thinkers or right-brained (Lawson, 2019, p. 192; Tokuhama-Espinosa, 2019). To evaluate the potential of creativity, researchers tend to rely on measuring only divergence – preferably with the highly popular Torrance Test – ignoring that they only examine one facet of creative thinking (Baer & Garret, 2017, p. 46). Convergent as well as divergent thinking creates ideas; then again both modes can be non-creative (Dietrich, 2019, p. 2).

Divergent thinking, also known as lateral thinking, is associated with openness, flexible and experimental thought processes, striving to a multitude of solutions with ample variance (Runco & Acar, 2019, p. 244). It includes developing and exploring a multitude of solutions to a problem (Mekern et al., 2019, p. 47). On the other hand, convergent or vertical thinking is the ability to analyse, to assess, to deduce, and think logically, the thought process striving to a single solution, that solves the posed problem precisely and successfully (Gabora, 2019, p. 1794; J. C. Kaufman & Glăveanu, 2019, pp. 32–33). Even if many people think otherwise, creative production is not expedient without convergent thinking (Baer & Garret, 2017, p. 46). “In fact, the essence of practical, productive, down-to-earth creativity lies in combining divergence and convergence” (A. Cropley, 2018, p. 50).

The work of designers is vastly inept without divergent and convergent phases (Lawson, 2019, p. 192). The classic Double Diamond of Design (see *Figure 19* on page 55) visualizes these phases to emphasis their importance to the design process (Drew, 2019). Bestley and Noble (2018, pp. 27–28) also describe the creative process including divergent and convergent steps, but place the phase of *transformation* in between them, which is where the designer creates variants based on the information amassed during the divergent step.

Design Thinking methods – even if the process typically is visualized with only two diverge-converge successions – applies this sequence multiple times, because iterations are implicit (Bonakdar & Gassmann, 2016, p. 62). “The process of the design thinker, rather, looks like a rhythmic exchange between the divergent and convergent phases, with each subsequent iteration less broad and more detailed than the previous ones" (T. Brown, 2019, p. 74). This frequent switching from one thinking mode to the other – Charles Dobson (2018, p. 300) calls it Flip-Flop-Thinking – is demanding and unfamiliar. People with good design training and exercise are exceptionally good at this oscillation, as will be discussed in chapter 4.4.4.1.

However, the divergent phases must not be too short. As research shows, the quality of the produced ideas increases during the creative process. The cognitive processes might change during a divergent thinking session, indicating the adoption of different cognitive abilities (Forthmann et al., 2019, p. 7). An interesting point of view for the divergent-convergent concept is given by Liane Gabora (2019): She proposes including context into the thinking modes. So, for divergent thinking, the extension into other – if possible unusual – contexts than the one given in the problem space should be considered. For convergent phases the conversion of given information/ideas into the given situation must be part of the reflection (p. 1797). Convergent thinking includes more than just weeding out ideas until only one is left. It is an assessment and development process towards the optimal pattern to solve the given task (Corazza & Agnoli, 2018, p. 165). Consciously leading the Design Thinking members out of and back into the problem-setting might be a fruitful course of action in some projects.

### 3.2.4. Insights, Abduction, Incubation, and Mind-wandering

Insights are a core element for problem-solving and innovation-finding in Design Thinking (T. Brown, 2019, p. 47; Lewrick et al., 2018b, p. 26). Liedtka (2018, p. 74) and Brown (2019, p. 70) identify insight as a derivative of inspiration. Both regard data as an inspirational source that has to be gathered and worked. Jeanne Liedtka (2018, p. 74) names the process of finding insights *sense-making*, and stresses the labour of the team where data "is transformed into insights" (p. 70). Tim Brown (2019, p. 68) explains that the transformation process from inspiration to insight is complex and that the Design Thinker uses various techniques to stimulate his or her mind for this leap from inspirational data to insight.

With their definition, "inspiration is the mental process that starts from the aware or unaware input of an unforeseen, unexpected, unplanned, irrelevant conceptual entity and terminates with the generation of a pattern that is afterwards seen to be relevant to one's focus" (Corazza & Agnoli, 2016, p. 13). Corazza and Agnoli confirm this attitude and recognise insight as the discovery of patterns or principles in inspirational data. Insights can be highly influential in creative processes. An insight can lead to a mindset-shift for the whole design team and, with this, to completely new access to solutions (Riel & Martin, 2017, p. 127).

Weisberg (2018, p. 191) identifies two strategies for problem-solving: First finding a solution by using given knowledge, coined reproductive thinking, and second – typically applied when method one fails – changing the way the problem is perceived to achieve insights that may finally lead to a solution. Sprugnoli et al (2017, pp. 100–101) describe three methods; (1) retrieval from memory, similar to reproductive thinking, (2) analytical problem-solving, a well aware, step-by-step process to work the given information and to synthesize the solution; and (3) insight, the appearance of a seemingly evident solution as result of an unexplainable, often not temporally definable process. However, the structured change of perception is missing in this explanation. Still, this strategy to find creative insight can only work when "it is funded by prior experiences and knowledge. In this way it is part of a dynamic sense-making or, more precisely, semiotic process" (Beghetto, 2019, p. 169).

Following this concept, and Peirce who names abduction the "act of insight", "the only logical operation that introduces any new idea" (C. S. Peirce in Barrena & Nubiola, 2019, p. 189), the phase of reframing the problem within Design Thinking is crucial to the outcome of the overall process. Roger Martin stresses the high importance of abduction as the leap from problem to solution. He calls it "the often-overlooked reasoning skill that is crucial to redressing the imbalance toward reliability and to achieving a productive balance of exploration and exploitation" (2009, p. 54). He underlines intuition as highly relevant to achieve new concepts and ideas that might change the world (R. L. Martin, 2009, p. 54).

Abduction uses creativity and imagination to create new ideas (Barrena & Nubiola, 2019, p. 188). "It can be thought of as the imagination of what *might* be (rather than the analysis of what *is*)"(Micheli et al., 2019, p. 135). Where deliberate attainment of ideas was undervalued in creativity research recent development has proven the importance of both methodical thought and unintentional revelation (Barr, 2018, p. 101). Researchers investigated if and how insight creation could be stimulated. Koskela and Kroll (2019, p. 248) argued that abductive ideation in science arises from anomalies. In contrast, design abduction has its source in the necessity to derive from long thread paths as they do not work in the given situation[11]. The destabilisation of the given state of art/knowledge showed to be a good start for abductive reasoning, even when strengthened through fear or high pressure to act. One prerequisite for new ideas is the willingness of the individual to embrace doubt and be willing to learn (Charmaz, 2014, p. 202; Reichertz, 2016, p. 141), while another is the limitation of stress factors to a manageable amount (Firth, 2019, p. 107) with the goal to stay in the flow state (Csikszentmihalyi, 2014, p. 147).

[11] See also chapter 3.1.7 for more details on design abduction

A creative insight can arise when an individual – surprised or in doubt by a given situation – decides consciously or unconsciously not to use the tried perspective in the situation any more (Reichertz, 2011, p. 285).

Mind-wandering, an apparently contrasting concept to the doubt-approach, is also an essential strategy for creative abduction. This was suggested by C. S. Peirce who encourages playing and daydreaming to reach what he calls "musement" (Reichertz, 2016, p. 144). Arnold (2016, p. 76) also favours mind-wandering. He stresses the importance of thorough preparation, calling it "unproductive hard work," but after that, he instructs putting the challenge aside and engaging in something completely different. "Relax and let the subconscious take over and incubate this new problem along with all your past experience" (Arnold, 2016, p. 76).

Csikszentmihalyi and Sawyer (2014, p. 68) also assert that "Insights often occur during 'idle time' when a person is removed from the tight schedule and time demands of the usual office routine" but with the prerequisite of intense preparation. The phenomenon is still a topic in prevailing research, its usefulness unanimously considered positive (Firth, 2019, p. 113; K. C. Fox & Beaty, 2019; S. B. Kaufman & Gregoire, 2016, pp. 30–44).

But the process is fragile. Motivation, for instance, which was discussed as relevant for creative processes in chapter 3.2.6, is problematic for mind-wandering. The mind seems to connect low-motivation time spans with the opportunity for new challenges and has shown itself surprisingly open to new thoughts (Benedek & Jauk, 2018b, p. 48). Distraction will end the mind-wandering, and, with this, the incubation. Open tasks, familiar problems, or suddenly arising emotions hinder the lingering inspiration (Dobson, 2018, p. 302). Still, it is not proven, that the states typically identified as mind-wandering are really that and not a subconscious state of the mind that is working dedicatedly on the given problem. As this mind-wandering state is connected with a seemingly effortless thought-process, this is still welcome for ideation (Benedek & Jauk, 2018b, p. 51).

Mind-wandering was recently intensely researched in neuroscience, and findings suggest that *thinking of nothing* is extremely relevant for creative processes. The findings and implications for Design Thinking will be discussed in chapter 4.4.4.1.

The goal of both strategies, embracing doubt and mind-wandering, is to override deliberate thought processes in order to activate subconscious cognition to deal with the challenge (Reichertz, 2016, p. 145). As current research suggests "Getting lost in our own thoughts might therefore represent a fruitful mental activity to promote the generation of original ideas" (Vannucci & Agnoli, 2019, p. 252). There is evidence in neuroscience that idea generation is often a subconscious act[12] (Chrysikou, 2018).

A third method to induce insight is drawing or sketching. Initially, drawing in abduction used diagrams to visualise models (Reichertz, 2016, p. 146), but today doodling or sketching is freer in its support of thought processes (Koskela et al., 2018, pp. 173–174). The process of drawing is used to precede or sidestep verbal expression, and to give more direct access to visual cognition and experiment with variations to discover new perspectives (Reichertz, 2016, p. 147). Designers often do not need to sketch to visualise their thoughts. They use their imagination to work on the formation of ideas: "the ability to visualise the wholeness of the task in its corporeal solution before it is executed so that it can be evaluated with lightning speed. … The vividness of this inner visualization is a measure of the designer's ingenuity" (Moholy-Nagy, 1947, p. 57).

Koskela et al. claim that Peirce's definition of abduction "as an evidencing process by using syllogistic formulations" (2018, p. 155) does not meet abduction in design. They determined five dimensions where abduction in design differs from the classical approach: "triggering factor, position in the process, nature of the abductive inference, outcome of the abductive inference, and psychological character of abduction" (Koskela et al., 2018, p. 169). They conclude that at least the standard limitation of abduction to 'inferring the rule from the given result' is too restrictive considering the wide variation of abductive inferences they found in design practice (Koskela et al., 2018, p. 179). Kees Dorst (2017, pp. 11–14) follows a similar train of thought and proposes design abduction (see *Figure 39*) as an evolution of abduction. He describes design abduction as the reasoning where neither what will provide the solution nor how the participants relate to each other is known. The only known element is the outcome – the value that should be approached. "Design abduction is the only way to deal with open, complex, dynamic and networked problems, and it lies at the core of creative practice – not just in design but for all disciplines" (Dorst, 2017, p. 14).

[12] Details to evidence in neuroscience research for creativity will be discussed in chapter 4.4.4.1

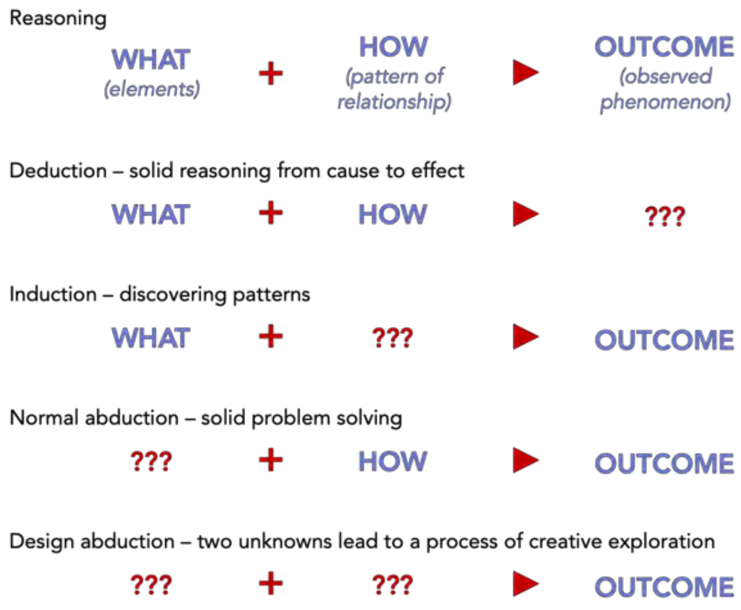


*Figure 39.* Variations in reasoning – After (Dorst, 2017, p. 13)

A similar reasoning is *innoduction* – or innovative abduction. This form of inference can create real innovation, as it crafts its own data and does not rely on given facts as deduction or induction do (Cramer-Petersen et al., 2019, p. 41). Roozenburg, who introduced innoduction, is convinced that innoduction covers Peirce's actual concept of abduction, with rule (how) and case (what) becoming simultaneously evident (Koskela et al., 2018, p. 160). This fits Barrena's and Nubiola's (2019) claim: "Peircean abduction is a much richer and more powerful understanding of human creativity than most of the available current theories" (p. 202), thus suggesting a broader view pf abduction that includes science and design.

Later, Dorst (2019, p. 120) points out that to work with two unknowns in one equation over strains the human mind as it demands for working with so many variables that we cannot manipulate them all together. Design abduction allows and demands for building variations of multiple solutions that play with different sets of *what* and *how* until a good solution is found. That this solution cannot be declared right or perfect, but just *satisficing* or good is another uncomfortable idea designers have to deal with (Baskerville et al., 2019, p. 4).

### 3.2.5. Sociocultural Aspects of Creativity

Why does Design Thinking take place with a group of people and not with a single person?
Design Thinking is strictly collaborative and team oriented (Lewrick et al., 2018b, p. 144). And, even if

creative work is done alone, the context emerges for the creative person with exposure to other people and their influence. So, it makes sense to investigate creativity under social contexts.

As research into the personal traits and cognitive processes of individual people is sensible and fruitful, research in creativity also needs to investigate the interaction that takes place between the individual his/her environment and the included or affected people (Sawyer, 2019, p. 567). Creativity, as we see it today, is no longer only the product of a single person. "We create not as isolated minds but as embodied beings who participate in a socio-material world" (Vlad Petre Glăveanu et al., 2019, p. 1). As technology gives us the opportunity for constant connection, as globalisation moves us closer, and as sharing experiences and knowledge is facilitated, it is high time for a collaborative view of creativity (Vlad Petre Glăveanu & Clapp, 2018, p. 51). "It is a shift from individual-based to social-based understandings of this phenomenon, from inner attributes to social interaction and communication, from a view of creators fighting the culture of their time to working from within society and culture" (Literat & Glăveanu, 2016, p. 330).

Mihaly Csikszentmihalyi was the main originator of the Systems Model of Creativity that first stretched the definition of creativity beyond the individual (J. C. Kaufman & Glăveanu, 2019, p. 36). Inspired by the theory of human evolution with its feedback loops that develop new species with improved properties to survive in the given environment (Csikszentmihalyi & Wolfe, 2014, p. 165), this model combines subsystems of the creative's family background, culture, and society to create a theoretical framework that thrives with feedback from one system element to the others (see Figure 40).

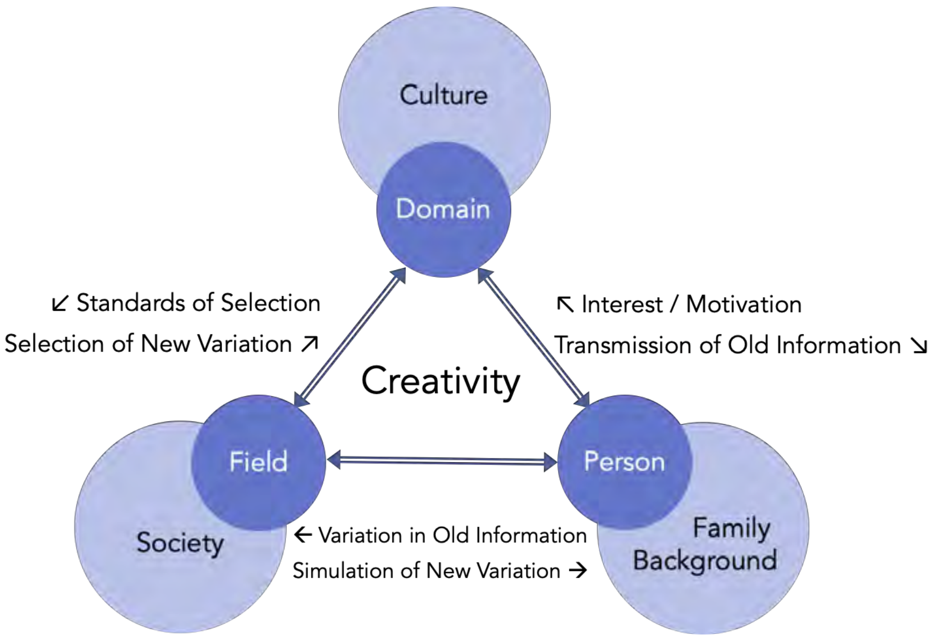


*Figure 40.* The Systems Model of Creativity – After (Csikszentmihalyi & Wolfe, 2014, p. 166)

A creative person is influenced by his or her cultural domain and creates novel concepts on this basis. The concepts are applied to a specific societal field and evaluated within it. If it is considered valuable it is established in the given domain to be part of the influential factors of the next evolutionary loop (Csikszentmihalyi & Wolfe, 2014, p. 167). Interesting is also the societal view of a creative achievement that changes with time and thus assigns new value to it (J. C. Kaufman & Glăveanu, 2019, p. 36). This altered view is demanding to the researchers, as the abdication of the minimalistic concepts adds manifold parameters, requires different research approaches, and will impede scientific proof (Vlad Petre Glăveanu & Clapp, 2018, p. 54). For example, when remembering the creative act, people often only recall the cognitive act. They are not aware of or bear down on the influence of their environment, thus occluding valuable information about the process (Stierand et al., 2019, p. 165).

The Systems Model focuses on the creative individual, as it regards the individual and his/her surroundings and the effects on creativity and creative outputs. The concept of Distributed Creativity formulated by Petre Glăveanu (2014) regards creativity in an interpersonal context instead. "Distributed creativity is, therefore, a conception that extends previous accounts of cognition and makes them engage with the sociality, materiality and temporality of the world" (Vlad Petre Glăveanu, 2014, p. 28). The concept takes the Five A framework of creativity, which was discussed in chapter 3.2.2, and sets it in relation to its environment, namely other people, affected and affecting objects as well as the past, present and future of the creative act (Vlad Petre Glăveanu, 2018, p. 167).

Stierand et al. (2019, p. 167) describe ideation as an interplay between cognitive processes and interactions with the world in a way that precedes the explicable in an unforeseeable, convoluted way. People, artefacts, and the environment merge to a collective source of creativity. Glăveanu and Clapp (2018, p. 56) see the combination as inevitable and postulate "all creative outcomes are best considered *co-creations*." On the other side, Walton (2016, p. 89) constitutes that humans, even if there is a fundamental need to be in contact with other people, have a distinct desire to be special and to stand out in their social community. This desire spurs creativity as a means to be special. The individual is constantly in the conflicting field of being and acting as an individual but always acting inside his or her social group (Vlad P. Glăveanu, 2017, p. 120).

The new viewpoints are revolutionary as they shift the creative process away from the individual to the social structure and the collaborative actions within a social communion. This does not degrade the individual but enables him/her to express their creativity within their social structure (Vlad Petre Glăveanu & Clapp, 2018, p. 57). Team creativity thrives not only from the variation in skill and attitude, but also because of the synergetic effects that teams can evoke (Aggarwal & Woolley, 2019, p. 1590). The t-shaped skill set (T. Brown, 2019, p. 33) seems to be of high relevance here, as Aggarwal and Woolley describe the reinforcing effect of team members that at least *know-what*, even if they don't *know-how* (North & Kumta, 2018, pp. 162–163) and thus in discussion can stimulate creative skill sets (Aggarwal & Woolley, 2019, p. 1591). An accordingly formed team can also embrace the diversity that is a pervasive factor in today's tasks (Vlad Petre Glăveanu & Clapp, 2018, p. 52).

Creativity is highly influenced by its environment. The task, the team, the required outcome parameters but also society and culture affect performance, quality and quantity of the process. Only with awareness to this interplay can the effects be changed or at least estimated.

### 3.2.6. Motivation as Factor for Creativity

Being creative is a fundamental human act. The desire for it goes deep and surmounts substantial impediments (J. C. Kaufman & Glăveanu, 2019, p. 31). However, without dedicated motivation, the process of seeking better ideas or taking risks would be hindered and therefore also impede creativity (Hennessey, 2019, p. 374). Psychology distinguishes between explicit and implicit motivation. Explicit motivation is consciously self-assigned and consists of premeditated goals and drivers. Implicit motivation is affect-driven and subliminal (Brandstätter et al., 2018, p. 83). Implicit motivations are essentially the drive to avoid negative emotions and to gain positive ones (Brandstätter et al., 2018, p. 169).

Manzini asks "What motivates the designer and what are the expectations of its potential beneficiaries?" and stresses the fact that the beliefs and their potential in design vary massively (Manzini, 2015, p. 36). "Motivational orientation is a key component of the creative process" (Hennessey, 2017b, p. 341) or even stronger: "Creativity, [...] is in large part a function of a specific kind of motivation"(Nakamura & Csikszentmihalyi, 2014, p. 196). Motivated people reach high productivity and quality in ideation phases (Mastria et al., 2018, p. 16).

Most researchers agree that there is a considerable difference between intrinsic or extrinsic motivation for creativity. If someone likes the task and is personally highly interested in finding a good result for the given problem, creativity can be increased; part of it is the willingness to work highly concentrated, as well as maintaining the curiosity about the solution needing to be found (Hennessey, 2017a, pp. 250–252). Interesting enough, if the motivation to solve the task is something outside the given assignment, like a reward, an assessment of the performance or the wish of a third person, the creative potential is diluted (Baer & Garret, 2017, p. 54). Csikszentmihalyi's state of flow is reciprocal with intrinsic motivation. Intrinsically motivated people reach the state of flow more easily, and working in this state not only promises best results, it also activates intrinsic motivation which again activates them to keep on working (Finley & Csikszentmihalyi, 2018, p. 86).

Intrinsically motivated people generally feel more self-reliant and better about handling a task; the positive sentiment optimising their attitude. In contrast, extrinsic motivation leads to a negative tendency in the task (I need to be rewarded/forced to do this, so it must be bad). So, even if an extrinsic motivation could give a short boost, its long-term effect tends to be negative (Finley & Csikszentmihalyi, 2018, p. 85). Motivation also appears to be a facilitator for attention shifts (Benedek & Jauk, 2018b, p. 48), and it helps us with the cognitive task switching discussed in chapter 3.1.6.
In spite of widespread agreement, the measurement of both motivation and creativity is complex and the given evidence is challenged. The field is open to discussion, and more research is demanded (Hennessey, 2019, pp. 375–376).

Amabile and Pratt (2017, pp. 169–170) emphasize the motivational influence of purpose for creative work. Meaningfulness is the all-encompassing factor in Amabile's and Pratt's model of creativity shown in *Figure 41*. The task needs to be perceived as significant and positive, but not necessarily as fun – even the contrary, sacrifice, can add to the perception of meaningfulness. The size of the Design Thinking team can be of relevance here, as a bigger group suppresses motivation as they feel superfluous and their contribution unimportant (Paulus et al., 2018, p. 2).

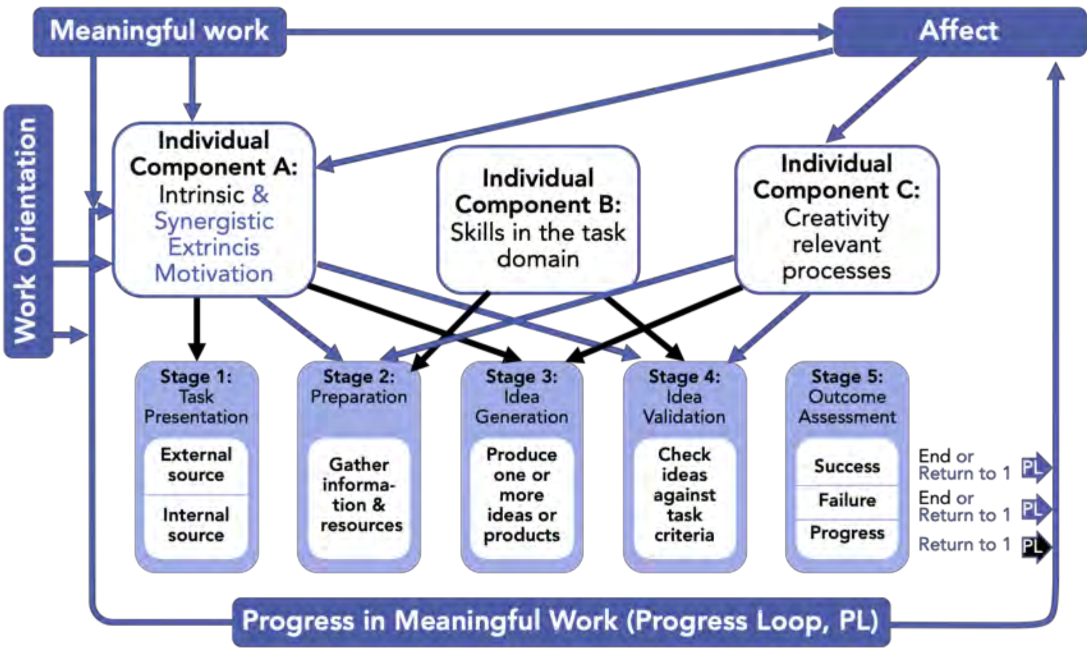


*Figure 41*. The Dynamic Componential Model of Creativity
Source (Amabile & Pratt, 2016, p. 164)

Nakamura and Csikszentmihalyi (2014, p. 199) complement purpose with passion. Passion for the task to be fulfilled is entirely intrinsic motivation, it can be – but does not have to be – fuelled by purpose that is at least partially externally driven. To avidly dream for a goal to be achieved or to keenly hope for a problem to be solved is part of an attitude that leads to creativity. If people can see their goals in their minds, they tend to be more open to experimentation and quirky ideation, but there is also research that indicates that having already seen the goal (if only imaginatively) reduces the willingness to hard work and sacrifice (S. B. Kaufman & Gregoire, 2016, pp. 27–29).

A motivating physical workspace is often named as a relevant prerequisite for Design Thinking (Curedale, 2019, p. 451; Elsbach & Stigliani, 2019; Lewrick et al., 2018b, p. 132). The physical environment is considered as a relevant motivational instrument to enhance creativity. Studies found improved innovation and product quality in companies that considered the workplace design (Kegel, 2017, p. 23). Scott Berkun (2012) claims that the team and the interrelation in the team establish the creative environment, not the office design. His list of famous examples includes the Apollo 11 moon landing team that was situated in ordinary offices, and the creative companies and music bands that started in garages. Zhou and Hoever (2014, p. 353) also see architectural influences as minor in importance to effects of nurturing leadership. Though, workspace design can express the appreciation of the employer for the employees (Pradeep, 2016, p. 4). It is the sum of efforts in this area that makes the difference. The organisational workspace, with good processes, appreciation through superiors, and the above-mentioned meaningfulness play a relevant role for creativity (Cromwell et al., 2018, pp. 76–77).

The Design Thinking approach imposes an additional critical factor to motivation: Failing is an integrated element of the Design Thinking process. "Fail early to succeed sooner" (T. Brown, 2019, p. 23) is a mantra at IDEO. The sequence of prototyping and testing needs failure to be successful. To Bernard Roth (2015, p. 12), gaining an achievement is only possible if one fails and learns from the failure. But to fail is highly frustrating for most people, so much so that they would rather stop being creative than suffer another failure (Thienen, Meinel, et al., 2017, p. 2). Countermeasures are: creating a physically and psychologically safe environment (Elsbach & Stigliani, 2019), priming the team members for (desirable) appearance of failure (D. Kelley & Kelley, 2015), early introduction of the non-linearity of the process (Hambeukers, 2018), and creating time pressure at certain stages to avoid perfectionism (Thienen, Royalty, et al., 2017, p. 10).

> "People are so negative about the negative. They don't see the value of the negative. I, personally, am much more positive about the negative. If you are not positive about the negative, you can't really do Design Thinking or any kind of prototyping." (Hambeukers, 2018, para 9)

### 3.2.7. Creativity and Innovation

Innovation is a critical factor not only for commercial businesses, but also for public sectors to be sustainable and to survive over a long time (Tidd & Bessant, 2018, pp. 15–17). Our world is changing quickly, and to keep up, organisations, as well as society need to innovate constantly. Innovative companies tend to be more successful and profitable than conservative ones (Eisingerich & Tellis, 2016). Moreover, pressing social and economic problems are globally present and pressing (T. Brown, 2009, p. 216). "The challenge facing any organization is to find the ways of managing the innovation process to provide a good solution for the problem of renewal or refreshing of the essence, creation, and delivery of a firm's offerings" (Tidd & Bessant, 2018, p. 48). Many organisations tend towards analytical thinking, using numbers, statistics and benchmarks to achieve consistent, predictable outcomes. The problem is that this approach will not find new insights that are outside the established domain, thus only exploiting what is there and not exploring new fields of venture (R. L. Martin, 2009, p. 37).

Human creativity and ingenuity are vital to innovation. An organisation needs to be aware of that and create an environment that nurtures new ideas and supports promising developments (Tidd & Bessant, 2018, p. 89). As Cropley and Cropley (2018, p. 15) illustrate, creativity and innovation are tightly knit and share so many patterns and attributes that it seems sensible to conduct conjoined research on both simultaneously. Still, there are differences (see *Table 10*) that must be recognized and respected to value both appropriately (D. Cropley & Cropley, 2015, p. 15).

Whether an innovation is fruitful depends heavily on the affected person. If he or she does not find any gain in the innovation or finds it hard to adopt, there will be no success. It was formerly possible to focus on five characteristics to judge the adoption potential of an innovation:

- *Relative Advantage*: Which benefit lies in this innovation for the user personally?
- *Compatibility*: How does this innovation fit into the user's prevailing environment?
- *Complexity*: How difficult will it be for the user to adopt this innovation?
- *Trialability*: How easily can the user test this without being stuck to it?
- *Observability*: How easily can the user observe the results of the innovation?

(Rogers, 2003, pp. 15–16)

*Table 10.* Distinction between creativity and innovation

| Creativity | Innovation |
|---|---|
| • generates entirely new ideas | • expands and adapts existing ideas |
| • is dominated by intrapersonal factors such as thinking and motivation | • is dominated by social factors such as communicating and "selling" |
| • is not bound by conventional logic | • is strictly bound by conventional logic |
| • is not confined by the constraints of reality | • is strictly confined by the constraints of reality |
| • does not need a concrete product | • must yield a concrete product |

After (D. Cropley & Cropley, 2015, p. 15)

Today, the discerning factors are much more complex and the importance changes massively with each individual. While Rogers' five points are still significant, Oturakci and Yuregir identified 39 characteristics that are relevant for the diffusion of innovation. They also discovered a massive variation of influence for these characteristics dependent on the target group observed (Oturakci & Yuregir, 2018). This research indicates the importance of human-centricity for innovation-success and therefore the importance of human-centricity in Design Thinking. Satell (2017, pp. 41–42) is adamant that identifying a good problem is the better way to succeed than having a good idea.

People are often averse to innovation. There is a common tendency towards inertia, to the well-known and customary (Vlad Petre Glăveanu & Kaufman, 2019b, p. 1). As shown above, creativity and intuition are closely related. However, while ideas born simply from intuitive thinking bear the seed of validity, they are often unreliable – too vague to be fruitful, too risky to be implemented. It is inevitable: where there is innovation, there is risk and turmoil. "Innovation is just plain messy and often inefficient – there is no way around that"(Liedtka & Ogilvie, 2011, p. 11). Yet, organisations cannot afford many big fails, inventions that disappoint and don't succeed. Therefore, neither analytical nor intuitive thinking is appropriate for innovation. Martin (2009, p. 54) identifies Design Thinking as the ideal possibility for interconnecting them and closing the gap between reliability and validity (see *Figure 35*, page 93).

In fact, Design Thinking strives to be more than only reliable and valid. Design Thinking is unthinkable without the human factor, and – as Rogers already proved – innovation is not possible if the personal desires of the target group are forgotten. So, Brown (2019, p. 25) as well as Kelley and Kelly (2015, p. 15) demand for the trinity of innovation (see *Figure 42*) and see the Design Thinking process as the way to get there.

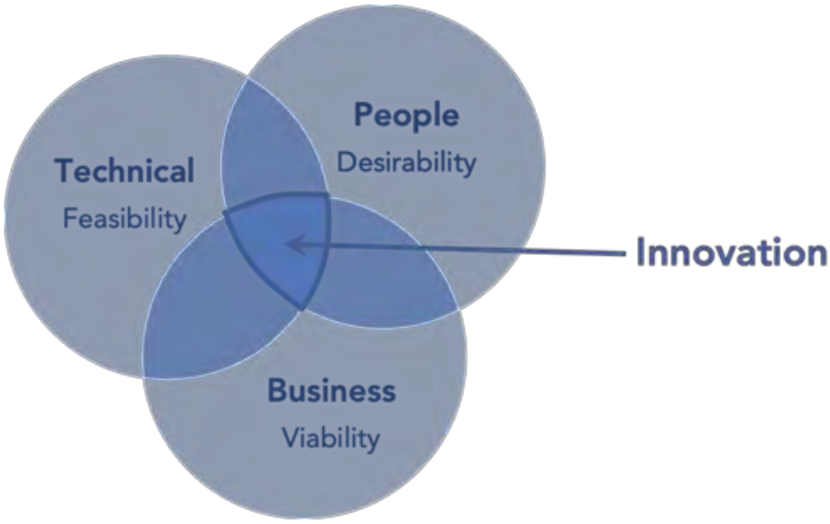


*Figure 42.* Finding the Sweet Spot of Innovation
After (D. Kelley & T. Kelley, 2015, p.15)

The demands of these factors are often regarded as heavily constricting, but: "The willing and even enthusiastic acceptance of competing constraints is the foundation of design thinking. […] A competent designer will resolve each of these three constraints, but a *design thinker* will bring them into a harmonious balance" (T. Brown, 2019, p. 24).

Innovation rises often from clever combinations, connecting seemingly separate data, linking the new product with the right service, and finding solutions in other disciplines (e.g. bionics) (Satell, 2017). Design Thinking strives for combination in various phases, be it building a good interdisciplinary team (Lewrick et al., 2018b, p. 24), or looking for a good Point-of-View that sources in finding the right connections between observations or insights (Doorley et al., 2018, p. 13b). The living lab in the ideas(r)evolution model focuses on co-creation and herewith on the combination of skills, knowledge and creativity from various sources (Mateus, 2016, pp. 290, 293, 295).

Activating creativity in teams is highly relevant in organisational contexts as most innovations are developed in a group context. Gilson et al. (2016) even title it "A Key Building Block for Innovation and Entrepreneurship" (p. 177). Yet, organisational creativity and the path to innovation is highly complex, the detection of the real cause for successful or failing innovation endeavours is hard if not impossible. The reason is at least twofold: the organisation, its rules and culture affect the results as well as societal and individual circumstances; secondly, socio-emotional factors play a major role in team work that demands for free flow of thoughts and cooperation (Ewald et al., 2019, p. 42).

Another challenge is the fact that it is mandatory for innovation processes to include people with intense and deep knowledge in the area of the problem/solution-space, as they can provide information about the technical features and properties precious for advancement. However, high expertise can lead to low creativity, as the expert has well-trodden ways and manifold thoughts and concepts that are obvious and don't deliver new solutions. Unfortunately, this cannot be consciously avoided because people are not able to actively disallow a thought to come to their mind (Sassenberg et al., 2017, pp. 128–129).

#### 3.2.8. Conclusion

This chapter could only scratch the surface of creativity and all its complex, deep facets. Creativity is an intensely researched field and the theoretical frameworks are vast. The discussion of the best explicatory, most comprehensive, and useful theories are ongoing and will be for some time (Sawyer, 2019, p. 567). Still, the intention of the author was to illustrate some relevant findings in this area, as Design Thinking is deeply interconnected with creativity. Because of this optimising Design Thinking demands knowledge of actual findings in creativity research.

The document "Advancing Creativity Theory and Research: A Socio-cultural Manifesto" (Vlad Petre Glăveanu et al., 2019) gives insight into the prevailing core subjects discussed and researched by a highly esteemed (if not the top leading) group of researchers in the field of creativity. Many of their propositions are of high concern for Design Thinking, as they discuss the intrinsic interrelations of the creative individual with her/his environment, the potential creativity has to change the world, and with this, the high level of responsibility creatives need to acknowledge and embrace.

When it comes to psychological experiences, emotion, motivation, as well as perception are relevant for creativity (Amabile, 2017, p. 336) and all might be relevant for this research.

The Sub-Question I.2: 'What is creativity and what are relevant aspects Design Thinking?' is answered with this and the previous chapter as comprehensive as it is possible in such a document.

### 3.3. Emotion

As described above (see chapter 3.1.9) the success of Design Thinking is dependent on the active and enthusiastic participation of the team members throughout all phases of the process. Emotionally disconnected people are neither willing nor able to innovate (Liedtka & Kaplan, 2019, p. 7).

This chapter first explores the nature of emotion before discussing the connection of emotion to creativity and innovation. As the Limbic Map is relevant for the first concept of this thesis, its foundations and implications are examined. Emotion recognition in images and videos may be a good method to identify the emotions of a Design Thinking team in a non-invasive way. Thus, the theory and practises of emotion recognition is investigated, in particular artificial intelligence systems for automatic emotion recognition, to evaluate its adaptability to the empirical research.

#### 3.3.1. What are Emotions?

The brain constructs emotions. It does so as a response to the environment, people's experiences, and how they physically feel, creating the fundament for appropriate reaction. (Häusel, 2019a, p. 27). Emotions and feelings are a crucial factor for human survival and thriving (Damasio, 2018, p. 22). They are safeguards of human well-being (Agnoli & Corazza, 2019) and thus an indispensable evolutionary development to ensure survival (Häusel, 2019a, p. 27). In other words, they support the maintenance of homeostasis (Burkitt, 2019, p. 2). This is not only true for human beings but it is ubiquitously true for all higher animals (Adolphs & Anderson, 2018, pp. 127–128).

"Who wants to emotionalize, must know how the emotional brain is structured"[13] (Häusel, 2019a, p. 27). The researcher's task and viewpoint, and his/her scientific discipline, affect how he/she regards and investigates emotion. Three abstraction layers (see Table 11) help to deal with different effects and seek answers to numerous questions. The first level studies how humans feel and act, the second examines why they act the way they do, and the third explores how the brain creates these reactions (Adolphs & Anderson, 2018, pp. 116–117).

All three levels may be interesting for the research in this thesis and will be consulted where appropriate. Additionally, Adolphs and Andler (2018b, p. 200) add philosophy of mind and – even more so –

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[13] Translation from German: „Wer emotionalisieren will, muss wissen, wie unser emotionales Gehirn aufgebaut ist."

philosophy of science as disciplines that should be integrated in an interdisciplinary discourse about emotion. This multi-perspective approach may also enrich the insights for Design Thinking, as the change of perspective – as discussed in chapter 3.2.4 – is a prerequisite for novel insights.

*Table 11.* Levels of abstraction for investigating emotions

| Level | Discipline | Questions |
|---|---|---|
| **Ecological** | Comparative ethology | What problems is this emotion adapted for? |
| **Computational** | Psychology | What algorithms solve these problems? |
| **Neurobiological** | Neuroscience | What neural mechanisms implement these? |

After (Adolphs & Anderson, 2018, p. 117)

Emotions affect the way we perceive our environment, and they change the way we act and make decisions (Bucurean, 2018, p. 423; Eder & Brosch, 2017, p. 188). They stimulate goal-oriented behaviour and help adaption to a given environment (Brandstätter et al., 2018, p. 164). The interdependence is reciprocal: “feeling an emotion like fear depends on the ability to perceive something in the world, remember it as a threat, and act to escape it” (Niedenthal & Ric, 2017, p. 2). More so, cognition, perception, and emotion build a continuum of cognitive processes that are, regarding the construction in the brain, of the same type (Barrett, 2017b, p. 34). Acting in affect, spontaneously and seemingly without thought, or executing a preconceived act are the same in neuroscience and behavioural psychology (Barrett, 2017b, p. 223). This fits nicely with the fact that at least 70-80 percent of our decisions are made subconsciously – controlled by emotions.

The impression that one reaches a decision through logical thought is subsequently constructed and false (Seßler, 2017, p. 32). Damasio (2004, p. 145) declares that decisions are impossible without emotion. Memory is also part of the cognitive continuum and it shows that the mental functions, e.g. to reflect, to perceive, to remember, also interact with each other. Humans remember information that is immersed with emotion. Data that does not resonate emotionally is almost impossible to reconstruct. If people are able to replay the emotion they felt when a certain event or fact occurred, they can replay the memory with high accuracy (Damasio, 2018, p. 93).

The science of emotion had its ups and downs. After an intense area of research in the psychology of emotions at the end of the nineteenth century, led by Sigmund Freud, Charles Darwin and William James, the subject fell into disrepute (Damasio, 2000, p. 38).

> "Throughout most of the twentieth century, emotion was not trusted in the laboratory. Emotion was too subjective, it was said. Emotion was too elusive and vague. Emotion was at the opposite end from reason, easily the finest human ability, and reason was presumed to be entirely independent from emotion." (Damasio, 2000, p. 39)

The research area fell dormant other than some rare exceptions. Only with the turn of the millennium did emotional psychology regain its significance. In these short two decades, several lines of research developed that have considerable intersections but still follow discriminatory concepts (Benecke, 2017, p. 100). Unfortunately, these differences within the complexity of emotional research lead to a lack of common ground that impedes fruitful discourse and cooperative development (Adolphs & Andler, 2018a; De Houwer & Hughes, 2019, p. 61).

It is not easy – if not impossible – to find a universally accepted definition for emotion (Desmet, 2018, p. 393). As mentioned above, the defining factors are manifold and their influence on one another is mutual and intertwined (Niedenthal & Ric, 2017, p. 2). Aggravatingly, emotion is a common term, void of precise definition but abundant with intuitive ideas and concepts that hamper objective analysis (De Houwer & Hughes, 2019, p. 61). The pioneer and highly esteemed researcher of human emotions (Manser, 2017) Carroll Izard explored this subject exhaustively and stated: "Yet there is still no consensus on a definition of 'emotion,' and theorists and researchers use 'emotion' in ways that reflect different meanings and functions" (Izard, 2010, p. 363). Izard concluded, quite unflatteringly for his scientific community, that even having proof there is no generally accepted definition does not withhold academics from using their own – nicely fitting – definition to proceed with their work (Izard, 2010, p. 369). This has not changed, as Adolphs and Andler (2018a, p. 233) confirm in their article: "We Don't Yet Know What Emotions Are (But Need to Develop the Methods to Find Out)." They propose an approximation approach that searches for overlapping spaces to identify commonalities as well as differences, and with this, gain a working basis for further research (Adolphs & Andler, 2018a, p. 236). As a first approach, they propose abstaining from the classification of emotions and developing dimensions that describe features of emotions that provide a more flexible basis on which to structure the field (Adolphs & Andler, 2018b, pp. 194–195).

Two leading theories in the field of emotion research in (neuro-)psychology are: a) emotions as functional states, and b) the Theory of Constructed Emotion (TCE). Both agree that the intuitive approach to emotion does not conform with reality, but their approaches to emotions are profoundly different (Adolphs et al., 2019, p. R1060).

#### *3.3.1.1. Psycho-Functionalism – Framework for Emotions as Functional States*

According to the functional state theory, emotions are defined by their outcomes. The process of emotion creation or their neural sources are not of relevance (Adolphs, 2018, p. 8).

Emotions were created during evolution because they are needed to fulfil certain functions that safeguard viability. Rolls (2018) identifies 9 functions that are fulfilled by emotions:

1. Elicitation of autonomic responses and endocrine responses
2. Flexibility of behavioural responses to reinforcing stimuli
3. Emotion is motivating
4. Communication
5. Social bonding
6. Cognitive evaluation of events or memories
7. Storage of memories
8. Produce persistent and continuing motivation and direction of behaviour
9. Trigger the recall of memories (pp. 19-23 extract)

In the functional theory, emotion is regarded as a kind of black box, where an input (stimulus) leads to a multitude of different outputs. What happens inside this box remains primarily unobserved (see Figure 43). “A functional account identifies the state by its causal relations (what does it do?). It does not identify the state by how it is constituted (what is it made of?)” (Adolphs & Anderson, 2018, p. 40).

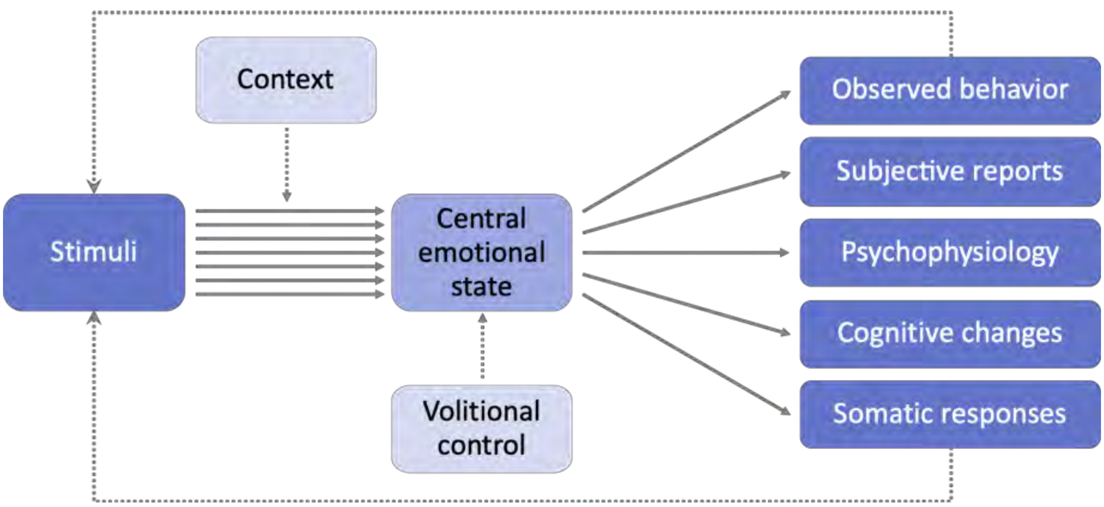



*Figure 43.* Emotions as Functional States
After (Adolphs & Anderson, 2018, p. 41)

These causal relationships are two sided: The creation side, where "emotions can be produced by the delivery, omission, or termination of rewarding or punishing stimuli" (Rolls, 2018, p. 19), and the reaction side, where emotions lead to various effects observable in facial and bodily expressions, speech, action, and sentiment (McDuff et al., 2019, pp. 1–2) and elicit autonomic and endocrine processes that optimise the physical readiness for action (Rolls, 2018, p. 21).

Emotions must be identified and evaluated through their multimodality. The various outcomes developed evolutionarily to react in the best way for survival. For instance, the wide-eyed expression often seen when experiencing fear helps to optimize vision, while wrinkling the nose and mouth in disgust reduces the amount of odour taken in (Cordaro et al., 2018, pp. 471, 475). Yet, the same action might be elicited through different emotions. Even if the recognition of a distinct emotion seems mostly easy and intuitive for lay people, research shows the variability and deceptive qualities of these signals (Keltner, 2019, pp. 15–16).

Emotions as functional states are seen through their correlation with the trigger that activates them, the line of actions they induce and the other mental states that interact with the given emotion (Adolphs & Andler, 2018b, p. 195). *Figure 43* displays the basic schematics of the functional state framework developed by Adolphs and Anderson (2018, p. 41). The model visualizes the feedback loops and diversity of both inputs and outputs that can be assigned to one emotion. That is, the exact same emotion can have a multitude of stimuli that triggers it, and can activate a plurality of reactions, respectively modulated through a variety of factors. The scientists especially justify the need to master this complexity with the implementation of their strict model (Adolphs & Andler, 2018b, pp. 195–196).

With the current state of scientific knowledge about the brain and emotional states, Adolphs and Anderson (2018, pp. 42–43) propose this model as a starting point for investigation in neuroscience and psychology. In its austerity, it provides openness to research in various disciplines and gives space for variability in both research methods and insights (Adolphs & Andler, 2018a, pp. 235–236).
The core point of investigation of Emotion as Functional States is its induced behaviour. Adolphs (2018, p. 7) describes three ways behaviour can be activated: (1) reflexes, the reaction to a stimulus without volitional process, (2) emotion, and (3) intentional, planned behaviour fairly decoupled from given stimuli. With emotions, the action varies from instinctive to premeditated, and responses on several stages of the bandwidth can often be observed (Sander et al., 2018a, p. 222).

Interestingly, Adolphs and Andler (2018b, p. 195) concede, that their concept might not explain all characteristics of emotions, what harmonises with the fact that they see the research in mental states at the very beginning of a long and difficult endeavour.

#### *3.3.1.2. Theory of Constructed Emotion*

With the Theory of Constructed Emotion (TCE) and its predecessor the Conceptual Act Theory, Lisa Feldman Barret (2017a, pp. 9, 16) claims that emotions are based on concepts developed in previous experiences and are holistic processes, including both brain and body. She declares:

> In every waking moment, your brain uses past experience, organized as concepts, to guide your actions and give your sensations meaning. When the concepts involved are emotion concepts, your brain constructs instances of emotion. (Barrett, 2017b, p. 31)

In other words: Emotions are interpretations of the stimuli that affect us (Barrett, 2017b, p. 30).

In the view of psychological construction emotion, cognition and perception are created in the same way and are aspects of the same continuum. They are all a construct built from sensory inputs (from external and internal senses) and our experiences (Barrett, 2017b, p. 34). So, the classically assumed conflict between rationality and sentiment does not exist (Wilkinson et al., 2019, p. 101). For instance, the neural systems that generate logical inference also generate emotions (Pober, 2018, p. 642). The alleged separation of emotion and cognition in the brain structure first led to their distinction, later this split was used strategically to structure research and argumentation (Agnoli & Corazza, 2019, pp. 49–50). Mental events are complex interplays and sequences in various areas of the brain, even if people perceive some processes as instantaneous and others as deliberate (Barrett, 2017b, p. 223). Emotion and cognition are in fact indistinguishable. Emotions control the organism through evaluation and activating the reaction of body and mind. The same can be defined for cognition. Both are creations of the same constructive processes and thus similar mental states (Agnoli & Corazza, 2019, p. 50).

There is also a functional element in the Theory of Constructed Emotions, along with physical and affective effects and changes in perception and appreciation of surroundings. It is crucial to note that the pursued function is situation-dependent and highly variable (Hoemann et al., 2019, p. 1831,1832). Barrett (2017b, pp. 138–139) lists five basic functions of emotions, three internal: (1) explaining what happened, (2) manifesting what is, (3) preparing for what might happen; and two external: (4) communicating what is felt and finally (5) influencing other people.

As described above, emotions (and their functions) are crucial for our survival. To do this efficiently, they cannot only act on what has already happened, it is mandatory that they predict what will happen next, to be able to prepare the body and mind to react as quickly as possible. As evolutionary beings are mainly interested in their personal wellbeing, emotions are created based on a model that predicts what would create the best bodily (i.e. interoceptive) signals (Wilkinson et al., 2019, p. 102). These predictions are built by comparing given sensory inputs with previous experience, and the knowledge about the imminent environment. This means that stored concepts of the world are compared with real time inputs to infer predictions about the imminent future (Spratling, 2017, pp. 92–93). The body fulfils a complex surveillance job, making sure that his actual state is good, and anticipating next steps to react swiftly (Damasio, 2018, p. 58).

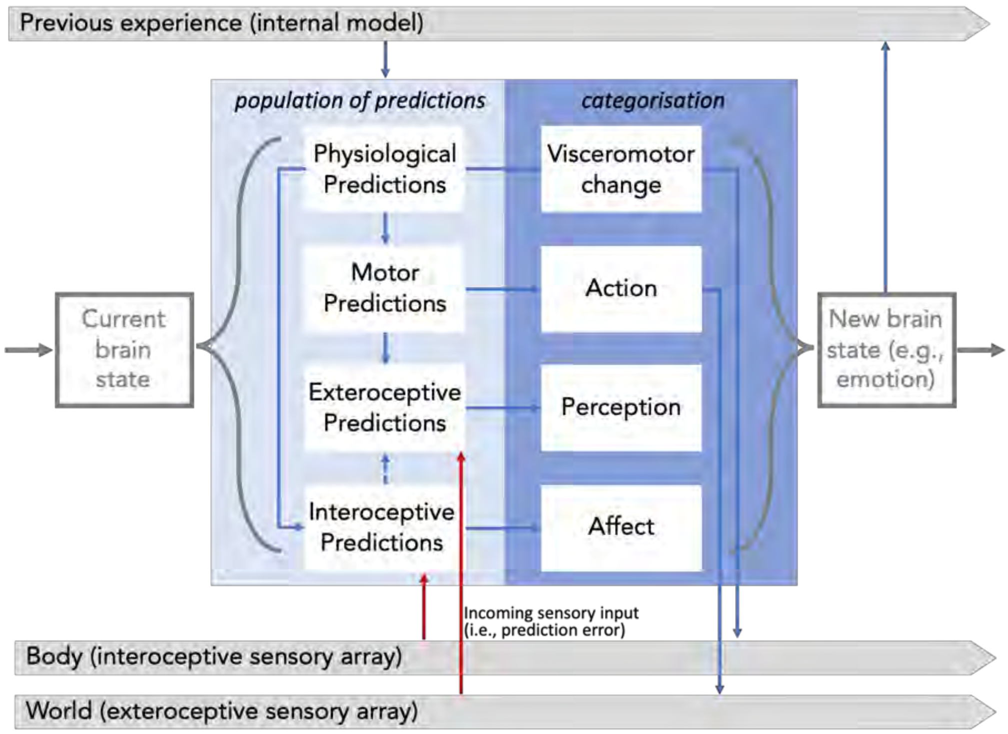



*Figure 44.* The Dynamics of a Mental Event – After (Hoemann & Barrett, 2019, p. 70)

As shown in *Figure 44*, the brain receives information from external and internal senses. Based on this data, it detects patterns that belong to specific categories, predicts the likely future, and "will subsequently prioritise perceptions, actions, emotions, and cognition that have previously been reinforced in similar situations" (Hoemann & Barrett, 2019, p. 68).

According to Theory of Constructed Emotion, the brain constructs each emotion. This is not only true for emotions, but every mental event, like remembering, reflecting, and perceiving is a constructive process relying on given concepts. The act of construction is rapid and automatic, happening subliminally and effortlessly (Barrett, 2017b, p. 86). The concepts or models humans use are not only built on personal experience; they are also shaped by our social environment and our culture or community (Niedenthal & Ric, 2017, p. 281; Smith, 2017, pp. 20–21). In particular, words play a crucial role as they facilitate the creation of concepts. This is especially true when it comes to forming abstract categories or understanding mental states (Hoemann et al., 2019, p. 1835). The effect becomes apparent in emotional states that have only words and meaning in one language, for example "saudade" or "dolce far niente" (Smith, 2017, pp. 72, 245). The terms and their emotions are untranslatable and are only to some degree comprehensible in other languages. This does not mean that words are irreplaceable for emotions. They help to express complex concepts but are only one of many possibilities for anchoring mental concepts (Hoemann et al., 2019, p. 1836). Emotions can be differentiated without needing separate words. Fear, for instance, stands for a variety of different concepts from fearing little discomforts to fearing to lose one's life (Siegel et al., 2018, p. 384).

To sum it up: "Emotions are constructions of the world, not reactions to it" (Barrett, 2017a, p. 16).

### 3.3.2. Emotionally Affected Creativity

Emotion and creativity are intensely linked, and the effect may be stimulating or inhibiting. Damasio (2018, p. 101) identifies emotions as indispensable for cognitive and creative practise. "The interaction of emotions with creative cognition is one of the most intriguing topics in the creativity research" (Mastria et al., 2019, p. 1). Agnoli and Corazza (2019, p. 48) mark emotion as the "spinal cord of the creative thinking process." They place the importance of emotion above cognition, claiming that knowledge and intelligence do not suffice for successful creativity. Creativity to them must be regarded as emotion-driven.

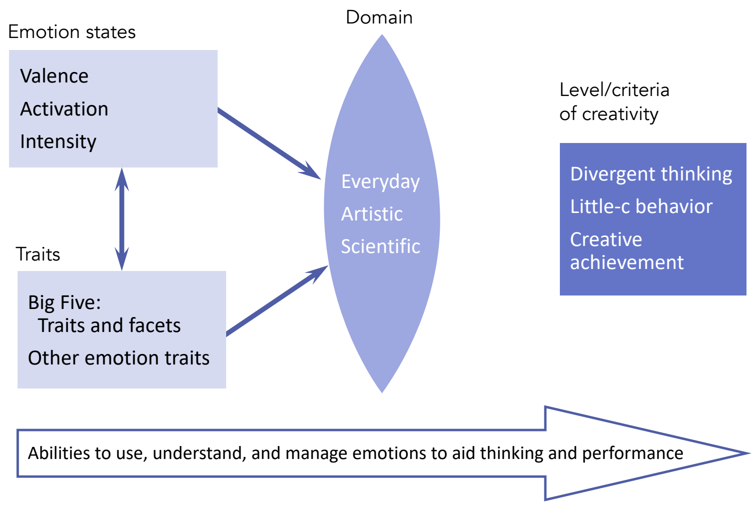



*Figure 45.* The Relationship Between Emotions and Creativity
After (Ivcevic & Hoffmann, 2017, p. 202)

Ivcevic and Hoffman (2017, pp. 202–203) propose a model (see *Figure 45*) that envisions the relationship between emotion and emotional traits with levels and domains of creativity. They also stress the ability to recognize and handle emotion as a relevant factor for successful creation.

Emotion influences the individual person, the team, the creative process, and the developed solution. The effects are often not easily allocated to one of those four elements because the mutual interference is considerable (Amabile & Pratt, 2017; Ivcevic & Hoffmann, 2019; McKee, 2018). In the light of the Design Thinking process, the first three elements of this list seem promising, as it might deliver insights for the design of the task, the team composition, and the orchestration of the project.

#### *3.3.2.1. Emotion and the Creative Person*

The acting/thinking person plays a central role within the complexity of creativity. Three factors define personal creative aptitudes: "intellectual abilities, personality traits, and emotional styles" (Mastria et al., 2018, p. 4).

Kaspi-Baruch (2019), as well as Ivcevic and Hoffmann (2019) start with the Big Five personality traits as a basis for investigating the association between personal creativity and emotion. The Big Five are the basic dimensions that define personality, namely openness, conscientiousness, extraversion, agreeableness, and neuroticism, often called the OCEAN Framework (Diener & Lucas, 2019, pp. 281–282; McCrae & John, 1992). As seen in *Table 12*, all five traits are considerable emotional dispositions. All show some correlation to creativity (Ivcevic & Hoffmann, 2017, p. 190).

*Table 12.* Description of the Big Five traits

| **Big 5 Trait** | Definition |
|---|---|
| **Openness** | The tendency to appreciate new art, ideas, values, feelings, and behaviors. |
| **Conscientiousness** | The tendency to be careful, on-time for appointments, to follow rules, and to be hardworking. |
| **Extraversion** | The tendency to be talkative, sociable, and to enjoy others; the tendency to have a dominant style. |
| **Agreeableness** | The tendency to agree with and go along with others rather than to assert one's own opinions and choices. |
| **Neuroticism** | The tendency to frequently experience negative emotions such as anger, worry and sadness, as well as being interpersonally sensitive. |

After (Diener & Lucas, 2019, p. 282)

Openness (to experience) and extraversion have proven positively connected to creativity, not only in artistically oriented people, but also in scientists and engineers (Corazza & Agnoli, 2018, p. 161; Mastria et al., 2018, p. 15). If merely the two abilities fluency and originality – factors for divergent thinking – are evaluated, only openness shows constant significance. (Runco & Acar, 2019, p. 229). Openness is also a good predictor for a high lifelong potential for creativity (Ivcevic & Hoffmann, 2017, p. 191). Confidence and excitement-seeking, both sub-factors of extraversion, are also positively related to creativity, while other sub-factors are less reliable (Feist, 2019, p. 32).

Feist (2019) condenses the big five into only two dimensions, called the Huge Two, that are a sound basis for the evaluation of creativity. The first dimension is plasticity, which consists of openness and extraversion, and as discussed above, these factors are positively correlated to creativity (Bridges & Schendan, 2019, p. 187). This also holds true for creative self-belief (Karwowski & Lebuda, 2016, p. 226). The second dimension of the Huge Two is stability, which envelopes neuroticism, agreeableness, and conscientiousness. Stability is rather negatively correlated to creativity (Karwowski & Lebuda, 2016, p. 229). In sum, people with considerable traits in plasticity and low to negative values in stability (i.e. neuroticism) tend to be more creative (Bridges & Schendan, 2019, p. 187; Feist, 2019, p. 33).

There are further emotional factors that are relevant for the creative potential of individuals. Highly motivated people who work passionately towards objectives they love will be stimulated to creative work (Amabile & Pratt, 2017, p. 172). Passion and intense focus are the relevant elements to get into Mihaly Csikszentmihalyi's flow state (2014). The state itself is highly emotional: "The person enters a tunnel, an almost euphoric state of bliss, in which the task at hand is performed, without strain or effort, to the best of the person's ability" (Dietrich, 2019, p. 4). Amabile (2018, p. 2) describes how curiosity leads to success, as it is an important element of the intrinsic motivation that drives people to high performance. If this intrinsic motivation leads to passion and a high identification with the given task, the creative potential gets an additional boost. Closely related, people in hypomania while working on a task showed higher activity, fluency, and originality as well as enhanced creative self-perception (Ivcevic & Hoffmann, 2017, p. 195).

A factor to consider for leaders of design teams, is that creativity is also correlated to low emotional stability, indicating that "creative people in general are less emotionally stable and more prone to anxiety and stress, less conscientious, and more hostile (less agreeable) than less creative people" (Feist, 2019, p. 32). Unfortunately, research has shown that creativity has some parallels to mental disorders, leading to often difficult team members that are hard to integrate as they tend to be non-conformists, disorganised up to being psychotic. On the positive side, they charm other people through wide-spread curiosities, charisma and confidence (Mastria et al., 2018, p. 15).

Emotions can also trigger associations. In his emotional-resonance model, Todd Lubart (2018, p. 137) postulates "that emotional traces in memory can serve as cues to connect concepts that are cognitively distant but emotionally similar." These emotional traces are called endocepts. Two concepts may resonate if their endocepts have high similarity, and thus the emotional pattern of one situation or person leads to the reminiscence of a cognitively unrelated memory. This effect is present in emotionally sensitive people (Botella & Lubart, 2019, pp. 268–269). Sensitivity also gives better access to the whole mental spectrum – cognition and perception, as well as emotion and memory – thus providing manifold access to creative inspiration (Bridges & Schendan, 2019, p. 191).

Emotion is a relevant element for creative people. With cognitive abilities and conation they build the personal fundament for high level creative accomplishments (Mastria et al., 2018, p. 5).

#### *3.3.2.2. Emotion in the Creative Team*

As motivation is a positive emotional drive towards a goal or situation (Benecke, 2017, p. 16) everything discussed in chapter 3.2.6 is also part of the discussion of emotion and creativity. This especially holds true for the start of the project. It is essential to meet the interests of the team member with fitting stimuli to activate their desire to solve the given problem creatively. The caveat here is the fact that individual team members will be differently aroused because no task can meet every person with the same effect (Agnoli & Corazza, 2019, p. 56). To work on an issue whose relevance is clear and personally important stimulates creativity. *Figure 41* (page 118) visualises the relevance of affect on creativity-relevant processes. Particularly, feeling valued and working towards meaningful ends spurs a team to high performance (Amabile & Pratt, 2017, pp. 169–170).

Typically, positive emotions are researched and correlated to creative thinking (Mastria et al., 2018, p. 16). Yet, not only positive but also negative emotions can enhance creativity. "If I wanted to have a creative idea, I had to be open to it and willing to fight for it. And fight I did – creative ideas don't generally meet with a reaction of quick acceptance and gratitude" (Sternberg, 2018, p. 318). While positive emotions provide for more adaptable, free thought, negative emotions activate stolidness and keep the person more resilient (Agnoli et al., 2018, p. 50). Still, Teresa Amabile (2017, p. 336) found that "creativity is higher when emotions and perceptions are more positive, and when intrinsic motivation is stronger." Seemingly contradicting theories that propose that positive emotions lead to relaxation and easy going, while negative emotions can spur persistence and ideation with their signals of problematic situations. Research has shown that both are true, because even as negative emotions lead to more diligence and activity, positive emotions give freedom to think more flexibly (Ivcevic & Hoffmann, 2019, p. 281; Mastria et al., 2018, p. 16).

A fruitful creative team needs an environment that provides security, both physically and mentally, and that guards and aids innovative movements. This holds especially true for arising conflicts founded in interpersonal animosities that can annihilate the team if not handled properly (Ewald et al., 2019, p. 43). Basically, a team has to deal with two types of conflicts: intrapersonal and task-oriented conflicts. As discussed above, the former is typically damaging for the process, the latter might be fruitful if it is handled with a cooperative, not a competitive, approach (Maltarich et al., 2018, p. 12). Discussions lead to verbalisation of ideas that can be refined and enhanced. If the conflict stays task oriented, the discussion reveals different perspectives and stimulates new approaches (Khan et al., 2020, pp. 51–52). As long as the team feels emotionally attached and strives towards a mutual goal, moderate conflict can be useful (Maltarich et al., 2018, p. 24). But it is important to keep a reflective, objective approach to the conflict to prevent destructive discord (Khan et al., 2020, p. 55).

Creativity needs an environment where it feels safe to be wild, where coming up with ridiculous or adventurous ideas is backed and valued (Ewald et al., 2019, p. 43). An environment where proposing risqué and demanding solutions is welcome (Gregersen, 2018, p. 70), and where defiance of presuppositions and beliefs leads to reconsideration, and not rejection, of given concepts (Sternberg, 2018, pp. 320–322). So, the failure issue discussed in the motivation chapter (3.2.6) is a significant part of feeling secure. Team leaders and facilitators must safeguard an atmosphere where missteps and outright failures are handled with welcome and care (Mosely et al., 2018, p. 184).

But not only conflicts are to consider in teamwork, because all emotions are contagious. “Strong emotions set the tone for the entire group” (McKee, 2018, p. 46). The emotional influence of only one team member can heavily affect the outcome of a working process (Ewald et al., 2019, pp. 45–46). Mostly positive emotion leads to a better feeling of belonging and teamwork, and to more and better creative outcomes, while negative emotions typically disturb the team spirit and impede ideation (McKee, 2018, p. 47).

#### ***3.3.2.3. Emotion During the Creative Process***

The work process must be designed to provide fitting emotions for the posed task to optimize the desired outcome (Mastria et al., 2018, p. 6). Agnoli and Corrazza (2019, pp. 54–55) claim that emotions not only suffuse each step of the creative process and power the mental states within these states, they also see emotions as drivers for the transition from one mental state to the next.
Design processes are often characterised by elusive problems and open goals. This inevitably leads to tense processes that affect people considerably – some thrive in this demanding atmosphere, some fade. Additionally, if the process itself is badly designed, conflicts may arise that weaken the potential of the team (Ewald et al., 2019, p. 43).

During the creative process, it is important to keep the curiosity of the team at a high level. If people are curious they are motivated to hunt down information that fills the knowledge-gap (Lydon-Staley et al., 2019, p. 14). Gregersen (2018, pp. 69–70) proposes a question-seeking brainstorming task in the *Define* phase as particularly suitable to further the team's curiosity.

Creative inquiry is not only a positive experience. On the contrary: searching for insights leads through disruptive experiences that leave us in discomfort. "The process of creative inquiry has the goal of moving us from an unsettled to a settled state" (Beghetto, 2019, p. 165). This discomfort must not lead to a negative mood, because mood and curiosity are interlinked, and happy people are considerably more curious and therefore better inquirer (Lydon-Staley et al., 2019, p. 13).

The management of a creative process must make sure that the team feels challenged but secure, valued and rewarded, relevant and heard. All these points foster creative work but can annihilate creativity when treated wrongly (Amabile, 2018, p. 13).

Emotion is not only relevant in ideation but also while evaluating ideas. Positive mood shows a tendency to overvalue ideas, while people in a bad mood tend to dismiss ideas of moderate quality more easily (Mastria et al., 2019, p. 10). The ability to time-travel emotionally is also relevant for prototyping and testing: people can mentally shift emotions into the past or future and thus imagine how they would feel about a possible invention. They can also share their imagined experiences, because they are able to express how they would feel about it with their team (Harris et al., 2018, pp. 293, 304).

### 3.3.3. Limbic Map

To get a basic structure that helps organise emotions for the Design Thinking phases, the author decided to use the Limbic Map model mainly developed by Hans-Georg Häusel (2019c). The model is named after the limbic system, the sum of all brain structures shown in *Figure 46* that are responsible for the processing of emotions (Komninos, 2017; Rajagopalan et al., 2017, p. 12). "Because the limbic system controls the basic emotions and urges which drive our behaviour, it is fundamental to survival" (Moseley, 2018, p. 961).

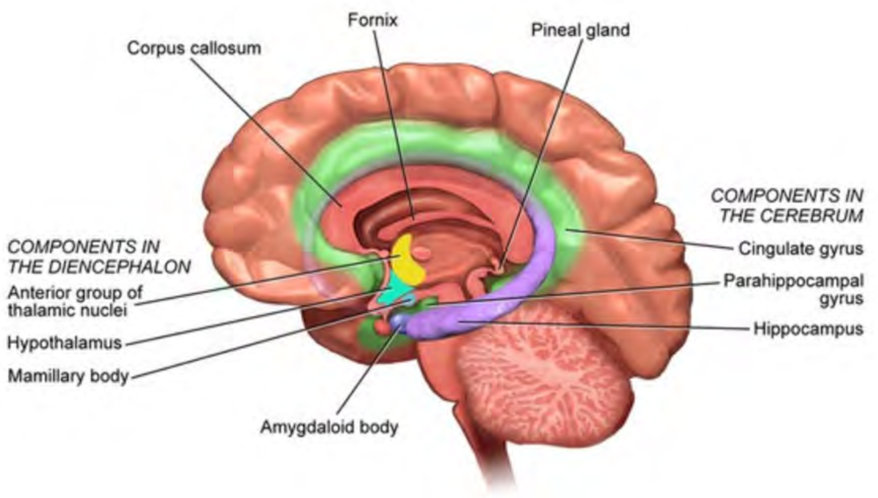



*Figure 46.* The Basic Structure of the Limbic System. – Source: (Komninos, 2017)

The limbic system creates and controls not only emotion, but also memory, attention, arousal and other highly relevant cognitions and essential needs. It is extremely powerful and capable of overwhelming rationality and does so on a regular basis (Joseph, 2017, pp. 8, 10; Moseley, 2018, p. 961). The limbic regions are also part of the neuronal network – *integrated allostatic–interoceptive brain system* – that control interoception (Kleckner et al., 2017, p. 5), relevant for emotional processing as discussed in chapter 3.3.1.2. Some researchers advise shunning the term limbic system for the creative functions of the brain, as the structures belonging to it are not reliably defined and neuropsychology indicates a much more complex anatomic localization (Pessoa, 2017, p. 635). For the concept of the Limbic Map discussed here, the precise anatomy is not the centre of interest and need not to be defined in detail. As with the Theory of Constructed Emotion, the Limbic Map Construct sets a link between psychology and neuroscience (Häusel, 2011, p. 6; Kragel & Wager, 2019, p. 238). The research field of cognitive neuroscience of emotion is especially relevant here, as the conscious or unconscious emotions and motivations play a central role (Panksepp et al., 2017).

The Limbic Map attempts to provide an integrative model of human personality. It envelopes human emotions, motivations, and values (Häusel, 2019b, p. 53). Approximately at the same time as the limbic systems, similar concepts were developed by Norbert Bischof and Jaak Panksepp and others (Strelow & Scheier, 2018). They share some similarities – as discussed below – but Häusel claims that his approach to integrate different fields of science, namely neuroscience and personality psychology, is unique and not based on Bischof's theories (B. B. Briesemeister, 2016, p. 21; Häusel, 2011, p. 47). The discussed theories are located in personality psychology and cognitive or affective neuroscience, and focus on the quest for the fundamental motives of human beings. Several come to the conclusion that there are three motives with considerable similarities that form the basic drives of human behaviour (Strelow, 2020, p. 64).

The Zurich Model of Social Motivation, for instance, proposes and explains the following motivational systems (Benecke, 2017, pp. 29–30; Scheier & Held, 2018, pp. 98–99):

- *Security*: Safety not only for themselves but also caring for others, feeling connected, and belonging
- *Excitement*: governs the contact to new stimulations, directs to discovery, attraction to new people to avoid incest, curiosity and playing (to learn vital skills)
- *Autonomy*: Distancing from the family (adolescence), striving for independence, establishing dominance, gaining/obtaining status, preventing heteronomy

The Limbic Map uses the terms Balance, Stimulant and Dominance, but with similar pursuits and equal terms in brain research as the Zurich Model of Social Motivation (see *Table 13*) (Scheier & Held, 2018, p. 100).

*Table 13*. The Three Fundamental Motives – Comparison of the Models

| **Motive** | **Security** | **Stimulation** | **Autonomy** |
|---|---|---|---|
| **Pursuit of** | Familiarity<br>Connection<br>Comfort | Newness<br>Stimulation<br>Change | Power<br>Prestige<br>Performance |
| **Additional aspects** | Care | Play instinct | Self-esteem |
| **Examples** | Family | Adventure holiday | Executive position |
| **Typical Car-brands** | Volvo "Safety from Swedish steel" | BMW "The joy of driving" | Audi "progress through technology" |
| **Terms in brain research** | Fear system<br>Panic system | Seeking system | Rage system |
| **Limbic Map terms** | **Balance** | **Stimulant** | **Dominance** |

After (Scheier & Held, 2018, p. 100) translation by author

The three main concepts are not independent but instead highly interconnected. So, hybrid forms arise to be able to assign human behaviour in a better way. Strelow (2020, p. 66) identifies adventure existing between excitement and autonomy, enjoyment between excitement and security, and discipline between autonomy and security.

Fink and Yolles (2018, p. 100) suggest a model of fundamental personality traits that extends the above described model to dichotomous properties:

(1) Emotional Attitude (stimulation vs containment);
(2) Figurative Affect Activation (ambition vs protection), and
(3) Operative Emotion Management (dominance vs submission).

Häusel's primary goal was a model for marketing purposes, to define target groups and to position brands and plan communication strategies (B. B. Briesemeister, 2016, p. 19; Seßler, 2017), but he also strove for a holistically implementable theory that can be used, e.g. for social and systemic phenomenon (Häusel, 2011, p. 48, 2019b, p. 49). One example is human resource management, where the model is used to better understand (potential) employees and to optimise communication while hiring and employing people (Stock-Homburg & Groß, 2019, p. 188).

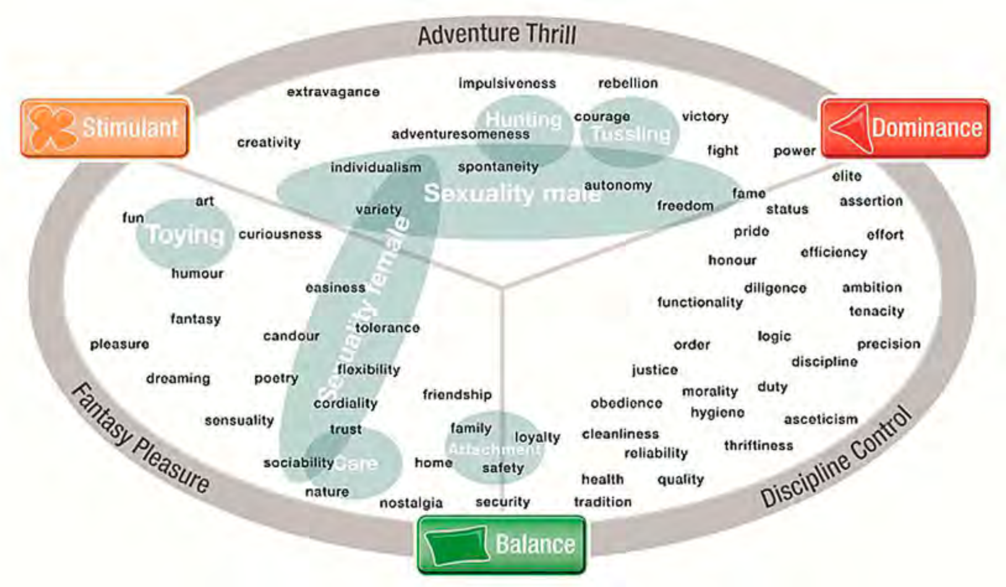



*Figure 47.* The Limbic Map® – The Structure of the Emotional Systems and Values
Source (Häusel, 2011, p. 48)

The Limbic Map (see *Figure 47*) is a functional holistic structure that maps emotions, values and motives in an arrangement that locates them between the three above mentioned fundamental motives and, akin to Strelow, the three hybrid concepts Fantasy/Pleasure, Adventure/Thrill, and Discipline/Control (Häusel, 2019a, p. 30). The mapping within the six basic elements was developed in an extensive research project where participants were asked to position the terms representing emotions or emotional values within the space spanned between the basic terms (Häusel, 2011, p. 48, 2019d, p. 103).

The system uses and combines insights from diverse scientific areas: molecular biology and genetics, neurochemistry, neuroanatomy, psychiatry, emotion and motivation psychology, personality psychology, sociology, and philosophy (Esch & Manger, 2019, p. 250; Häusel, 2019b, p. 51). This model is not only valid in Germany, or a European or Western culture, but globally so. Seelmann-Holzmann (2019, pp. 174–176) shows that the emotional system is applicable in Asia, even though the cultural expression is vastly different and has to be handled differently than in western countries. For instance, striving for perfection (assigned to Balance) is much more prominent in Asian culture, but wild karaoke parties (Stimulant) after long business days are more foreign for western people.

The limbic system forms the personality, and as the Limbic Map not only helps structure emotions but also long-term motives and values, it gives a basis for better understanding personalities (Häusel, 2019d, p. 109). This knowledge is used to assign target groups and create personas. The five personality traits discussed in chapter 3.3.2.1 can be localized within the emotion space as illustrated in *Figure 48* (Häusel, 2019d, p. 215).

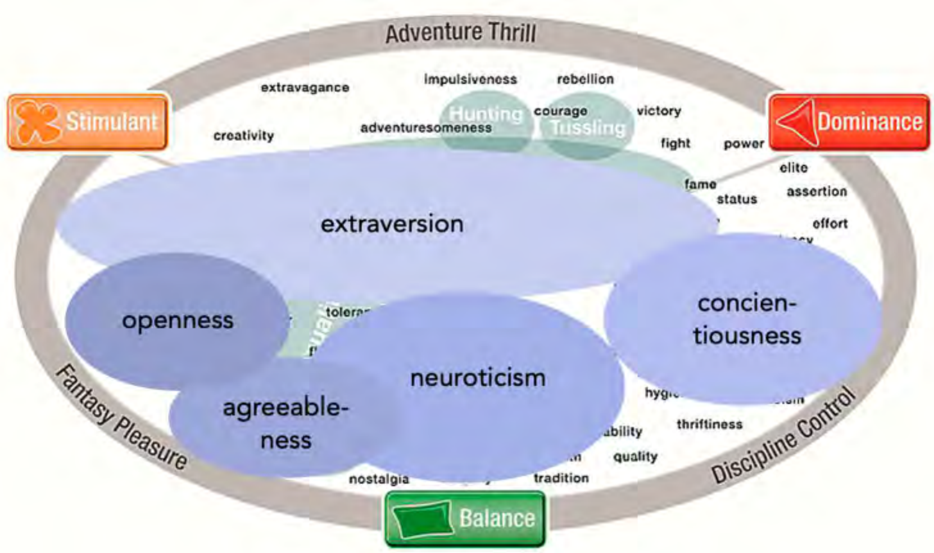



*Figure 48.* The Five Basic Personality Traits Located Within the Limbic Map – After (Häusel, 2011, p. 56) layout by author

Seven personality profiles – named Limbic Types – are identified within the Limbic Map with a neuropsychological target group segmentation. These Limbic Types that can be used as basis for persona development (Stock-Homburg & Groß, 2019, pp. 189–190).

Esch and Manger (2019, pp. 251–252 translation by author) describe them as follows:

- *Disciplined*: High sense of duty, low consumerism, love of detail
- *Traditionalist*: Low future orientation, desire for order and security
- *Harmoniser*: High social and family orientation; less promotion and status orientation, desire for security
- *Receptives*: Openness for new things, feeling good, tolerance, gentle enjoyment
- *Hedonist*: Active search for new things, high individualism, high spontaneity
- *Adventurer*: High risk taking, low impulse control
- *Performer*: High performance orientation, ambition, high status orientation

The utilisation possibilities of the system are comprehensive. The lighting company Zumtobel, for instance, uses these insights to optimise the lighting in retail shops to accommodate the target group of the presented products (N. Schweitzer, 2017). In a field study conducted with the fashion company Gerry Weber, various types of ambient light were tested with people assigned to the different Limbic Types. The result revealed apparent differences between the preferences of the different types, resulting in three distinctive lighting designs (Bernd et al., 2015, pp. 94–95). Implementing the lighting according to the target group of Gerry Weber resulted in an increase of turnover by ten percent (N. Schweitzer, 2017, p. 41). A further study also examined how lighting according to the Limbic system can support a positive emotional state and cognitive performance of office workers according to the given situation (Pichardo, 2017, p. 11). Labay (2019) proposes the use of the Limbic system as a tool in empathic design to better predict the emotion of the target group the design is being made for.

The Limbic System is trademarked and commercially only usable under licence by Gruppe Nymphenburg Consult AG (Ott, 2020). This incapacitates scientific research and hinders further development outside of the consulting firm. Nevertheless, the model is used and researched, especially in neuromarketing fields, and is highly attractive as the best-known neuromarketing approach in Germany (B. B. Briesemeister, 2016, p. 19).

For the research documented in this thesis, the Limbic approach seems promising to assess and compose the team, but more so to assess the emotion in a specific Design Thinking step and to plan how to encourage it in the project.

### 3.3.4. Identifying Emotion

Research uses emotion as a triggering and triggered factor. To evaluate, for instance, how emotions affect mental or social processes, the desired emotion must be induced and probably modified in a standardized repeatable way. If the emotion itself is a subject of the research, a reliable method for emotion measurement is needed (Brandstätter et al., 2018, pp. 183–184). In this thesis research project, both elements are relevant, as (1) it must be evaluated which emotions are prevalent in the Design Thinking process, (2) the consequences of this must be evaluated.

Emotion identification as "the process of attributing an emotion to an individual […] can be based on observable perceptual cues, but also includes identification of an individual's state based on contextual information or inferential reasoning" (Coll et al., 2017, p. 133). According to Schirmer and Adolphs (2017, p. 217), the process of identification needs three steps: (1) the emotion must be observed, (2) it must be renowned as an emotion, and finally (3) it must be classified. The classification is typically done by attributing a word from the language in the research environment to that emotion (Smith, 2017, p. 19). The attribution of a word also implies the connection to a culture. This might seem less relevant, as emotions are evolutionary developments and thus universal, but research revealed that cultures still mould expressions and their meaning for the intended receiver (Ekman, 2017, p. 54).

A possibility to get to better results while identifying emotions is to measure them in a multifaceted process, but this is extremely difficult if not impossible – especially in a real-life team environment (Ewald et al., 2019, p. 47). Measurements that can be used in laboratory examinations, like skin conductance response or magnetoencephalography, are not suitable for natural environments (Häusel, 2019c, p. 209). Instruments like self-reporting or emotion checklists are quite popular as they are relatively simple to implement (Pekrun et al., 2017, pp. 1268–1269). Yet, self-reporting captures only feelings, i.e. emotions the tested person is aware of, and not unconscious emotions (Damasio, 2018, p. 100). To measure emotion in a Design Thinking project, an unobtrusive and long-range method is needed. A possible variant is text analysis where every spoken word must be recorded, transcribed, prepared for the analysis system and analysed. This method is highly time-consuming, needing approximately nine times the amount of time for coding to the time that is supervised, and the results are not guaranteed to be unflawed (Ewald et al., 2019, p. 47). It also exceeds the capabilities of this research, as the author has no research team and the method needs several persons to supervise and protocol the recordings.

There are some points that are beyond dispute in emotional science. Stürmer and Schmidt (2019, p. 100) describe the so called emotional triad as the three manifestations of human emotions:

1. the subjective experience (the sensation),
2. the bodily and physiological changes, and
3. the impact of the behaviour, including gestures and facial expressions.

To give emotions credit, one has to regard all three factors. Nevertheless, the various theories in emotion recognition often focus just on one or two of these factors (Niedenthal & Ric, 2017, p. 4) and most methods that measure emotions work only with one (Desmet, 2018, p. 393).

This shows how difficult it is to measure emotion validly. Skin conductance response, for instance, measures only the activation. Without context, the result is not interpretable (Stürmer & Schmidt, 2019, pp. 100–101). Nevertheless, emotions are not structureless and can be identified and evaluated. This holds especially true for the so-called “basic emotions such as anger, surprise, happiness, sadness, disgust” (Agnoli & Corazza, 2019, p. 52). They are seen as proven in emotion research today and have clear, appraisable structures. However, even slightly more complex emotional classifications like pride, guilt, and envy are still highly disputed (Ekman, 2016, p. 32). Even the idea of basic emotion is not shared by all scientists. Notably, the fact that those basic emotions are categorized with English terms renders the concept debateable (Adolphs & Anderson, 2018, pp. 6–7; Barrett, 2017b, pp. 103–104).

Still, facial expressions are promising for identifying basic and even more complex emotions. McDuff presents research where emotions like informed, inspired or persuaded were detected in facial expressions analysed in video sequences (McDuff, 2016, p. 74). There are sometimes different expressions for the same type of emotion, but still Ekman (2017, p. 52) affirms the evidence of distinct expressions for certain types of emotions.

### 3.3.5. Automatic Emotion Recognition

A researcher needs specialized training to reliably identify emotions (Ekman, 2007, p. 240). Those specialists are not available in the given research project. Thanks to artificial intelligence, emotions can also be recognised via automatic image analysis (Zhang, 2018). To be precise, what is recognised are emotional expressions, that is “any bodily change that provides information that the agent of such change is undergoing an emotion” (Scarantino, 2019, p. 50).

The system that will be used in this thesis research is based on the facial action coding system (FACS) that is the prevalent system to identify emotional expressions in human faces (Mishra et al., 2018, p. 2).

The fundamentals of FACS were first researched and developed by Carl-Herman Hjortsjo (Calistra, 2015; Hjortsjö, 1970).

Twenty-three muscles and muscle clusters create emotional expressions in the human. Hjortsjö (1970, p. 70) identified and illustrated 24 types of emotions from "Precise, resolute, firm, servere" to "Bitter, woeful, disappointed" (for examples see *Figure 49*). Each group uses very distinct muscles and movements. These expressions are universal and not dependent on culture, gender, or facial form (Hjortsjö, 1970). This insight was already discovered by Charles Darwin: "We can thus also understand the fact that the young and the old of widely different races, […] express the same state of mind by the same movements" (Darwin & Darwin, 2011, p. 372).

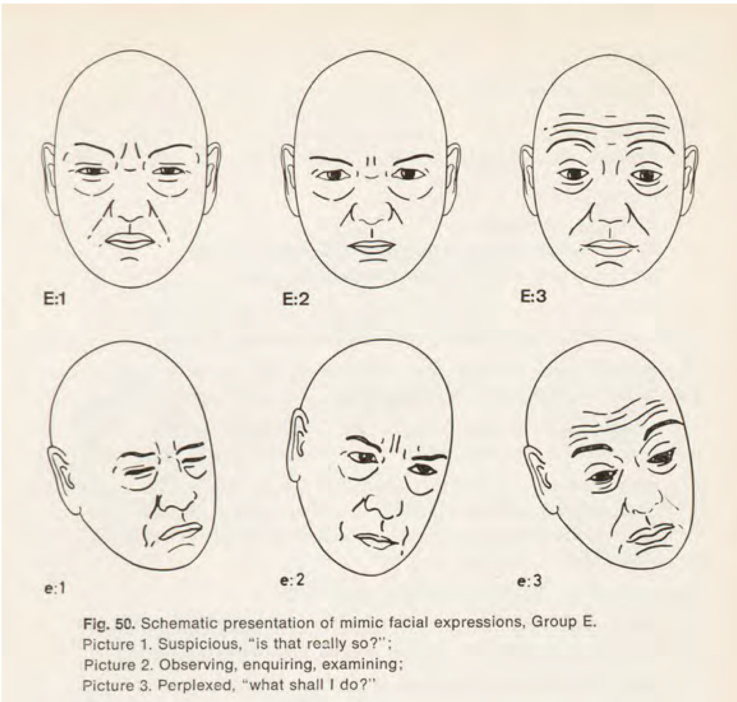



*Figure 49.* Example for the Schematic Presentations – Source Hjortsjö (1970, p. 87)

Ekman and Friesen based their research on Hjortstö, but concentrated their research on the basic emotions of anger, surprise, happiness, sadness, disgust plus fear and contempt as discussed in chapter 3.3.4. Each of these is a general term for a multitude of emotions varying in intensity and modulation, thus giving space for a wide variety of expressions (Ekman, 2007, p. 58). The system classifies the movement groups of muscles - so called Action Units – to identify emotional tendencies. The action units include muscles that move facial elements like brow, nose, or lips (see *Table 14*) but also determine how the head is held and where the observed person looks (Vicente-Querol et al., 2019, p. 224).

In contrast to Hjortsjö, who simply asked his probands to simulate a distinctive mien (Hjortsjö, 1970, p. 67), Ekman and Friesen developed strict rules to elicit valid information. Not only must the emotion be positively aroused and identified, but the circumstances also need to be controlled and comprehensible. Furthermore, the films and photos have to have high quality to allow for optimal measurement basis (Ekman et al., 2015, p. 25). Following these demanding rules, the refined emotional Facial Action Coding System is very precise and allows detecting emotions in the human face with high reliability (Ekman & Friesen, 2015, pp. 194–198). It "is the most comprehensive and widely used taxonomy for characterizing facial behavior" (McDuff, 2016, p. 72).

*Table 14.* Excerpt of a List of Action Units

| AU number | FACS name | Muscular basis |
|---|---|---|
| 1 | Inner brow raiser | *Frontalis, pars medialis* |
| 2 | Outer brow raiser | *Frontals, pars lateralis* |
| 4 | Brow lowerer | *Depressor glabellae; depressor supercIii,* corrugator |
| 5 | Upper lid raiser | *Levator palpebrae superioris* |
| 6 | Cheek raiser | *Orbicularis oculi, pars orbitalis* |
| 7 | Lid tightener | *Orbicularis oculi, pars palpebralis* |
| 8 | Lips toward each other | *Orbicularis oris* |
| 9 | Nose wrinkler | *Levator labii superioris, alaque nasi* |
| 10 | Upper lip raiser | *Levator labii superioris, caput infraorbitalis* |

After (Ekman & Friesen, 2015, p. 186)

Still, the analysis of a considerable amount of data is complicated, time-consuming and needs highly trained personnel to do it. Therefore, automated systems are needed to perform the emotion recognition in an efficient way (McDuff, 2016, p. 72). The first endeavours proved very complicated and prone to fault. The restraints for size, position, light, and exposure were stringent and did not leave much space for natural action. Furthermore, as face detection was still in its infancy, the relevant face elements had to be detected manually (see *Figure 50*). So, the process was semi-automatic at its best (Cohn et al., 1999, p. 36).

*Figure 50.* Semi-Automatic Recognition of Facial Movements as a Basis for FACS
Source (Cohn et al., 1999, p. 39)

Modern systems, like the Microsoft Cognitive Service used in this research, recognise faces automatically and are even able to identify the same face in different circumstances. The Microsoft service can detect 27 landmarks (see *Figure 51*) in a face and evaluate them to detect attributes like age, gender, and emotion (Farley, 2019).

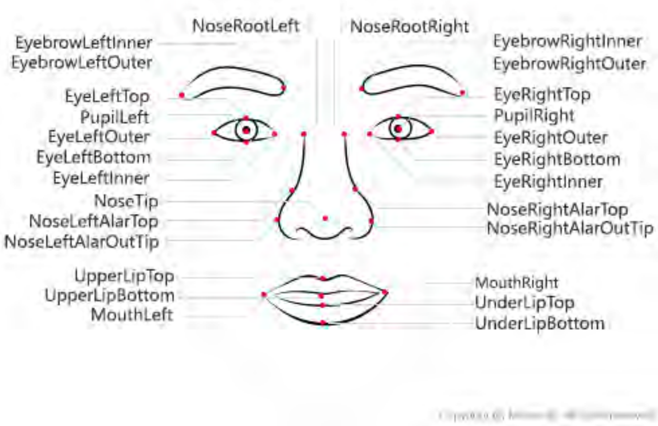



*Figure 51.* Face Landmarks Used for Face Identification and Emotion Detection
Source (Farley, 2019)

A system to identify facial actions and emotions "consists of several fundamental components, including data acquisition, face detection and registration, feature extraction, dimensionality reduction and classification" (Zhi et al., 2019, pp. 2–3). As shown in *Figure 52*, each fundamental component includes several tasks that together fulfil the component's function (Zhi et al., 2019, p. 3).

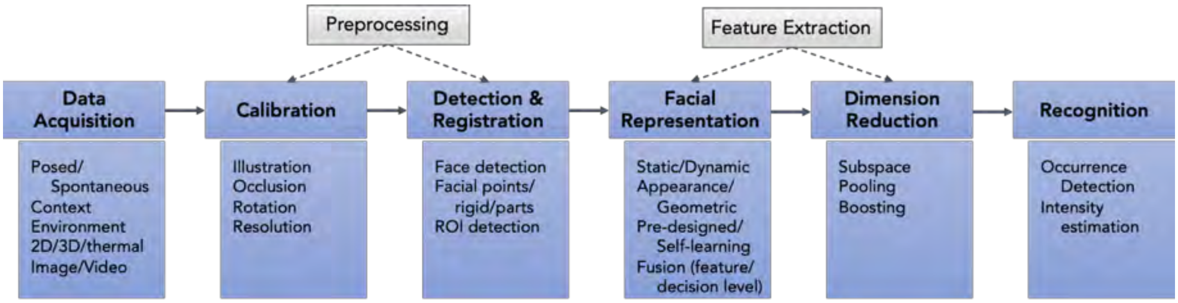



*Figure 52.* The Workflow for an Automatic Emotion Detection System
After (Zhi, Liu, & Zhang, 2019, p. 3)

The tasks are highly complex and only attainable with the help of deep learning artificial intelligence systems. The systems continuously collect information and optimize their learning results from each feedback loop the structure provides. The systems simulate the learning process of the human brain. They consist of multi-layered neuronal networks of highly specialised algorithms (Schmidhuber, 2015, pp. 86–87).

The mere recognition of faces in images shot in natural circumstances is highly demanding. The software must find faces even if they are semi-profile, different postures, various illumination or even out of focus. This calls for the sophisticated combination of various detectors to get good results. Sticking to just one method would provide inferior outcomes, as each of the detectors has its own weaknesses that are compensated through adding other elements (Yu & Zhang, 2015, p. 2). The next step unifies the faces in size, position, and image quality to get standardized cut-outs of the objects of investigation (Yu & Zhang, 2015, p. 3). To recognize emotions, a deep learning system is trained with thousands of manually classified images. With each image, the system gets feedback and takes this into account for the following cycles (Goodfellow et al., 2015, pp. 60–61).

The Microsoft Cognitive Services include all these processes and a sophisticated development system, that provides a quick and secure access to emotion recognition with simple software commands (Larsen, 2018, pp. 78–79).

The field for emotion detection is wide and has already established its usefulness. Marketing and media communication are using automatized emotion detection regularly to analyse the media reception and buying behaviour of potential customers (McDuff, 2016, p. 72). Zhi et al. (2019, pp. 1–2) list also medicinal tasks like pain detection and schizophrenia, security issues like unusual behaviour, affective analysis for education, and emotion simulation for robotics.

### 3.3.6. Conclusion

Emotions are constructs of the human mind in response to stimuli from the environment and the body. They are the indispensable basis for appropriate reaction on those stimuli and thus crucial for survival. Emotions are highly complex, and their creation and influence stand under high dispute. Research into emotions is affected by knowledge in biology, neuroscience, psychiatry, emotion and motivation psychology, personality psychology, sociology, and philosophy.

Creativity is highly influenced by emotion. They can fuel and impede the creative process. The OCEAN Framework with the Big Five personality traits openness, conscientiousness, extraversion, agreeableness, and neuroticism that are all emotional dispositions, show the profound influence. Not only creativity but all cognitive functions are also influenced by emotions. They are indispensable enablers and influencers of acts and decisions.

The Limbic Map model serves as a basis for the first hypothesis of this thesis' research. Limbic Map encompasses human emotions, motivations, and values, visualised in a two-dimensional map spanned between three terms representing the fundamental human motives: Balance, Stimulant, and Dominance.

For the research, it is vital to be able to recognise and document emotions throughout a Design Thinking process. Emotion recognition is a highly specialised skill that needs training and experience. Emotions are expressed not only via facial expressions but multimodally through body language, speech, pulse and others. To get to reliable results, emotion recognition needs to consider all these elements.

Because of the complexity of emotions, there are only recently appropriate technological systems and know-how to achieve some results in this area. Based on deep learning artificial intelligence systems, automatic emotion recognition is possible. This technology will be deployed in the upcoming empirical research.

The Sub-Question I.3: "What is emotion, how can it be identified, and how does it affect creativity?" can be considered as answered.

# 4. Empirical Studies

## 4.1. First Cycle

As already outlined in the literature review, the first research cycle investigates into the emotional status of the participants in Design Thinking projects and matches them with a first concept that locates presumed beneficial predominant emotions within the Limbic® Map. The research uses the Microsoft deep learning system to identify emotions in images, project observation and participant survey.

### 4.1.1. Pre-Conceptual Observation

During the diverse Design Thinking projects the author observed (approximately ten in and outside of university environments in the three years preceding the research), there were regularly phases when the project did not seem to work well. There were those phases when probably imprecise guiding or exhaustion through long working led to irritation. But sometimes there was the impression that the team members did not know how to think and act within the given task. The participants eventually stopped working, looked at each other and expressed feeling lost.

Part of this can be traced to the *groan zone* in Design Thinking (Lewrick et al., 2018b, p. 37). This area is defined as the intersection between divergent and convergent phases: "the time, when the team feels at odds [with] what is going on, how to interpret the outcomes from a divergent process, and how to align as a team" (Kun et al., 2019, p. 348).

Still, there seemed to be more. Some people thrive in certain phases of the process and seem to be totally lost in others. The same can happen to whole teams. To the observer this did not seem to be induced through lack of skill or motivation; the people appeared to be *out of sync*. The facilitators struggled to activate the team again, typically they dropped the task and commenced with the next. The author of this thesis presumed that the emotional connection to the process and to the other team members was missing. Aware of the concept of the Limbic Map (discussed in chapter 3.3.3) and the implications given in this concept, the author developed the hypothesis: To be productive, each step in a Design Thinking project needs to engage a certain emotion for the given task.

#### 4.1.2. Starting Concept

Developed from the pre-conceptual observations and literature review in Design Thinking, creativity and emotion, the author developed a possible connection between emotions and the phases of the Design Thinking process. The author used the standard IDEO model (see *Figure 27*, page 72), as this is the best established Design Thinking model (Waidelich et al., 2018, p. 7).

The connection between emotion and creativity is the subject of various research projects in psychology, and the correlation is considered proven. However, the research mainly distinguishes only between positive and negative emotions, typically with a direct correlation to creative output (Amabile & Pratt, 2017, p. 173). But this reduction to valence does not do justice to the manifoldness of these mental states. Even the basic six emotions that scientists (mostly) agree upon (Ekman, 2016) are by far not enough to cover the multitude of the emotional bandwidth (Keltner, 2019, p. 16). There are various models of emotions that are in use, like the Geneva Emotion Wheel or Plutchik's Emotion Wheel (Warpechowski et al., 2019), but as discussed in chapter 3.3.3 the Limbic map seems to be the only one that also covers motivational factors. This model also allows for emotions like *curiousness*, *sociability*, *adventuresomeness*, or *diligence* (Häusel, 2011, p. 48, 2019b, p. 53) that fit with observations made by the author prior to this research.

A creative process is complex and consists of very diverse tasks. There are varieties of emotions that foster particular kinds of creativity, and thus the right emotion could optimise the performance in specific steps of a creative process (Amabile & Pratt, 2017, p. 180).

The idea behind this concept was to find appropriate areas in the Limbic Map for each phase of the Design Thinking process. The phases were located on the map following prior observations and statements from literature review[14]:

UNDERSTAND:

– "Explore your project from both broader and narrower perspectives." Screening the challenge, looking for hidden problems, discovering fruitful openings; this task needs explorers to be productive (Liedtka et al., 2019, p. 8).
– Get to know the team and familiarize oneself with the task. The goal is to feel infused with the situation and to identify with the given goal (Osann et al., 2018, pp. 34–37).

[14] The listing provides statements that in some instances could also be found in similar fashion in other sources. In favour of readability the author typically only mentions one source per statement.

– There is a rather passive – understanding – and an active – defining – approach found for this phase. E.g. Liedtka et al. (2019, pp. 6–11) describe the task as something the team leader models and defines, while Kelley and Littman stress the need to comprehend all elements of the project, embracing what is given to the team but not actively (in this phase) modelling the data (T. Kelley & Littmann, 2016a, pp. 6, 37).
– People should feel intensively attached to the problem and have a strong intrinsic motivation (Amabile & Pratt, 2017, p. 176). Dave Evans (in Coyle, 2018, p. 66) is even more adamant in his claim: "You can't solve a problem you are not willing to have."

This phase demands a positive, motivated stance regarding the task, the willingness for objective understanding and the volition for a good team spirit. The emotional basis clearly gears towards *Balance* with a touch of *Stimulant*. Building trust and feeling familiar should be the goal. As the exploration in this phase is not an active one (going out in the field) but focuses on given data, the adventure-element is not so strong.

OBSERVE:
– The importance of the human-centred approach of Design Thinking grounds its work in an intensive *Observe* phase. Direct observation and emergence with the affected people is mandatory for the success of a Design Thinking project (T. Brown, 2008, p. 90).
– Empathy is the basis of the observation phase. Intense contact and immersion with affected persons is mandatory. This is a phase of discovery (Doorley et al., 2018, p. i.).
– Curiosity and openness are vital to discover what is behind the plainly obvious (Lewrick et al., 2018b, p. 71).
– Here, exploration is at its peak – Kelley (2016b, pp. 16–19) assigns this phase to the anthropologist, seeking a *beginner's mind*, observing even well-known situations as if it is for the first time.

Empathy and discovery are the key factors of this phase. To be curious, to really want to know the target group, their desires and problems, should be the key emotional driver here.

DEFINE:
– The first task is communicating and understanding the data collected in the last phase, then to organise and analyse the data (Doorley et al., 2018, pp. 6–7).
– Sosa et al. (2017, p. 476) declare this phase needs a learning attitude instead of an evaluating one.
– Liedtka et al. (2019, p. 22) demand to focus on the user's needs, and to reframe the design problem to reveal these needs.

- Kolko (2018, pp. 75–80) splits the phase into four stages, where the first stage is arduous, needing some stamina to go through, the second one is introspective, demanding for some guess work, the third is a stage to generalize and provoke, and finally in the fourth a prescient and ambitious stance is demanded.
- The point of view is a condensate of the collected data (Curedale, 2019, p. 434).

Finding the problem statement and defining the point of view requires diligence and structure. To keep the target group's needs at the forefront, a point relatively close to the centre of the Limbic Map is sensible, albeit not too close, as the design team needs to keep their cognitive distance.

IDEATE:

- Developing as many ideas as possible – being creative (Osann et al., 2018, p. 64).
- Daring to be crazy. Novel ideas are often bizarre in the face of given beliefs – so the idea giver must risk being ridiculed and maybe even threatened (Szostak, 2017, p. 26).
- An attitude of sharing and stimulation helps ideating (Paulus et al., 2018, p. 2).
- "Encourage weird, wacky, and wild ideas" (Siang & Dam, 2018, para 47).

Ideation needs creativity, adventurous minds and some risk taking. So, this phase is well positioned in the top left area of the Limbic Map.

PROTOTYPE:

- Phantasy for storytelling and being to be able to play without losing both the fun of playfulness and the seriousness of the task (Kolko, 2015, pp. 69, 82).
- Prototyping needs a tendency towards improvisation (Doorley et al., 2018, p. 20).
- Kelley and Littman (2016b, pp. 42–47) assign this phase to *the experimenter* who has a risky attitude of learning by trial-and-error. He/She seeks enlightenment in the learning endeavour of making ideas tangible.
- Stickdorn et al. (2018, p. 261) describe very emotional aspects of prototyping. On one hand they portray the minimum "loveable" prototype instead of the minimum viable one, and on the other hand they describe the calming effect prototyping has on the team members.
- "A playful, iterative approach to problems is one of the foundations of our culture of prototyping" (T. Kelley & Littmann, 2016a, p. 105).

Prototyping is well positioned in the Adventure/Thrill section of the Limbic Map. It needs some courage and spontaneity, but as it should visualize the developed solution and stick to its concept, it needs to be close to the stricter Dominance area.

TEST:

- Tolerate failure as part of the iterative process – "Fail early to succeed sooner" (T. Brown, 2019, p. 23).
- In the 4W-process, *Test* includes learning launches as a main step to find optimizations for the presented solution (Liedtka et al., 2019, p. 38).
- Testing means demanding and accepting even harsh critique. Even if it does not seem to be objective, there is a chance for optimization (Stickdorn, Hormess, et al., 2018, pp. 229, 413).
- Start with a minimum viable prototype (MVP) and enhance fidelity over time to engage critical feedback (Lewrick, Link, et al., 2020, pp. 207–210).
- Empathy and rigorous assessment is mandatory for a good test (Lewrick et al., 2018b, p. 119).

Testing is a disciplined task. It needs to strive for quality, but also needs trust and the willingness to work for the target group. So, nearness to the term loyalty in the map is advised. Unfortunately, learning has no position on the Limbic Map, so it can't be integrated. Almost looping back to the position of the *Understand phase* seems reasonable and underscores the Design Thinking focus on the target group.

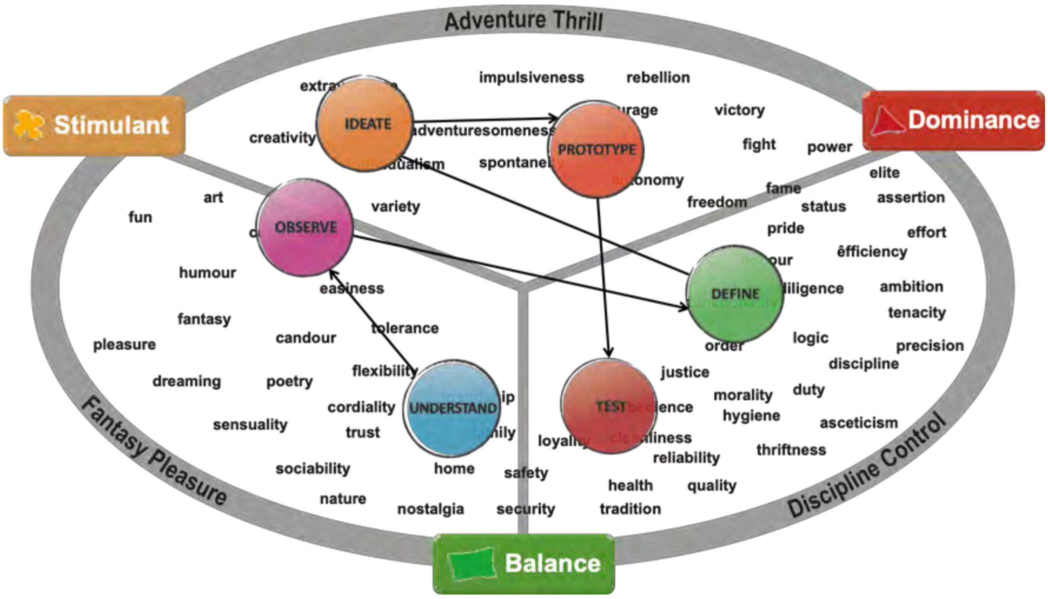



*Figure 53.* Starting Model: Emotional Journey of Design Thinking – Illustration by author on the basis of (Häusel, 2011, p. 48)

The resulting concept can be visualized as distinct focus points on the Limbic Map as shown in *Figure 53*. Note that it is expected that the emotion will not be exclusively in the area indicated for the phase, but that there will be some kind of emphasis in the identified area. As the emotions are visualised as moving points on a map during the Design Thinking project, the author coined it *emotional journey*. This model is the hypothetical theory of the research project.

#### 4.1.3. Project One – FHV Dornbirn 2016

As a first research cycle, an intense 3-day Design Thinking session with a class of students of the study program InterMedia (communication design) at the university of applied science in Vorarlberg (Austria) was investigated. The course consisted of 13 design students from various countries (international exchange semester). As it was an elective class, the students were very dedicated and active. All students consented to the research and collection of data (signed forms exist).

The data collection consisted of three elements (see *Table 15*):

1. Emotion recognition based on of constant photography of the teams during the process and analysis with an AI-based software service for emotion recognition
2. Observation of the process and discussion with the students
3. A paper-based survey during the process

*Table 15*. Project One – Research Plan – ideas(r)evolution Design Bachelor Class, Dornbirn 2016

| IDEO phase | ideas(r)evolution | Implemented tasks | Research methods |
|---|---|---|---|
| | | Warm up – Ball throwing stories | |
| Understand | Involvement | Presentation and discussion | Emotion recognition photography<br>Project observation and discussion<br>Survey |
| Observe | | Ethnographic interviews | |
| | Inspiration | Roots | |
| Define | | Critical success factors | |
| | | Warm up – ball game | |
| Ideate | Ideation | Brainwriting/brainstorming<br>Windmill | |
| Prototype | Integration | Poster-presentation<br>Visualize | |
| Test | Implementation | Personas<br>User stories | |

Devised by author

Remark: All participants of this and the following projects signed agreements or agreed in the online questionnaires that they consent to the gathering of data and being photographed for research purposes. Where the agreement is not absolutely secure (only photography) the faces of the participants are blurred.

#### *4.1.3.1. Project Description*

The class followed the ideas(r)evolution framework (see *Figure 30*, page 75). As the goal of the class was to introduce the students to Design Thinking, the workshop consisted alternately of lecture sessions explaining the process and active learning-by-doing phases with ideas(r)evolution research methods and templates. The duration of the class was three days with ten teaching/project hours each day.

#### *4.1.3.2. Data Gathering*

##### *4.1.3.2.1. Emotion Recognition with Photography*

The data gathering attempts to capture and document the emotions of the team members during the phases of the Design Thinking project. This probe needed a scientifically proven method for emotion recognition and a technology that could cope with a large amount of image data. It was highly important to gather the data as unobtrusive as possible in order to avoid a disruption of the project and tamper with the acquired data through its the measurement (Saunders et al., 2015, pp. 364–365). To capture the needed images, professional cameras with automatic exposure devices were used, as this allowed for continuous capture without the use of camera-operators.

The developed solution uses the above (see 3.3.4, page 143) delineated Emotional Facial Action Coding System (FACS) with the development status acquired by Ekman and Friesen (2015, pp. 184–190). The deep learning systems of Microsoft Cognitive Services (*Microsoft Cognitive Services - Emotion API*, 2016) provided an API to analyse the images and determine the emotions of the depicted team members. This is a service included in the cloud service Microsoft Azure.

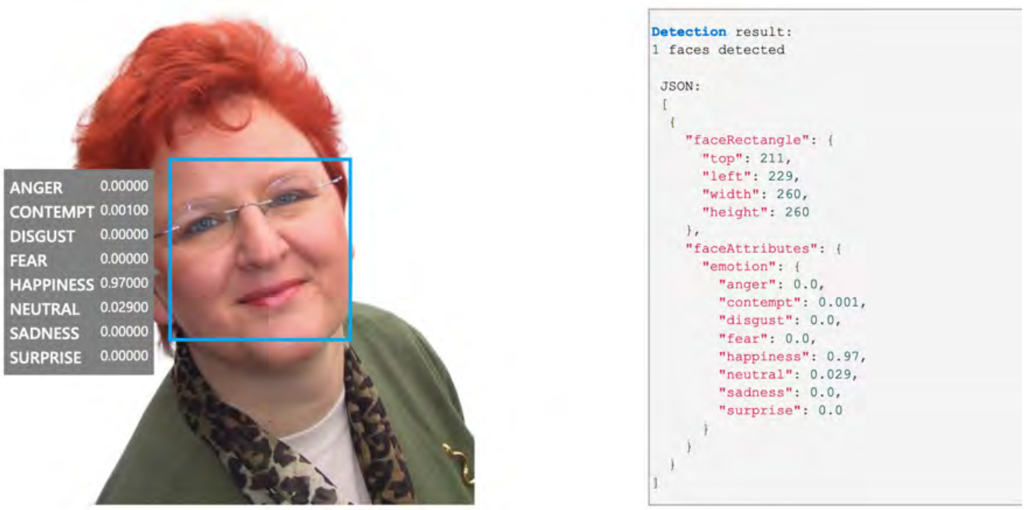



*Figure 54.* Demonstration of the Emotion Detection Function
Technical demonstration based on photography by author

The Microsoft Azure service is recognised for the high reliability of its results and is thereby usable for research missions (McDuff et al., 2019, p. 3). The system analyses still photography, detects faces in these files and evaluates the emotions in these faces. *Figure 54* shows an example of the given result for one face.

To gather the needed images, three single-lens reflex cameras (SLR) were positioned around the worktables of the Design Thinking teams. The camera position was selected in a way to get as many students as possible with front facial or slight profile angles (*Figure 55*). As there were two groups working at the same time, one camera was assigned to each group respectively. The third camera was used where appropriate.

*Figure 55.* Project One – Examples of the Camera Positions for the Image Collection
Photography by Américo Mateus

Each camera was triggered at 60 second intervals to shoot a photo. The camera timepieces were set to get precise timing information. Simultaneously, a timing log was kept to identify the phases of the project.

To gather the data, the author developed a solution based on PHP and mySQL using the Microsoft Cognitive Services. The first step was the development of an entity-relationship-model (Elmasri & Navathe, 2016 Chapter 3) for the database that allowed for maximum flexibility to use it also in follow up sessions or similar research using the Cognitive Services (see *Figure 56*).

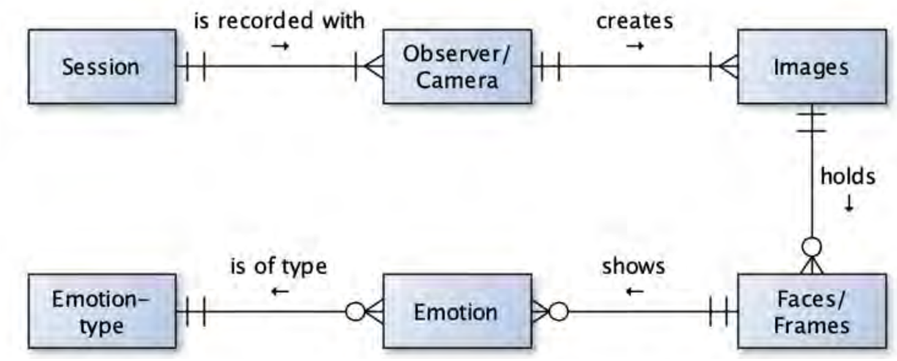



*Figure 56.* Project One – Entity-Relationship-Model of the Database Developed for the Project – Simplified model, developed by the author

The needed database was then developed with the structure shown in *Figure 57*. The PHP-code of the programme is listed in the appendix A1.


*Figure 57.* Project One – Database Structure for the Data Gathering of the Emotion Recognition Project – Devised by author

The Cognitive Service provided a string (a sequence of characters) for each image that included a rectangle for each recognised face and the emotional values detected in these faces. Example (includes two rectangles, the first seems to be of a rather angry face, the second is considerably neutral):


```
[{"faceRectangle":{"height":77,"left":1300,"top":349,"width":77},"scores":{"anger":0.494623035,"contempt":0.003738962,"disgust":0.0105080921,"fear":0.0107938172,"happiness":7.50795743E-06,"neutral":0.44200176,"sadness":0.0129284291,"surprise":0.0253984053}},{"faceRectangle":{"height":75,"left":1050,"top":430,"width":75},"scores":{"anger":0.000271838042,"contempt":0.004863225,"disgust":4.70162558E05,"fear":3.45343E-05,"happiness":0.0148457335,"neutral":0.9770476,"sadness":0.00252301758,"surprise":0.0003670246}}]
```

| | | |
|---|---|---|
| **anger:** | 0,00004 | 0,00592 |
| **contempt:** | 0,00203 | 0,00574 |
| **disgust:** | 0,00020 | 0,00013 |
| **fear:** | 0,02548 | 0,00000 |
| **happiness:** | **0,98505** | 0,00184 |
| **neutral:** | 0,01258 | **0,98576** |
| **sadness:** | 0,00001 | 0,00049 |
| **surprise:** | 0,00009 | 0,00013 |

*Figure 58.* Project One – Exemplary results of the emotion recognition data gathering Photography and listing by author

*Figure 58* shows the results of another image with two recognizable faces. The data gathering resulted in 3379 faces with 8 values for the included emotions. The identified emotions were combined to an average value for each ten-minute time span. The resulting graphic is depicted in *Figure 59* (for a bigger representation please refer to the appendix A.1).

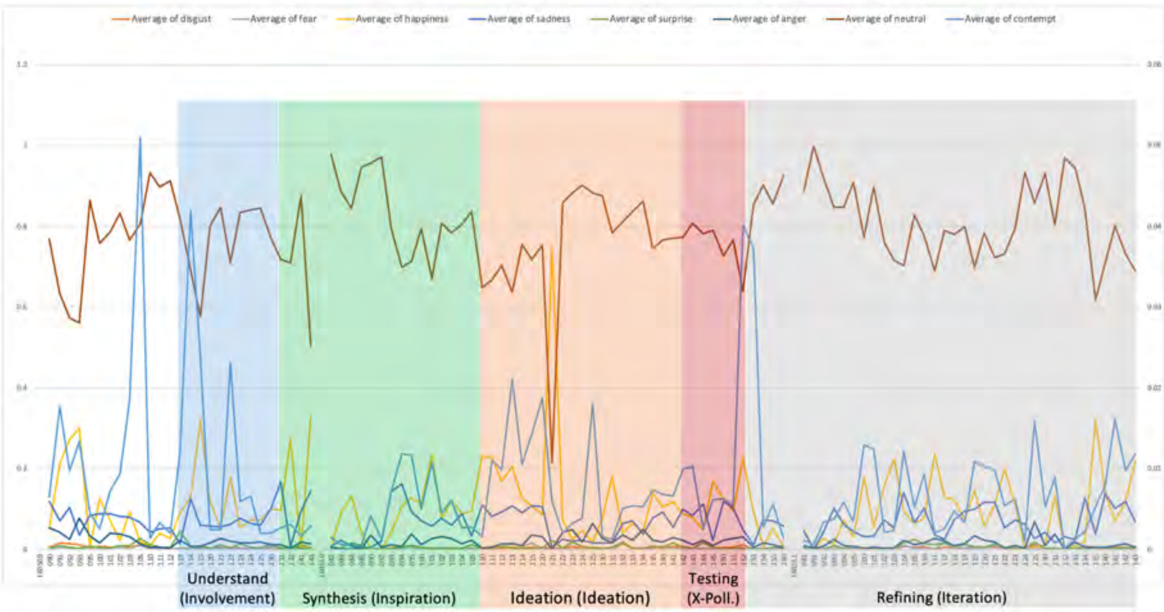
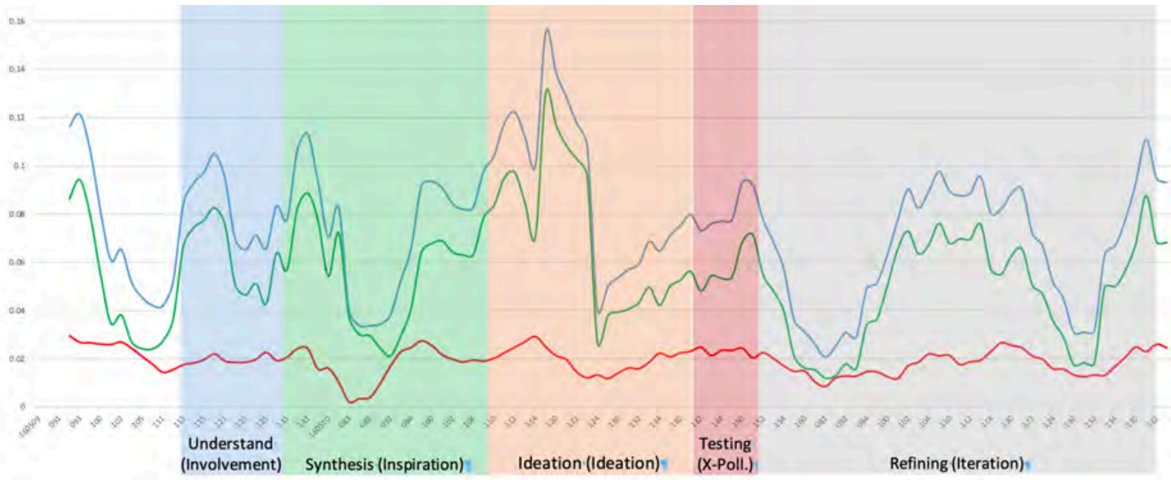



*Figure 59.* Project One – Overview of all Emotion Recognition Values During the Project Devised by author

"Neutral" (dark red) distinctly predominates the findings. There is no real discernible pattern. The same was true when filtering only one group's values or devising statistical analyses.




Positive emotion – green, negative emotion – red, general agitation – blue

*Figure 60.* Project One – Emotion Intensity Combined to Posemo and Negemo Emotions with Rolling Average – Devised by author

Following the concept of Ewald et al. (2019), the data was also grouped by negative (negemo) and by positive (posemo) emotions (see *Figure 60*), combining anger, sadness, fear, contempt, and disgust as *negemo* emotions (red) and happiness and surprise as *posemo* emotions (green). Additionally, all non-neutral-emotions (blue) were combined to visualize the general agitation (emotional level) of the team (Ewald et al., 2019, pp. 52–53).

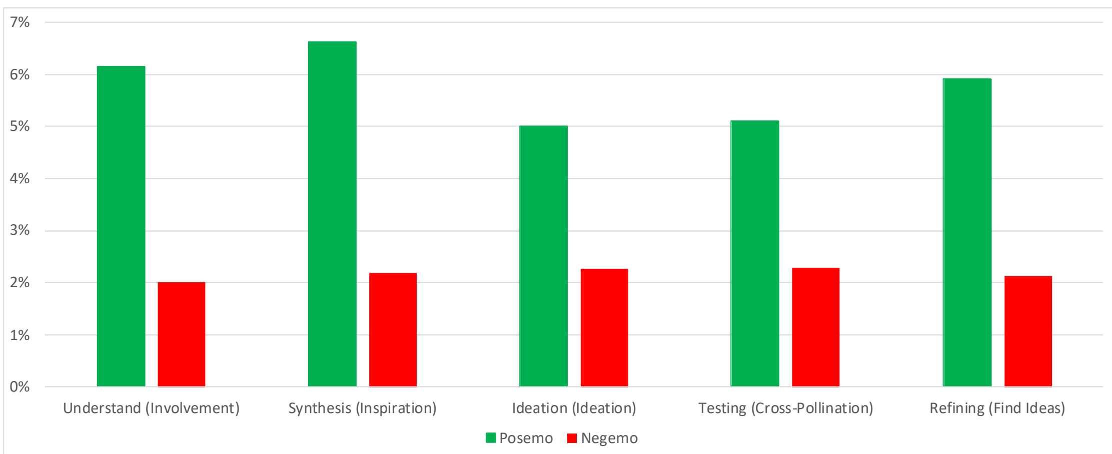



Figure 61. Project One – Emotion Intensity Grouped by Positive and Negative – Devised by author

Again, following Ewald et al. (Ewald et al., 2019, p. 53) the data was accumulated into the phases of the Design Thinking process and depicted in Figure 61.

*First analysis:*

The detailed emotion recordings did not yield relevant information. The results show no evident patterns. 79% of the emotional intensities are below 1%, only 3% show values above 30%. So, the individual emotion recognition does not seem to reveal insights applicable to the research.

The split into positive and negative emotions exposes some information. *Figure 62* shows the same graph as Figure 60 complemented with four indicators that seem interesting:

- Indicator 1 aligns with the time frame where the teams had to switch from divergent to convergent thinking. Lewrick et al. (2018b, pp. 36–37) label this phase as the 'groan zone' as it marks the transition from a divergent to a convergent phase. Typically, it is hard for the Design Thinking team members to manage this transition and they do not feel very positive about it. So, the sharp reduction of the posemo emotions might illustrate this.
- Indicator 2 matches with a period where ideation is well established. The teams were active and positive. "We all recognize the euphoric moments when ideas and decisions come effortlessly. It's a kind of magic that loosens us up and lets us perform at our peak" (T. Kelley & Littmann, 2016a, p. 179). The timing matches well as this was when the ideas get a little crazy, and the teams fooled around a bit.
- Indicator 3 and 4 are in the iteration phases where the teams might have reached groan zones again. Another possible reason might be discussions about critical feedback. As the two teams were working parallel to one another and this phase is quite self-directed, a precise attribution is not possible.

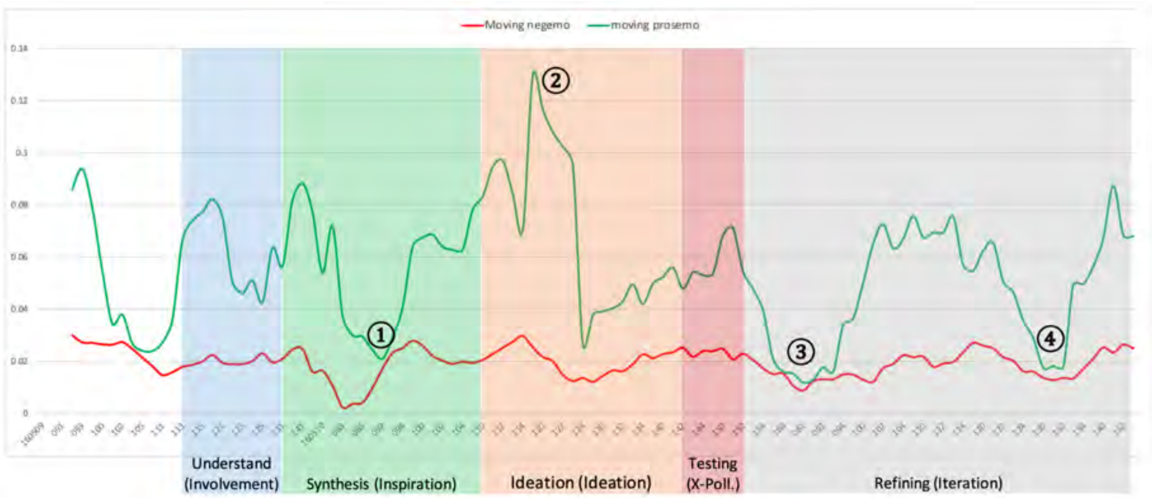



*Figure 62.* Project One – Emotion Intensity Combined to Posemo and Negemo Emotions with Indicators for Remarkable Points – Devised by author

The chart with the data grouped by emotion type and project phase (Figure 61) shows that positive emotions prevail and that both groups were relatively stable. However, the intensity is constantly low.

#### *4.1.3.2.2. Survey Based on the Limbic Map*

After each phase of the project, the students were asked to draw a marker on the limbic map printout they were given. This marker should fit with the prevalent emotion they felt during the task (examples of the result: see *Figure 63*). The participants were asked if they needed further explanation for the map, but they concordantly expressed that the form was clear and easy to use. The data gathered from the printouts was unattributed; merely the team each participant belonged to was identified.


*Figure 63.* Project One – Two Examples of the Survey Results, First Cycle Limbic Map – Devised by author

The terms in the limbic map are not positioned according to a mathematical identification. As described in chapter 3.3.3, while developing the map, the positions were determined visually through an empiric survey (Häusel, 2019b, p. 53). Even if it is displayed in a two-dimensional system, there are no mathematical dimensions. The data is nominal not numeric, so statistical methods like median, variance etc. cannot be applied (Saunders et al., 2015, pp. 500–501).

Therefore, a visual and intuitive analysis is appropriate, as it is encouraged for the use of Limbic Map surveys (Häusel, 2019d, p. 102). In a first analysis the results were separated for each phase of the project (see *Figure 64*).

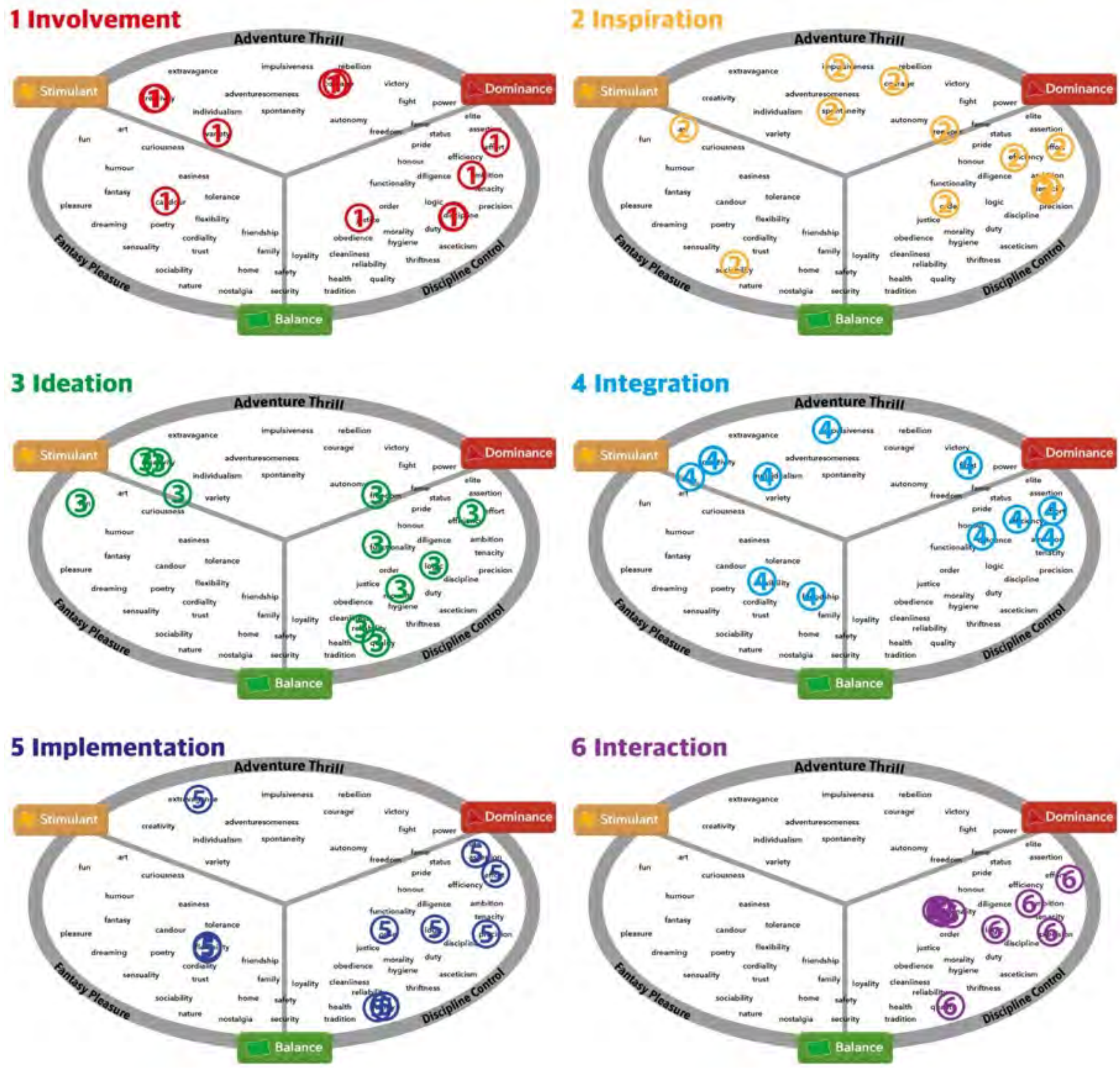



*Figure 64.* Project One – The Results of the First Survey Separated by the Phase – Devised by author

The results show some clustering in several phases, with significant clustering only occurring in the sixth phase. The *Ideation* phase shows two distinct cluster areas: the area around creativity and curiosity, but a second, more highly populated area in the discipline sector. *Inspiration* shows a slight concentration towards dominance terms while *Integration* led to the selection of the upper half (adventure, thrill) of the map. *Implementation* and *Interaction* were mostly experienced as emotionally focused in the discipline/control area.

In a further analysis the results were visualized with a heat map. Heat maps can be used to identify clusters in areal results. Heat maps visualize data points in a way that makes groupings easily detectable and variations in density well recognizable (Guo et al., 2017, p. 39). This kind of heat map is for instance, used to visualize and assess user interaction in web and computer interface designs (Jacobsen & Meyer, 2017, p. 53).

The heat map shows all survey inputs in one graphic (see *Figure 65*).

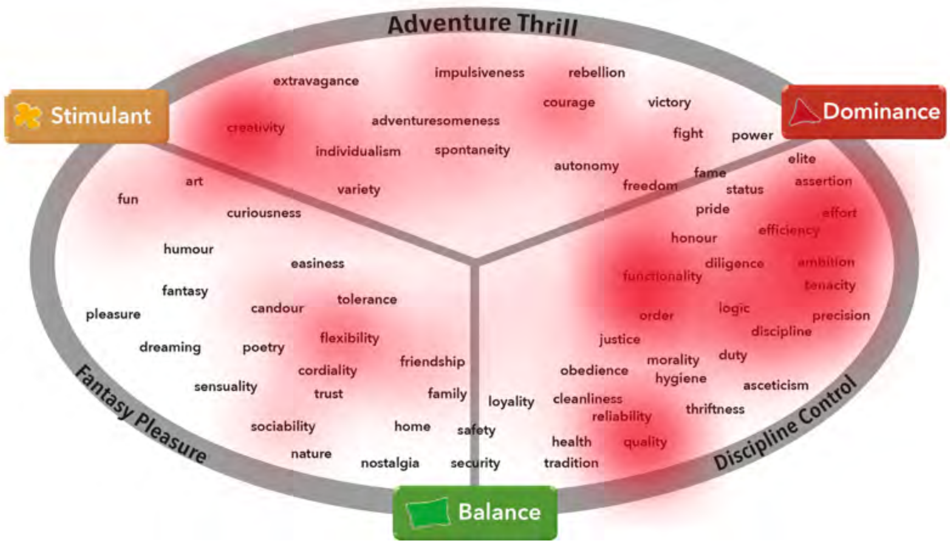



*Figure 65.* Project One – The Results of the First Survey Visualised as Heat Map – Devised by author

The heat map shows a clear focus in the *discipline control* sector and an additional heat point near *stimulant*. A closer look shows several foci at *effort/efficiency, functionality, quality,* and *creativity*.

The interpretation of these findings follows in chapter 4.1.5.

#### *4.1.3.2.3. Observation and Discussion*

The observation in Project One was done by the author and Prof. Américo Mateus as lead lecturer for the class. During and after the class both faculty talked to the students using informal, unstructured communication. Additionally, the students had the possibility to use a digital survey to express their impressions of the course. Immediately after the class, Mateus and the author discussed the findings.

The three-day project was a mix of lecture and practical exercises in the form of a Design Thinking project following the ideas(r)evolution structure (Mateus, 2016, p. 289). The timing was firm, with lecture and task following in swift succession with clear time frames for each given task. The students were given a very open problem space with the general topic of digitalisation and its contemporary ramifications (e.g. Broeders, 2016; Kenney et al., 2015; Manzini, 2015). There was no further restriction; the students' task was to find a proper challenge in this problem space and to define a point of view according to the ideas(r)evolution workflow. The students worked in two groups. Sub-tasks were assigned independently in the group.

The tasks assigned to the teams included:

INVOLVEMENT

- Foresight (Mateus, 2016, p. 309):
  The tool suited to the given task, as all students needed to find their standpoint and to gather data about the given situation, the heralded trends and the challenges arising from this. So, they had the chance to immerse themselves in the problem space in a short time.
- Taylor Challenge (Mateus, 2016, p. 309):
  The Taylor Challenge helps consolidate the findings and come to a common ground. The output was a defined challenge for each team that they could face in the inspiration phase. The students created a first creative question at this stage. Example: "How could we keep digital technology from distracting us without hindering the functionality of an educational environment?"

INSPIRATION

- Cross Information (Mateus, 2016, p. 313):
  The tool allows systemising the existing information and identifying gaps and critical data. The class worked without a printed wallpaper of the tool, but used the sectors "science, culture, technology and trends" (Mateus, 2016, p. 313) to discuss the issues.
- Critical Success Factors (Mateus, 2016, p. 313):
  This tool guides the team to the most important elements of their challenge and gives them a hierarchy. As the team needs to brainstorm, vote and synchronise their findings, using Critical Success Factors is quite energizing and thus gives a good basis for ideation. Because of the short time frame of the project the critical success factors served as POV for the next phase.

IDEATION

- Windmill/Idea Cycle (Mateus, 2016, p. 289)
  The tool uses the defined critical success factors and ideates on them first emotionally (free flow of ideas, 'how do you feel about this factor?'), then sorting them with the target to identify ideas that are feasible, viable and human centred. The varying basis of the tool creates a high energy mode for the phase.
- Exploration (Mateus, 2016, p. 319)
  The teams split into sub-teams and worked on three possible solutions with a focus on visualisation. The task was to discover the potential of each solution. As each participant hat

to switch roles from solution provider to stakeholder, their view of the task reached more dimensions and better objectivity. Additionally, this task served as a test phase in the short-term project and delivered insight into possible improvements.
As a final step in this task, the students combined the three ideas in order to achieve maximum strength and to reach the best consensus about the optimal solution.

IMPLEMENTATION

– Value Proposition Canvas (Osterwalder et al., 2014)
  With the Value Proposition Canvas (VPS) the Design Thinking team has the possibility to validate the desirability and viability of their solution. While visualizing a transparent comparison of user needs and benefits (values) the students needed to change to a mode of business thinking but still keep in touch with the empathic insights they gathered about the beneficiaries of their solution. So, they built a basis to transform their creative idea to a real innovation.
– Systemize (Mateus, 2016, pp. 322–323)
  In this final phase, the students developed a plan for the dissemination of their solution to a market. They had to find potential investors, partners, communication strategies and distribution channels. This challenging task demanded intense business thinking and strategic sensitiveness.

The students expressed a high interest in the subject and showed dedication and seriousness to the task. In discussions with the supervisors, the students conveyed their fun with the project and satisfaction with their progress. This also showed this in an informal satisfaction survey. Interestingly, both supervisors agreed that the facial and bodily expressions of the students did not reflect this positive mood. Their faces appeared rather stern or inexpressive, often focused on the speaking team member or the working paper.

The anonymously filled in feedback form provided the same result. Most evaluated the class positively; the open text elements expressed positive experience in the team project. Merely the time pressure during the lecture-phases and the teamwork were remarked on negatively. Also, the considerably loud exposure sound of the cameras was perceived as distracting.

#### 4.1.4. First Cycle – Further Literature Review

The observations and data from the first project called for further literature review. Notably, doubts arose about the nature of emotions and the way they can be evaluated. Subsequently the hypothetical model with the emotional journey is severely put into question.

To clarify the matters at hand, emotion and other affective states had to be investigated in more depth. There were indications that emotion is not the adequate affective state to investigate.
In anticipation of the conclusion to this research cycle and as preparation for the next cycle, the nature of attitude and mindset are investigated in further literature review.

#### ***4.1.4.1. Affective States – Emotion, Feeling and Mood***

##### *4.1.4.1.1. Emotion*

Emotions are an affective state with a typically high valence. Research is providing more and more evidence that using facial expressions only in a still photo to discover emotions is not enough for accuracy, and gives at most an indication about a probable emotional state (McDuff et al., 2019, p. 3). Schlegel and Scherer (2016, p. 1384) suggest that at least body language, the face in motion, and the voice must be analysed to get to dependable results. Furthermore, the sociocultural as well as the immediate context of the emotional expression must be considered to recognize emotions. For instance, upbringing, social standards, peer pressure and the current atmosphere play a distinct role in how we behave and which emotions are allowed to surface (Scherer et al., 2019, p. 3).

To categorize emotions in only eight states is considered to be insufficient to reflect human emotion (Barrett, 2017b, p. 45) and it surely does not help to use the Limbic Map as intended in this research. Schlegel and Scherer (2016, p. 1384) suggest using a compact form of the Geneva Emotion Wheel with 14 emotional categories for identification tasks.

The Design Thinking team investigated in the author’s research consisted of students from diverse western and non-western countries. As Barrett (2017b, chapter 3) explains, emotional expressions are not universal but – at least partially – learned and forged through cultural effects. For instance, the emphasis on individual freedom versus collective needs vary greatly from culture to culture, and cultures focused on general welfare conceal emotions – especially negemo variants – while individualistic cultures express them unreservedly (Mishra et al., 2018, p. 3). The FACS emotion recognition system is trained mainly with American participants and leads to significant failure when used with date from other cultures (Mishra et al., 2018, p. 15). Research has shown that emotion expression and emotion recognition varies in different cultures (Barrett et al., 2019, p. 42).

The face can express an emotion that does not correlate with the emotion one feels in that moment. This ability is used by actors in their performances, but also by laypeople in public life to obscure one’s feelings (Brandstätter et al., 2018, p. 164; Eder & Brosch, 2017, p. 190). Even neutral faces are easily judged to hold expressions of emotions that are not really there. Slight changes can lead to totally different assessments even if they are not triggered by emotion (Todorov, 2017, pp. 164–165). "Human cultures take the lead in reorganising and restructuring bodily sensations into symbolically and linguistically specific feelings and emotions" (Burkitt, 2019, pp. 6–7). The fact that blind babies smile and frown led to the erroneous idea that emotion expression is totally natural. In fact, even if blind infants are showing a happy or angry face they do this in a much more restrictive manner and without the subtle variants sighted children express (Valente et al., 2018, p. 486).

In conclusion, even if emotion recognition plays a vital role in human interaction, identifying emotions via facial attributes alone will not generate reliable results; neither humans nor computers are capable of recognizing all relevant factors and too are ignored (Barrett et al., 2019, p. 46). If further thought and research shows that the identification of emotions is crucial to the project, other approaches must be identified.

As shown in chapter 0, emotions are relevant for creativity and thereby for Design Thinking. A more in-depth investigation into the very nature of emotion and other affective states is needed to understand how they affect this research.

##### *4.1.4.1.2. Feeling*

The concepts of affect, emotion, and feeling are often unclear and intermingled, but must be distinguished in order to work with them. Affect is the umbrella concept embracing the experience of both emotions and feelings (Damasio, 2018, p. 99). "Emotion is the result of the initially unconscious processing going on in brain systems, while feeling is the conscious awareness of emotion that arises only in certain circumstances" (Burkitt, 2019, pp. 1–2). Or, as Damasio (2004, p. 28) dramatically expresses it: "Emotions play out in the theatre of the body. Feelings play out in the theatre of the mind." Humans experience not emotions but feelings. When they give an account to affective states, they talk about their feelings and not their emotions (Brandstätter et al., 2018, p. 191). Emotions and feelings can be tightly connected as humans feel the affective states they emote. They feel anger, sadness, or happiness (Burkitt, 2019, p. 6). However, feelings have a broader bandwidth as they do not only occur in combination with emotions, but also with other interoceptive sensory inputs like, for instance, hunger (Barrett, 2017b, p. 66). Humans experience feelings consciously as their connection to the external world but also as connection to their body and mind (Burkitt, 2019, p. 6).

##### *4.1.4.1.3. Mood*

Emotion and mood are closely linked. However, the details of this linkage are still in high dispute in the research community (Ekman, 2016, p. 32) While emotions are typically only held for a short time – seconds or minutes – moods can last for hours and days. Highly relevant: they build the background for our cognitive processes and our emotions (Brandstätter et al., 2018, p. 164). Unfortunately, "Moods don't have their own signal in either the face or voice" (Ekman, 2007, p. 50). People tend to laugh more often when they are happy, but they will not laugh constantly, regardless of how happy they are.

Where emotion is a direct reaction to an object with a temporal restricted change in perception and behaviour, moods last significantly longer (hours and days) and do not have a reference object (Eder & Brosch, 2017, p. 188). Amabile and Pratt (2017, p. 173) distinguish between the general, nonspecific mood and the unambiguous emotional reaction.

The correlation of creativity and mood is under intense research. Even if some researchers observed that moods with a perceived positive valence lead to more and better quality creative output (Langley, 2014, p. 15), this is questioned today. Recent research indicates there is some correlation, but not only the valence of a mood is relevant but also its intensity and orientation towards or away from a situation (Baas, 2019, p. 259). The dual pathway model identifies a significant effect of the arousal dimension of mood. Highly activated, positive mood enhances cognitive flexibility, while aroused negative mood leads to higher persistence and deeper reflection on the problem state (To & Fisher, 2019, p. 105). Other studies show that moods change the way we access information. While in a positive mood, we tend to heuristics, but when in a negative state, we tend to use systematic procedures. So, appearances like proficiency, likeability, or attractiveness influence us more when feeling pleasant than in a more negative state (Lerner et al., 2015, p. 807). Contrary to Ekman (2007, p. 50) who stated "Moods reduce our flexibility, as they make us less responsive to the changing nuances in our environment, biasing how we interpret or respond", Baas (2019, pp. 267–268) found that activating moods like happiness, anger or even fear can have a positive effect on creativity, while being in a relaxed mood does – contrary to many beliefs – not spur creativity.

Amabile and Pratt (2017, p. 180) add another factor: Being in a positive mood provides a better basis for tasks that demand daring and radical changes, like idea generation, while negative moods lead to a focus on detail and incremental work, e.g. idea validation. A positive mood arises in a secure environment, and being adventurous comes more easily in psychological safety, while negative moods like fear or anxiety promote the creation of safeguards (Amabile & Pratt, 2017, p. 168).

##### *4.1.4.2. Attitude and Mindset*

As discussed above, moods are not object related. So, even if they have a longer duration as emotions and could be persistent during a Design Thinking phase, there is still a factor missing. Therefore, research commenced to examine attitudes, seeking an affective relation towards a task, a problem or a target group in the Design Thinking process.

##### *4.1.4.2.1. Attitude*

"We define *attitude* as an overall evaluation of an object that is based on cognitive, affective, and behavioural information" (Maio et al., 2018, p. 4) or in short "a summary evaluation of an object of thought" (Vogel & Wänke, 2016, p. 2)[15].

The evaluated objects can be material – non-living and living – or immaterial. People build attitudes towards individual humans as well as small, distinct (e.g. team members) or big, ambiguous groups (e.g. ethnic groups) (Vogel & Wänke, 2016, p. 2). The attitude affects our perception of the evaluated object. Hence, it not only judges what is there but changes the information we gather, and – in a loop – biases the object's evaluation (Maio et al., 2018, pp. 67–68).

Early research included not only evaluation but also affect, cognition, and behaviour in its view of attitude. Today those three components are still closely linked to attitude, but are considered only probable companions (Bengal et al., 2018, pp. 357–358). Consequently, how a person thinks about an object (cognitive relation) is not inevitably connected to how she/he judges this object – even if there is often a strong link. Beliefs about an object form the attitude a person holds against an object (Maio et al., 2018, p. 39).

Most importantly for this thesis, attitude influences information processing. Attitudes can be activated instantaneously but can be altered through cognitive processes. Accordingly, an instinctive dislike can be changed to acceptance or even a positive stance through cognitive processes – that is the reflection about the object and its connection to its environment (Vogel & Wänke, 2016, p. 4). However, people attempt to keep consistency and so they filter out information that contradicts their attitudinal judgments and set priorities on ratifying data (confirmation bias) (Vogel & Wänke, 2016, p. 202). Whether we have a positive or negative attitude towards something is intimately connected to our perceptual fluency in the cognitive processes required by the object (Bengal et al., 2018, p. 374).

A "subjectively experienced ease at processing" tends to produce likes. New thoughts tend to trigger dislikes (Vogel & Wänke, 2016, pp. 61–62). Even open-minded people strive for stability in their lives. Innovation is considered to be precarious, and so the attitude towards a problem and a solution must be such as to stand the risk involved (S. B. Kaufman & Gregoire, 2016, p. 171). Not only the way we perceive and think, but also the way we store data is influenced by our attitude. We tend to remember information about facts that we appreciate more easily and in more detail than data that is linked to

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[15] Alike: "An attitude is an evaluative judgement about a stimulus object" (G. R. Maio et al., 2018, p. 5)

aversive objects, people or situations (Maio et al., 2018, p. 62). So, recalling details to negatively rated structures will fall short to positive ones.

Attitude and creativity are strongly linked. Canaan (2004) claims "Creativity is an attitude, not a mysterious gift "(p. 236). Sternberg (2019, p. 91) also describes "creativity as an attitude towards life" and lists various attitude-related methods to instil creative thinking (Sternberg, 2019, pp. 91–97). The creative self-belief of laypeople is strongly attached to their attitude towards openness and design tasks. So, changing their attitude can give them higher confidence (Batey & Hughes, 2017, p. 206; Plucker et al., 2019, p. 52). Creative confidence helps to tap their abilities and to boost their performance. If people alter the attitude towards their own creativity – *decide* to be creative, they can improve their performance significantly (D. Kelley & Kelley, 2015, pp. 75–77).

##### *4.1.4.2.2. Mindset*

Mindsets can be defined as a special kind of attitude: "A mindset is a mental attitude that determines how we interpret and respond to situations" (Mehregany, 2018, p. 32). Sobel et al. (2019, p. 1696) use an almost verbatim definition. Additionally, they specify Design Thinking mindsets as supportive models while striving to optimize cognition and affect in Design Thinking projects. The mindset influences the whole cognitive process from perception to processing to storage, our attitude, and our affective state (French, 2016, p. 676). It is, in fact, a cognitive orientation that determines how we handle a given task through a set of cognitive procedures (Achtziger & Gollwitzer, 2018, p. 491; Keller et al., 2019, p. 26).

Mindset in Design Thinking is an often mentioned and apparently important subject. John Arnold has already lectured on mindset. According to von Thienen et al. (2018, p. 17), Arnold specified "The creative mindset is characterized by problem sensitivity, fluency, flexibility, originality, daringness, drive and confidence."

The importance of mindset is also evident in the fact that some authors call Design Thinking a mindset in itself (Brenner et al., 2016; Kadam, 2018). Characteristic is the postulation of the one mindset that is required for Design Thinking (e.g. Baeck & Gremett, 2011, p. 231; Leifer & Meinel, 2019; Luchs et al., 2016, pp. 9, 164; Yen & Bouhdary, 2016, p. 5).

Very often, this one Design Thinking mindset consists of a set of mindsets, traits or attitudes. Tim Brown is often referenced for describing the mindsets that are relevant for Design Thinking in his fundamental article, but he talks about "A Design Thinker's Personality Profile" which is shaped with the five characteristics "Empathy", "Integrative Thinking", "Optimism", "Experimentalism", and "Collaboration" (T. Brown, 2008, p. 87). Sobel et al (2019, p. 1697) identify nine mindset attributes based on an earlier set of even eleven mindsets determined by the same research group in an intensive Design Thinking literature review (J. Schweitzer et al., 2016, pp. 74, 76). These distilled nine attributes consist of the four characteristics a Design Thinker should adopt ("be curious", "be collaborative", "be emphatic", "be optimistic") and five calls to action ("Reframe", "Embrace ambiguity", "Embrace diversity", "Make tangible", "Take action") (Sobel et al., 2019, p. 1697).

The importance of mindset in Design Thinking is again strengthened by Kelley and Littman (2016a, pp. 59–60) who ascertain that not being in the right *mode* can weaken a Design Thinking session immensely.

#### 4.1.5. Discussion and Conclusion to the First Cycle's Results

The emotion recognition data did not reveal much significant data. The detection values of anger, contempt, disgust, fear, and surprise never exceeded 50%, only sadness (2%) and happiness (10%) showing distinct results.

Emotions relate to a specific object or event, and are ephemeral, lasting only a short time (Brandstätter et al., 2018, p. 164). For this research, more persistent states are needed and relevant as the investigation is geared towards the way participants act and think during longer tasks of the Design Thinking process, like a judgement-free, emphatic collection of data at one time and systematic, evaluative selecting and rejecting of data at other times (e.g. Liedtka et al., 2017, pp. 269–271, 286–291).

Additionally, the research showed that in opposition with numerous research and projects (e.g. Ekman, 2007; *Microsoft Cognitive Services - Emotion API*, 2016) emotions are not reliably detectable, particularly outside laboratory conditions, taking into account only the facial expression and involving multicultural participants (Barrett et al., 2019, p. 46; Burkitt, 2019, pp. 6–7).

One and the same emotion can lead to various expressions and behaviours, depending what seems to be the best in the given situation (Barrett, 2017b, p. 35). Emotion and the expression of emotion is learned and varies with social environment and age (Hoemann et al., 2019, pp. 1832–1833; Plate et al., 2019, p. 1824). People are able to mimic false emotions (Ekman, 2017, p. 51) and often do this because of cultural affordances or because of an image they want to keep (Brandstätter et al., 2018, p. 164). The complexity of expression easily leads to wrong interpretations of emotion. So, the relatively high factor of the sadness area (in relation to the other emotion detection from the author's study) might source partially from scowling because the student was highly concentrated (Barrett et al., 2019, p. 4). Not only creating an emotional expression but also reading them must be learned. "Perceptions of emotion are guesses, and they're 'correct' only when they match the other person's experience" (Barrett, 2017b, p. 195). Still, even if people know in theory that detecting emotions or other clues in faces is highly prone to failure, they instinctively believe in what they detect, trusting their own judgment over the scientific proof that this is deceptive (Todorov, 2017, p. 261).

Emotion with a high valence is a strong affect that distracts cognitive procedures. The brain prioritises cognitive procedures that are needed to act on the given intense affect (Hoemann & Barrett, 2019, p. 68), and strong emotions can distract from concentration in the ongoing task and be highly unwelcome (Straub et al., 2019, p. 1). An analysis of the agitation level (sum of non-neutral emotions) in Project One showed distinct ups and downs. The observers of Project One agreed that low-level agitation phases tend to be more productive. Interestingly, sadness-levels showed some peaks during these time frames and might originate from the scowls of concentration mentioned earlier. So, to investigate if the agitation hypothesis holds true and if so, how to keep the emotional level low might be a fruitful endeavour.

The limbic map, with its very detailed emotional and attitudinal terms, might also be problematic for this thesis, as some terms might have different meanings for different people. Furthermore, people can only indicate how they feel, not what they emote, because the latter is not a conscious affect (Burkitt, 2019). Researching into further affective states showed that feelings (see chapter 4.1.4.1.2) are also not suitable, as they are expressions not only of emotions but also of interoception to body and mind (Sander et al., 2018b, p. 239). Mood (see chapter 4.1.4.1.3) also did not fit, even if it might have a suitable duration for a Design Thinking phase, because moods are not geared toward a specific object but are very personal and are typically based on a multitude of elements (Bucurean, 2018, p. 242).

Attitudes are judgements about objects (Maio et al., 2018, p. 5; Vogel & Wänke, 2016, p. 2). As they are accompanied by cognition, affect and behaviour (Bengal et al., 2018, p. 357), they seem to be good candidates to investigate how people perceive subjects and think about them. Attitudes change the way we look at and think about people, situations and data (Vogel & Wänke, 2016, pp. 201–221), or, rephrased for Design Thinking, how they interact with the problem space and the solution space. Cognitive biases are good evidence of this statement. For instance, data that fits with existing attitudes weighs more heavily than data that contradicts prevailing concepts of people or situations. There is also a tendency to prefer success stories over failures, even if the failures are backed by more reliable data (Greene, 2019). People judge easily and quickly and draw conclusions from this first judgment. Previous experiences can be heavily persistent and affect the judgment (Kahneman et al., 2018, p. 109).

As discussed in chapter 4.1.4.2.2, a mindset can be defined as a mental attitude, that is, an intellectual not a physical attitude. Additionally, mindsets are adaptable and can be altered in a short timeframe.

They can change radically according to the situation (Klein, 2016). As mindsets are a well-known model in Design Thinking that is often used to understand and to guide the phases, tasks, and procedures (Tschepe, 2017), it is sensible to continue research in this direction.

So, the second cycle of this thesis research will investigate if and how mindsets need to adapt during a Design Thinking project.

## 4.2. Second Cycle

### 4.2.1. Second Cycle Concept

Having identified *mindset* as the subject of investigation for the second cycle, this chapter describes the developed concept based on the literature review and the observations of the previous projects.

Most literature in Design Thinking describes one mindset or a set of traits demanded for all sequences of a Design Thinking project (e.g. Betancur, 2017; Brenner et al., 2016; Lewrick et al., 2018b). However, the Design Thinking process demands such various tasks that this single-mindedness seems questionable. Furthermore, Csikszentmihalyi (2013, p. 56) described the idiosyncrasy of creative people as complexity. He emphasized the dichotomy and versatility of the creative mind, listing and describing ten opposing characteristics (see *Table 16*) that determine the creative spirit (Csikszentmihalyi, 2013, pp. 58–73). He particularly mentioned the fact that creativity demands clear standpoints, disallows indifference or "a golden mean" (Csikszentmihalyi, 2013, p. 57), and that creativity is built by the shifts from one side of a dichotomy to the other (Csikszentmihalyi, 2013, p. 76).

*Table 16.* An Overview to Csikszentmihalyi's Characteristics of Creative People

| **Contradictory traits of creative people** | |
|---|---|
| have a great deal of physical energy | are also often quiet and at rest |
| tend to be smart | [tend to be] naïve at the same time |
| discipline and responsibility | playfulness and irresponsibility |
| imagination and fantasy | a rooted sense of reality |
| extroversion | introversion |
| humble | proud |
| escape this rigid gender role stereotyping | |
| rebellious and iconoclastic | traditional and conservative |
| passionate | objective |
| suffering and pain | a great deal of enjoyment |

After (Csikszentmihalyi, 2013, pp. 58–73)

Corazza and Agnoli (2016, p. 14) also describe the contradictory structure of creative skills and the demand to create a curriculum to teach young designers how to handle the dichotomy. A further highly interesting example is the eight *personal creative modes* (see Table 17), developed by Douglass J. Wilde, that create a matrix with C.G. Jung's cognitive functions conceptual and factual perception, plus objective and subjective judgement using extraversion and introversion – Csikszentmihalyi's fifth dichotomy – as a modifier (Kim et al., 2010, p. 46).

*Table 17.* Eight Personal Creativity Modes

| | Perception | | Judgement | |
|---|---|---|---|---|
| | **Conceptual (Intuitive)** | **Factual (Sensing)** | **Objective (Thinking)** | **Subjective (Feeling)** |
| **Extroverted** | Synthesizing | Experiential | Organizing | Teamwork |
| **Introverted** | Transforming | Knowledge-based | Analysing | Evaluating |

Source (Kim et al., 2010, p. 46)

Creative people are found to change their behaviour and attitude as the situation demands (Kaspi-Baruch, 2019, p. 326). The ability to switch to different identities, even to lead a dialogue between those identities gives the creative person the capacity to distance himself/herself from the situation emotionally and the ability to adopt the position of individuals that are affected through the handled situation (Vlad P. Glăveanu, 2017, pp. 125–126). Design Thinkers need to be aware that they must switch the way they approach a task during the process and that they need to think differently about the problem and the solutions while developing a solution (J. Schweitzer et al., 2016, p. 79).

Three mindset-pairs build the foundation of the second research cycle:

– *Collecting* versus *selecting* elements, may it be information, ideas, solution variants:
  This is not identical to divergent and convergent thinking, as it focuses on the mere gathering and elimination of elements. Inquiring for additional design constraints during the *Understand* phase, for instance, also belongs to *collecting*, as does the gathering of ideas (Studer et al., 2018, p. 424). Similarly, combining ideas in a novel way will need lateral thinking, while still reducing the set (Lewrick et al., 2018b, pp. 101–102).
– *Analytical* versus *imaginative*. The structure was inspired by the Design Thinking model of Kuznicki (2013) who split the process into two areas (see *Figure 66*) of problem and solution finding. Linda Naiman (2019) also points out that Design Thinking includes both analytical thinking and imagination, using rational reasoning and inference as well as fantasy, playfulness and intuition. Analytical thinking is relevant to dissect a given situation and find its relevant details while imagination helps in finding goals, creating ideas and crafting prototypes (T. Brown, 2019, p. 75).

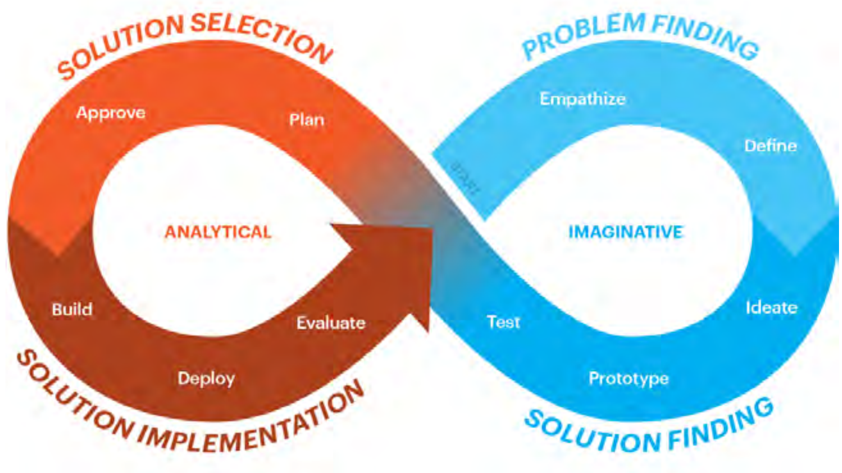


*Figure 66.* The Moment Innovation Framework – Source: (Kuznicki, 2013)

– *Experimental* versus *Observant*. The concept behind this mindset-pair was the diagnosis that perception plays an imminent role in creative problem-solving. Additionally, Csikszentmihalyi's extroversion/introversion trait and the idea that the introversion phase also needs and gives space for play and construction lead to this combination[16]. Beckmann (2020, p. 146) also proposes experiment and observation. She assigns experiment to an active and observation to a reflective phase.

Applying these mindsets to the individual phases:

UNDERSTAND:

As the point of this phase is to comprehend the task given to the Design Thinking team (see chapter 3.1.6.2), the minds should be set to a collective, analytical and observant stance. *Collective*, to make sure that all information of the project briefing is really captured (Stickdorn, Hormess, et al., 2018, p. 102); *Observant*, because the team first needs to see exactly what the problem is they are given (Lewrick, 2018, p. 46); And finally, *analytical* to first check if all relevant information is there and comprehensible and, where required, request more information, second, make sure there is a shared understanding of the given problem throughout the team (Liedtka et al., 2019, pp. 10–11), and third, develop a research plan for the next phase (Gerstbach, 2017, p. 61).

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[16] Wilde's personal creativity modes were not known to the author while developing this concept, but the presented pair matches to some degree with Wilde's conceptual perception modes (Kim et al., 2010)

It is important though, that the analysis of a project is not overstressed, as the problem might be wicked and it is not possible to fully understand the task. Design Thinkers must be able to let go and live with this ambiguity (D. Kelley, 2019). It might be advisable for the facilitators to switch to a visionary mode for some time to show how meaningful the project can be for a better future with the new solution (Amabile & Pratt, 2017, p. 163).

The tool 'Foresight' was fitting with the situation in Project one, as it gave the students very fast access to the needed information. The high speed of the task demanded focus but prevented overthinking. While using the second tool, 'Taylor Challenge', they grasped the given information quickly and analysed it to reach the first creative question.

OBSERVE:

As the name of the phase indicates, observation is the heart of this phase. Collecting information, surprising acts, and empathic resonance make up the second important element (Doorley et al., 2018). The information treatment should be rather more analytical than imaginative. Though, during observation, the mind should be genuinely focused on observing and not on reflecting on the witnessed facts: It demands for "a focused, nonjudgmental awareness of the present moment" (S. B. Kaufman & Gregoire, 2016, p. 102). To use analytical reflection is mainly stipulated around the observation phases. Selecting the right people to watch, to identify how to research and to infer first conclusions from the observables needs an analytical mind (T. Brown, 2019, pp. 49-50,112).

Understand and Observe seem to have the same mindset profile. But while in the *Understand* phase the analysis is salient, the Observe phase demands mindful observation with minimum cognitive treatment of the information.

The author draws here also from her own experience. It is essential to *stop thinking* while observing in order not to miss out. Still, a bit of analysis helps to discern the next questions or to find out what to watch.

DEFINE:

As described in chapter 3.1.6.4, the *Define* phase is rather complex, with four sub-phases that demand different approaches. Categorically, the goal of the phase is to condense the given information in the preceding phases to create a potent creative question (Luchs, 2016, p. 6). Even if the data needs to be soberly analysed, a good point of view also needs imagination to achieve a question that really answers the target group's needs (Lewrick et al., 2018b, pp. 84, 87).

The survey with the limbic map shows that the students, apart from two outliers, are drawn towards Dominance in this phase (see *Figure 64*, page 164). This attitude can be interpreted as an appropriation of the task: The student's own thought is important here; not so much what others think or do.

Understanding the observed people with reflective tools like What-How-Why or WWWWWH (Curedale, 2019, pp. 318–319) and synthesizing the data into personas, journey and system maps, jobs-to-be-done, etc is clearly *selective* (Stickdorn, Hormess, et al., 2018, pp. 128–131). Generating possible creative questions is *collective*, going back to *selective* when choosing/developing the one question for the next task (Luchs, 2016, p. 6). Liedtka (Liedtka, 2018, p. 77) coined this task 'Alignment' and asks "If anything were possible…" clearly indicating the imaginative sentiment of this step.

Mateus' framework (2016, p. 288 see also Figure 30) delivers a better structure there, as it divides Define in two distinct phases that align with the observations described in this paragraph. The subdued mood in the middle of the phase (see indicator ① in *Figure 62*, page 162) was probably caused by the disruption in the task at this point. For the purpose of this research the author sticks to the basic IDEO process that focuses on finding the point of view as the bridge into the solution space (Cross, 2018b, p. 703; Plattner et al., 2009).

IDEATE:

The mindsets for this phase are geared towards imagination, collection and experiment, adding as many ideas as possible and staying concentrated but relaxed (Firth, 2019, p. 5). The macro-trait plasticity (see chapter 3.3.2.1) including openness and extraversion, can play to its strengths in ideation (Feist, 2019). Ideation quality and quantity rises when the team has the freedom for experimentation (T. Brown, 2019, p. 79).

Dumping ideas (e.g. writing them on post-its) helps the collective mind, as it makes space for additional ideas and provides potential sparks of inspiration for the team members. Switching perspectives means experimenting with different views (Osann et al., 2018, p. 67). Relentlessly sticking to the given task, trying all variants that come to mind and helping to gather what solutions come to mind is a liability for every team member, no matter his or her position or professional competence (Gregersen, 2018, p. 71). De Bono advises to think more about the potentials and possibilities than about what is there already, thus speaking for an experimental and visionary approach (de Bono, 2016a, p. 111).

This also meets with the author's own experience and with the discussion in the first project with Professor Mateus. It is a time for play and wild imagination, but also a time for seclusion where additional information or influence from outside the team is rather hindering. Even if the demand is to collect many ideas, this spurs ideation and eventually leads to unexpected results. For instance participants try to draw solutions from other domains, applying for instance an effect observed in nature to a technological problem (biomimicry) or combine two different small ideas to something bigger.

After ideation, but typically assigned to *Ideate*, still, follows idea sorting and selection, or in the Four-Questions framework "Develop Concepts" (Liedtka et al., 2017, p. 276). In this step, *collecting* changes to *selecting*, but it is still *imagination* and *experiment* that is mostly required as the team does not just weed out but looks for potential and creative combinations (McCarthy, 2017, p. 90). Thinking about opportunities, and creating interesting arrangements, finding synergies makes these tasks into inventive challenges (Liedtka et al., 2019, p. 28,72).

The limbic-map survey (see *Figure 64*, page 164) shows a split impression here. While part of the teams felt they were in the *creative* area of the map, the other part grouped in the *discipline* section. This indicates that the students also perceived this phase as divided.

PROTOTYPE

Prototyping is analytical, experimental, selective. "Prototyping – the willingness to go ahead and try something by building it – is the best evidence for experimentation" (T. Brown, 2019, p. 94). A prototype embodies a concept, makes it tangible and ready for testing. As such, the phase needs to analyse the given solutions, select the features that should be testable and transform thoughts into products (D. Kelley & Kelley, 2015, p. 130).

The author's impression was that the students highly enjoyed this phase. The transfer from concept to visualization demands good analysis and some trial and error to really express the core of the solution. The experience that a minimal prototype must be reduced to the core concept is often demanding but also inspiring in Design Thinking projects.

TEST

Testing is about evaluating and optimizing the solution. The term 'Learning Launches', used in the four-questions framework, represents the goal of a *Test* session clearly (Liedtka et al., 2019, pp. 38–39). Each *Test* must have a dedicated purpose to make sure that the right prototype is handed to the right people and that observation is focused on the right issues (Stickdorn, Hormess, et al., 2018, pp. 221–213).

The focus for the design team is to observe the people who are testing the prototype (Doorley et al., 2018, p. 57 card 22), to analyse the feedback and to select the elements that work and should be refined (T. Kelley & Littmann, 2016a, p. 112).

The limbic-map for this phase shows all students in the Discipline/Control area, with a significant cluster at *functionality*. The students obviously took the testing very seriously and tried to strive towards optimization of the solution. This needs analytical thinking and filtering out of ideas that did not work.

Figure 67 shows a visualization of the desired mindsets through the Design Thinking phases. As seen in the descriptions, these mindsets are only the prevailing mindsets, with short changes to other attitudes where needs be. Nevertheless, for a facilitator, it should be beneficial to know where to lead the team in order to achieve their best results.

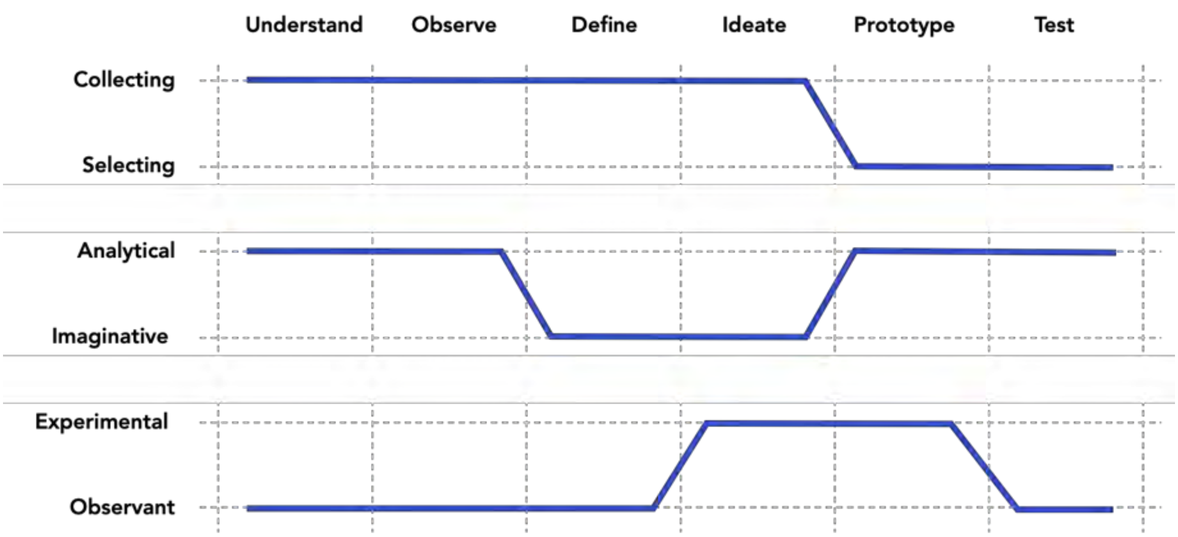



*Figure 67*. The Main Mindsets Through the Design Thinking Phases – Devised by author

The informal hypothesis for this cycle is: "The way to think and act during the phases of Design Thinking projects can be best determined by mindset pairs."

### 4.2.2. Project 2 – IPAM, Porto 2017

The project was conducted at IPAM – Instituto Português de Administração de Marketing, in a masters course in design. The course's goal was to introduce the students to Design Thinking. The class consisted of ten students, all regular students of the masters program with English as a foreign language.

The research goal was the observation of the behaviour of students in the intense, hands-on setting that led them through all six phases of the IDEO framework in one day. Additionally, it gave the author the possibility for a first evaluation of the second cycle concept.

*Table 18* shows the research plan for IPAM. The implemented tasks and their sources are outlined in the appendices. Discussion and survey mainly took place after the project. The core was observation and discussion.

*Table 18.* Project Two – Research plan – Porto, IPAM, 2017

| IDEO phase | ideas(r)evolution | Implemented tasks | Research methods |
|---|---|---|---|
| | | Warm up – Ball throwing stories | |
| Understand | Involvement | Presentation and discussion | Project observation & photography; Survey |
| Observe | | Ethnographic interviews | |
| | Inspiration | Roots | |
| Define | | Critical success factors | |
| | | Warm up – ball game | |
| Ideate | Ideation | Brainwriting/brainstorming<br>Windmill | Discussion |
| Prototype | Integration | Poster-presentation<br>Visualize | |
| Test | Implementation | Personas<br>User stories | |

Developed by author

#### *4.2.2.1. Project Description*

The class started with a short lecture on Design Thinking. As the students did not know the lecturer and the situation, the next step was a warm-up game to make the students more confident. After that, the task was presented with a TED-speech (Pariser, 2011): "Beware online 'filter bubbles'". The students were asked to think of a way to deal with the given information. They were not asked to solve the issue, to avoid it, etc., but only presented with the situation itself. After that, they had one hour to become familiar with the problem and to interview people on the university premise.

The tasks were carried out as described below, with a second warm-up after the lunch break. Finally, the students presented their solutions and received some feedback on their work. Then, they were asked about the experience and their thoughts on Design Thinking.

The tasks assigned to the teams included:

FIRST WARM-UP/ACTIVATION GAME

- *Ball throwing stories* help to activate creative confidence and loosen up the group (Thiesen, 2012, p. 81). The facilitator starts a story with one or two sentences and throws a ball to a random participant who continues the story and passes the ball to the next person.

OBSERVE

- Due to the short timeframe, the research was conducted as *autoethnography*, *online ethnography* (Stickdorn, Hormess, et al., 2018, pp. 119–120) and short *interviews* at the university. The goal was to show the students the importance of these experiences in a condensed way.

- Roots (Mateus, 2016, p. 315) helps to organise research findings in an efficient way, using 5 categories and time lines to get a quick overview. The goal is to find influences on and from the desired solution of the project.

DEFINE

- Critical Success Factors (CSF) is a tool to collect the evaluation of the ideas developed in the last task (Mateus, 2016, p. 318). Through individual assessment and then sharing and reaching consensus in the team, this tool allows equal votes from every team member and helps avoid biased judgement through the discussion.

SECOND WARM-UP/ACTIVATION GAME

- *Saudade and Desenrascar* is an adaptation of 'The last Samurai' (Gerstbach, 2017, p. 251). The goal is to activate the participants, in this case after the noon break, and to loosen them up a bit. It is a mix of ball throwing, word calling and running around, that inevitably leads to laughter and slightly out of breath people.

IDEATION

- *Brainwriting and Brainstorming* (Stickdorn, Lawrence, et al., 2018, pp. 115–119) work well together as they give each person the possibility to express their ideas without getting distracted and still use the power of mutual inspiration. After some minutes of brainwriting, the team shares their ideas and brainstorms on them, then gets back to brainwriting and finally brainstorms again.

- The tool *windmill* (Leonor et al., 2017, pp. 16–17) helps to organise and condense the ideas into concrete concepts. Similar to CSF, it is a democratic method to reach mutual agreement for the solutions that will be refined in the next steps.

PROTOTYPE

- To visualize an idea in a scribble or drawing is a very basic way in prototyping, helping to get quick results (Liedtka et al., 2019, pp. 80–81). Even rough sketches help to understand and verify the concepts and to feel more motivated, as the team created something perceivable.

TEST

- *Personas* and *User stories* or user journey maps (Hanington & Martin, 2019, pp. 244–245) are typically used in *Observe* or *Define* to get a better understanding of the affected people. But in situations where direct testing is not feasible, both can help to identify weaknesses and gaps. The students had to think of possible situations where their solution was active, in order to devise a sequence of events that might happen, and finally to think of obstacles and annoyances that might prevent the solution from being effective.

#### *4.2.2.2. Data Gathering*

##### *4.2.2.2.1. Observation and Photo Documentation*

The students were highly interested in the subject and willing to take an active part. But it took the morning to get them to follow what the teacher told them to do in a more responsible and active position. It was not possible to observe their mood through all stages in a reliable fashion but there were some points that are remarkable:

Both warm-up games worked to get them in a better state to work actively and as a team. Yet, the first game (chain stories) intimidated them a bit, demanding creative thoughts right from the start. It seems advisable to use such a game only after building some trust and self-confidence. The second game led to much better results, as it required their full attention but was not very creatively demanding, while having distinct action and fun factors. The activity really changed the mood in class and left them motivated.

The difference in how the students dealt with the tools Roots and Windmill were highly remarkable. Roots is at the intersection between *Observe* and *Define*, at least partially in the groan zone. The students seemed very reluctant and insecure in this phase. They appeared a bit withdrawn, even distancing themselves from their team members (see *Figure 68*).

*Figure 68.* Project Two – IPAM Students During Roots Task – Photography by author

Even if they had a lot of data to share, this happened without much interaction. The motivation to solve the problem seemed low.

*Figure 69.* Project Two – IPAM Students During CSF Task – Photography by author

This changed remarkably when they started working on the solution space. *Figure 69* shows a typical situation. They started to work more as a team, laughed more and discussed more freely.

Also interesting was how a rather rough approach to drawing the solution led to all team members being involved in working on the poster, while the attempt to draw a more sophisticated version left one student doing most of the work while the others just watched (see *Figure 70*).


*Figure 70.* Project Two – IPAM students working on their poster presentation
Photography by author

The presentations were lively and positive. The fact that both teams started to add some elements to their posters when the position of the posters changed from horizontal on the table to vertical on the pin-board was very interesting. They saw new or forgotten elements but also new points that they felt were worth adding.

The final discussion about the project was quite short because the students were exhausted. They liked the course and felt they learned a lot, but they were incapable of recalling details and talking about them.

*4.2.2.2.2. Survey*

Unfortunately, the students did not want to participate in the survey, feeling a bit overwhelmed with the mass of information they had received on that day. The data is therefore not applicable to the research.

### 4.2.3. Project Three – FHV Dornbirn 2017

The project was conducted in an elective class in the design program InterMedia at FHV Dornbirn. There were 18 students with 10 regular students and 8 guest students from other countries. The class was carried out in one week with a full workload for all five days.

Prof. A. Mateus led the class, the author assisted. All tasks were according to the ideas(r)evolution methodology described in (Leonor et al., 2017; Mateus, 2016).
*Table 19* shows an overview of the research plan. The following subchapters provide information about the project. Further details see Appendices A.3.

*Table 19*. Project Three – Research Plan – Ideas(r)evolution Design Bachelor Class, Dornbirn 2017

| IDEO phase | ideas(r)evolution phase | Role model / archetype | warm-up activity | Research methods | | | |
|---|---|---|---|---|---|---|---|
| Understand | Contextualize | Child | What is their color? | --------- Project observation & photography --------- | ---Paper based Surveys: Semantic differential --- | Discussion ---------------------------------- | |
| Observe | Observe | Detective<br>Sherlock Holmes | What changed? | | | | |
| | Understand | | | | | | |
| Define | Inspiration | Diagnostician<br>Dr House | Candle on the wall | | | | |
| Ideate | Ideation | Artist<br>S. Dali | Ball throwing stories | | | | |
| Prototype | Integration | Inventor<br>Da Vinci | Marshmallow challenge | | | | |
| Test | Implementation | Judge<br>Justitia (sighted) | Charmer and critic | | | | Final evaluation form |

Developed by author

#### *4.2.3.1. Project Description*

The class had a practice-oriented focus, with short impulse lectures and extended learning in the project. The lecturers coached the students as needed during their work. The task was presented as a challenge: The students should think about the relation of Millennials to the brands they love. There was no problem issued and no precise task defined to empathise the freedom the students had in identifying their own task and problem statement.

The students in this class were divided into three teams that worked in separate rooms, only receiving the lectures together. The students could choose freely which group they wanted to belong to, the only demand being evenly sized groups. The author tried to find out if the application of warm-up games or role models had an effect on the group's performance. So, group 1 – named ZOE – just received the class as planned through Prof. Mateus. Group 2 – Package – was introduced to role models/archetypes for each phase; the third group – Happy Cow – started each task with a warm-up activity. The group names were created/assigned by the group members.

Each role model was introduced with a short story, explaining what is so special about this real or artificial person and why he[17] is fitting as example how to think and act. Additionally, the group received a poster with the image of the representative to remind them during the task of their paradigm. The selected images were chosen for their iconicity and intensity.

For the third group, each phase started with a fitting activity and a short reflection afterwards. The activity was closed with a short summary of the key learnings.

#### *4.2.3.2. Data Gathering*

##### *4.2.3.2.1. Survey - Semantic differential*

The survey was designed as a semantic differential questionnaire for each of the three mindsets of the second cycle concept (see *Figure 71*). Additionally, the students could indicate the team they worked in.

**Diagnostic**

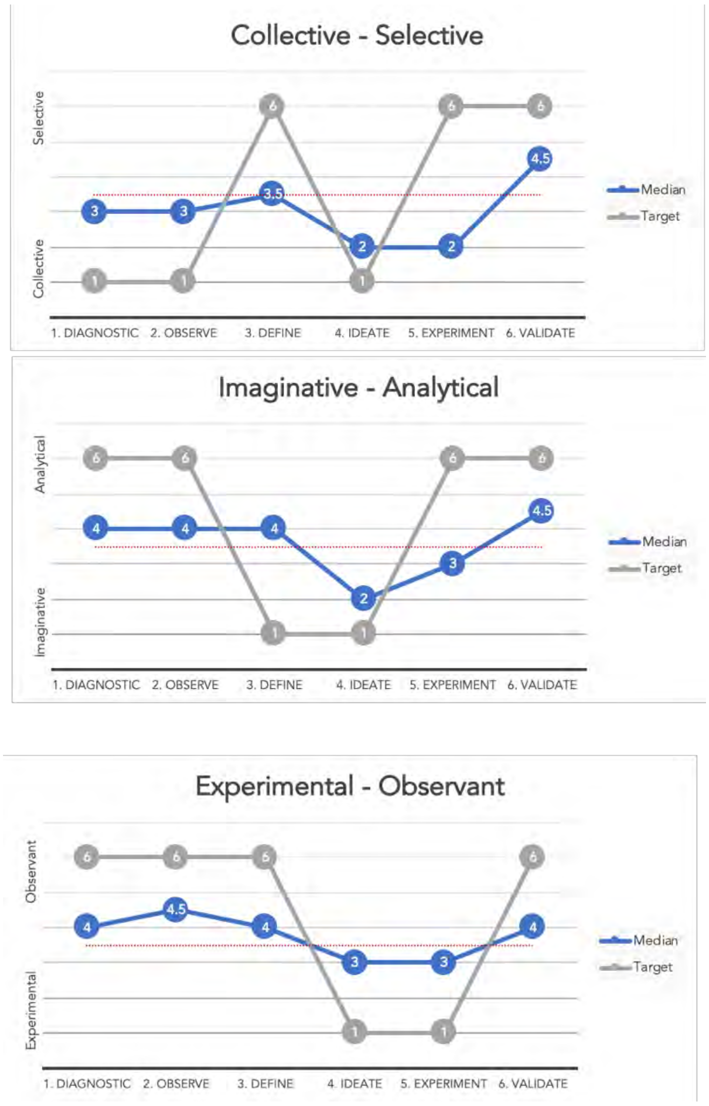
| | | |
|---|---|---|
| collective | o ........ o ....... o ........ o ........ o ........ o | selective |
| visionary | o ........ o ....... o ........ o ........ o ........ o | analytical |
| experimental | o ........ o ....... o ........ o ........ o ........ o | observant |

*Figure 71.* Project Three – Extract from the Questionnaire SS2017 – Devised by author

At the beginning of the class, the students received paper forms to fill out through the class. They were reminded after each phase of the project to check the fields they felt were appropriate to the completed sequence. Two of eighteen students did not hand in the survey, three did not indicate their team. So, there was not enough data to split analyse the data in teams. The result of the handed in

[17] The author only realized in the very last round of proofreading that she only chose male role models. She apologises with all her heart. This should not have happened. She promises to develop a set of female role models as she already should have done.

forms gave an indication that the used concept might resonate with the impressions of the Design Thinking participants.




The grey 'Target' line depicts the values assumed in the second cycle concept.
The blue line shows the median value from the student survey.

*Figure 72.* Project Three – Survey Result – Showing the Median from 16 submitted forms – Devised by the author.

With sixteen participants the results can only show an indication for the concepts.

As semantic differential values are ordinal, the results are computed as median values (see *Figure 72*) and controlled via the chi square test (Eid et al., 2017). The chi square test was positive with 96 to 98 % for each factor. As the number of entries is so small, these calculations would not pass a validity test and were only conducted out of curiosity. With the exception of the collective-selective and imaginative-analytical values for the *Experiment* phase, and the collective-selective value of the *Define* phase, all values showed a tendency towards the conceptual values.

Thus, it can be presumed that the students felt a draw towards the mindsets that the research concept identified as required for the given phase. Due to the small number of participants, the researcher decided not to split the data into the three groups.

##### *4.2.3.2.2. Observation and Discussion*

Observations were made and discussed by the author and Prof. Mateus. The three team's results did not differ much. The role-model-group seemed to be the most motivated group with rather more laughter and lively discussions than the others. The games group was more restrained and less active. All groups were very productive and dedicated. Unfortunately, another class the students had to attend scheduled a major exam (delivery of a design task) for the week of the project. This led to a considerable distraction and noticeably influenced the outcome of the teamwork noticeably.

The unfamiliar task, various tools as well as the freedom to research as they wished was not always welcome. The students needed to find their own way and did not feel as guided as usual. The role models seemed to help with this. The story that came with the archetypes also was considered as a guide.

The lecturers consulted the concept of this research phase regularly and compared it with the action in class. There were some indications that the concept has its merits, but did not really match what could be observed. Especially the all-encompassing model of mindset did not fit well with the behaviour. The action seemed too fleeting and too variable to fit the view of mindset the observers had in mind. The contradictory structure and the prevalence of one pair-element mostly fit well with the phases and the execution of the project. There were some noticeable weaknesses in the *Define* and *Prototype* phase that needed to be addressed. All in all, the concept was promising.

The final discussion indicated that the team with the role models was the most satisfied with the project and also felt that they learned a lot. The warm-up activities group was not that happy, feeling overwhelmed with the information and the task. Discussion showed that the activities were considered a bit too much and enhanced the overload they already experienced. Still, some of the warm-ups were rated as interesting and inspiring – namely the 'marshmallow challenge' and 'candle on the wall'.

##### *4.2.3.2.3. Final Evaluation*

The class and project were received well by the students. Their overall evaluation was positive. All three groups graded the class approximately evenly. The two altered groups offered considerably more positive remarks than the test groups. The role-model-group offered more detailed positive feedback than the other groups, especially lauding the learning and group dynamic. In the activities-group, the most used word was ‘interesting’ in their feedback. The control group’s feedback often focused on the product/project result.

The negative feedback of the control group was the wordiest, concentrating on time-management. Throughout all the feedback, time pressure in the project and through other demands led to most of the complaints. The role-model class was extremely distracted by the Print midterm exam.

Talking to them led to more results. All were positive about the first day (dedicated to *Understand* and *Observe*) but felt frustration with the second day (*Define*, *Ideate*). The first day was the hardest for the first group, who did not feel that secure in their task. The second day the role-model group felt ineffective and a bit lost. Asking them about the role models (especially the diagnostician/doctor (Dr. House)) did not reveal any connection. The role model function did not work in this case. In contrast, Sherlock Holmes for the *Observe* phase and Da Vinci for *Prototype* led to smiles and positive remarks (“We are investigating!”, “Now we are getting somewhere.”, “Let us try this differently.”). Day 3 with *Test* and *Iteration* was the best day of the project for all the teams, working intensely together and immersing themselves deeply into the task.

### 4.2.4. Second Cycle – Literature Review

The observations in the second cycle showed that the nature of mindset needs further investigation to evaluate its appropriateness for this research. Secondly, the research needs more information about the way a task can be guided to lead to the best interaction between the challenge and the team. Finally, the mindset-pairs need to be scrutinized and revised for the next research cycle.

#### ***4.2.4.1. Mindset***

As already discussed in chapter 4.1.4.2.2, mindset can be defined as mental attitude. But there are also other approaches to the subject.

A pioneer in cognitive research on mindset is Peter Gollwitzer, who has worked on mindset since the 1970s (French, 2016, p. 675). Achtziger and Gollwitzer (2018) define mindsets along the Mindset Theory of Action Phases: “The term ‘mindset’ describes a certain kind of cognitive orientation (i.e., the activation of distinct cognitive procedures) that facilitates performance of the task to be addressed in each action phase" (Achtziger & Gollwitzer, 2018, p. 491). With this theory, a mindset can change in an instant to fulfil the task needed in a given situation, switching from deliberative, to planning, to action oriented, and to evaluative (Achtziger & Gollwitzer, 2018, pp. 491–493). Target oriented persons that cope with a challenge are able to modify the cognitive procedures supporting the goal – their mindset to the task – to be optimally attuned to the job (Keller et al., 2019, pp. 29–30).

Other definitions of mindset focus on human beliefs. According to Dweck and Molden (2017) a mindset is "a network of beliefs and goals that work together to produce important behaviours and outcomes; … the meaning systems that give rise to the behaviors and outcomes we care about" (C. S. Dweck & Molden, 2017, p. 135).

Zion and Crum (2018) add the origin of beliefs as "a lens or frame of mind that orients an individual to a particular set of beliefs, associations, and expectations, and functions to guide attentional and motivational processes" (Zion & Crum, 2018, p. 141). Bernecker and Job (2019, p. 180) define mind-sets as *implicit theories* – firm convictions about human features typically held by laypeople. Most of these convictions are built during childhood and are resistant to longer-term modification.

It is possible to nudge them for a short period of time, but rarely to sustain change (Bernecker & Job, 2019, p. 182). The definition that a belief is an attitude towards a proposition (Schwitzgebel, 2019) loops back to Maio's definition (see chapter 4.1.4.2.1) that beliefs form attitudes.

Karwowski and Brzeski (2017, p. 367) define a creative mindset along the lines of implicit theories, but confine it to those implicit theories that are geared towards creativity. They propose, that people can hold both fixed and growth mindsets on creativity, but only when they are highly involved in creativity and are aware of its complexity. These people are convinced that people can have some creative abilities that are not changeable, and other creative abilities that can be activated and modified with the actual need (Karwowski & Brzeski, 2017, pp. 372–373). This approach equates mindset with a trait, that might be perceived as changeable or not (Karwowski et al., 2019, p. 43).

When Tom and David Kelley talk about *creative confidence* in their thusly named book, it is the growth mindset, the belief that abilities can be raised through determination for creative abilities that is in the centre of their explanations (D. Kelley & Kelley, 2015, pp. 30–32). Those people in creativity tests who perceived their creativity as highly malleable and minimally static, achieved best grades in creative abilities like insight and lateral thinking. So, it is suggested that the creative mindset – i.e. the implicit theories – affect creative performance (Karwowski et al., 2019, p. 45). This is confirmed by research results which show that creative self-belief is self-confirming. When people expect themselves to be creative, they are more active, perceptive and engaged in divergent thinking, find better information and create more and higher quality ideas than people who think they are not creative (Liu et al., 2019, p. 4). Additionally, people with a high creative self-belief tend to have a more radical cognitive style and thus more radical solutions (Liu et al., 2019, p. 8).

There is also disagreement as to whether mindsets are stable or flexible. "While our mindsets can be shaped by an intentional awareness, they are also largely driven by our experiences and what we are (intentionally or unintentionally) exposed to" (Bosman & Fernhaber, 2018, p. 8). Furthermore, when people get accustomed to their mindsets, these mindsets shape their identity (Klein, 2016, p. para 8). Yet, Klein (2016, p. para 12) stresses the fact that mindsets can be altered astonishingly quickly and with significant influence on future actions. For instance, switching one's belief about the malleability of a personal trait is a powerful alteration that can have life changing consequences (C. S. Dweck, 2019, p. 23). This change can happen almost instantly or needs some time to let go of the old, versant belief (C. Dweck, 2017, p. 231). Attitude oriented mindsets change differently: Fraser (2019) describes various mindsets that should be prevalent during different design phases, shifting from positivity and open mindedness, to empathy, and courage (Fraser, 2019, pp. 54, 72, 110). Bosman and Fernhaber (2018, p. 8) as well as Groeger et al. (2019, p. 10) state that mindsets can be developed and altered through coaching and learning activities. In sum, a change of mindset is possible, but short nudges don't lead to long-lasting changes – training or altered beliefs might.

Mindsets are supporters of cognitive functions. They help us be more efficient and focused on our actions by directing our attention, suggesting goals and courses of action (Klein, 2016, para 8). Mindsets are "how an individual thinks or is inclined to think" (Carlgren et al., 2016, p. 42). Thinking is the centre of mindsets and it is in the centre of Design Thinking. So, it is sensible to research more deeply into cognitive processes.

##### *4.2.4.2. Cognition*

Cognition is the transformation of information – the fundamental mechanism of human thought (Testor, 2018, p. 14). Cognitive processing is defined as "a series of cognitive operations carried out in the creation and manipulation of mental representations of information" (Krch, 2018, p. 859). Behind this minimalistic description lies a complex system that is researched in psychology, neuroscience, and biology and that builds the basis for many questions in diverse social sciences (Anderson, 2019, p. 3). These processes are unmistakably distinct from bodily movement or sensory input (Eagleman, 2018). Cognitive processes comprise, among others, functions for perceiving, handling, and storing data that are executed both with volition and automatically. So, a sequence like sensing something, then identifying it, establishing emotions, reflecting on it, and finally making decisions consists of cognitive processes (Krch, 2018, p. 859; Newen, 2017, p. 4259). They are learned methods, approaches, or techniques for a task. The concept of cognitive procedures helps investigate the relation of information handling and the existing cognitive background of a human being (Krch, 2018, p. 859).

Closely related to cognitive processes are cognitive strategies and cognitive styles: "Cognitive strategies are sets of mental processes that are consciously implemented to regulate thought processes and content in order to achieve goals or solve problems" (Cameron & Jago, 2013, p. 453). People develop preferences when there are strategies that all serve reaching the same goal. These can be rooted in aptitudes or just personal inclinations (Bendall et al., 2019, p. 70). "Cognitive styles are psychological dimensions that represent consistencies in how individuals acquire, organize and processes [sic] information" (Aggarwal et al., 2019, p. 112/2). Cognitive styles are the preferred cognitive strategies or cognitive procedures of individuals (Bendall et al., 2019, p. 68).

In sum: Cognitive processes consist of cognitive functions. People develop cognitive strategies that consist of cognitive processes to solve complex tasks. According to their abilities, their inclinations and frequent tasks they prefer, specific cognitive strategies that they evolve to their cognitive styles.

Teresa Amabile names cognitive style as important for the creative process (Amabile, 2019, p. 25). In her seminal work "Creativity in Context" she describes 9 creative style features relevant for creativity, summarizing them as the capabilities to comprehend complex situations and to cross perceptual and mental borders where required (Amabile, 1996, pp. 88–89). Aggarwal and Woolley (2019, p. 1587) research cognitive style in creative teams, as team members with inclinations towards diverse cognitive styles provide a good basis for multifaceted approaches to solutions.

Cognitive processes can often be subdivided in more distinct processes. Kim and Park (2020) take Robert McKim's seminal model for visual thinking, which consist of *seeing*, *imagining*, and *drawing,* and segment each of the three elements into smaller sections. Seeing, for instance, consists of perceiving, analysing and interpreting the visual intake (Kim & Park, 2020, p. 7).
On the other hand, some researchers even cluster all cognitive processes that are related to creativity into one cognitive process which they coined 'creative cognition' (Mastria et al., 2019, p. 1).

Being aware of one's thought processes – metacognition – has proven highly relevant for creative performance. It gives the creative person the ability to act strategically and to be more active in selecting the right processes at the right time (Valgeirsdottir & Onarheim, 2017, p. 226). Metacognition also provides the ability to assess one's own creative capabilities as well as those of other team members, and to strive for better cooperation using the team's respective strengths (Riel & Martin, 2017, p. 43). If one has a clear concept of the cognitive processes needed in the given task of the creative process, it should be possible to enhance creativity. With their DIMAI-Model Agnoli and Corazza (2019, pp. 54–55) propose to use mental states to anchor cognitive processes, "defining the action tendencies and the starting arousal level which will be essential to put effort in the generation of a new idea" (Agnoli & Corazza, 2019, p. 54).

How can a Design Thinker him/herself channel his/her thoughts, how can a facilitator help the team to achieve and maintain the best cognitive performance? As mentioned above, cognitive awareness is the first element. As the second element, she/he should have access to methods and tools to lead as desired. The following chapters will start to investigate some of the areas where leverage should be available.

#### ***4.2.4.3. Guides***

Design is a talent all human beings possess to some extent. However, it must be roused to work. This chapter seeks insight in guiding the creative process through priming and framing.

Framing is discussed because it is already a core instrument for Design Thinking. The phases *Understand* and *Define* seek to frame and reframe the problem, and the other phases use task frames to spur efficiency (Beckman, 2020, p. 147).

##### *4.2.4.3.1. Priming*

As discussed in chapter 3.2.1, creativity is prevalent in every sane person, but with misuse or neglect it becomes dormant in many people. Ritter and Mostert (2017, p. 252) show that creativity can be activated and brought back into use in a short session[18]. with the proper guidance. For this, it is important to keep the team members present in the given task. For instance, they should not start ideating while their attention is needed for the research task, or they should be persistent when the ideation phase is getting a bit arduous (Schallmo & Lang, 2020, p. 55,59).

"Priming is a psychological technique to affect performance on a task via exposure to a stimulus that activates a particular idea, contextualization, or feeling" (She et al., 2018, p. 252). A small, knowingly placed impulse can be enough to guide the behaviour of people. The stimulus-response pattern remains below the threshold of perception (Hofmann, 2019, p. 121). Priming can support remembering facts, change perceptive impressions and activate affection, motivational states and cognitive processes.

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[18] The author is well aware of the ethical problem of manipulation. But each team leading role, be it as moderator or facilitator, includes guiding the team members towards a given goal. So, the methods should help to better performance but not hinder the free will of the participants.

Even subconscious contact with a concept can influence action (Anderson, 2019, p. 239; Wänke, 2017, p. 63). Priming is often used in marketing, where one of its goals is to influence perception. The gustatory sense, for instance, is affected by visual effects (colour and shape) and expectations for the brand of the consumed product. Emotions of priming cues reflect on the emotions and actions of the affected person. Images of happy people spur enjoyment and consumption (Wänke, 2017, p. 64). Feeling warm and cosy enhances empathic receptivity (Hofmann, 2019, p. 128). The priming trigger and the targeted task must be diligently aligned. If this is the case, priming can enhance the efficiency, namely recognition-time and accuracy rate of the cognitive process (Porges, 2018, p. 2816).

Priming is an acknowledged tool to enhance divergent thinking and reasoning (She et al., 2018, p. 252). Sassenberg et al. (2017) use priming in ideation to induce thoughts that are not closely linked to experience and knowledge in the given knowledge/solution space, and thus generate more creative ideas that are far from typical apparent associations. "DT [Divergent thinking] can be enhanced with explicit instructions" (Runco & Acar, 2019, p. 244).

The variety in priming is broad. Explicit priming is typically done by instructions, directing the team's attention openly towards the desired direction. But implicit priming can be more effective, because it is more subtle (Sassenberg et al., 2017, p. 129). The use of keywords and stereotypes to activate a prime is very common (Anderson, 2019, p. 239). But some environmental changes, like symbolic objects (e.g. a leather briefcase for power) or furniture can also be influential (Okamura & Ura, 2019; She et al., 2018, p. 254).

Priming effects must be used with caution. The triggered effects are not always as expected. There is doubt, for instance, that images of cancer effects primed people enough to keep them from smoking, as a reminder of one's mortality is known to trigger fortification of self-assurance and thus – if smoking is associated with self-esteem – the priming might rebound (Wänke, 2017, p. 64). A much subtler but therefore more treacherous threat, is the fact that priming not only focuses the mind, but also excludes elements (information, emotions, perceptions) outside the focusing range (Barrett, 2017b, p. 45). Valgeirsdottir and Onarheim (2017, p. 224) explicitly warn that priming might lead to design fixation.

Small words can change the way people think and act. To seek affirmative terms, to avoid "no" or "but" and using "yes, and", instead shifts the mind to the quest for possibilities instead of seeing problems and impediments (Kasperowski, 2018, p. 8). The team creating the claim "Think different" for Apple was aware of the subtle effect that even word forms can have. Although it was grammatically faulty, they insisted on not using "Think differently" because this induces slightly different concepts than “Think different” (Livesley, 2019). This fragility also shows the strength that lies in careful priming. The right words, symbols or instructions can induce significant effects.

The practice of Design Thinking often works with priming in the form of immersion. The direct contact of the team with the potentially affected people not only serves as data collection, but also as multimodal priming (Liedtka, 2018, p. 75). But also in the other phases, immersing with material, data, and people related (or intentionally not) to the problem, primes all senses and thoughts (T. Brown, 2019, p. 41). In short: “New ideas come from seeing, smelling, hearing-being there.” (T. Kelley & Littmann, 2016a, p. 31).

##### *4.2.4.3.2. Framing*

Frames are cognitive heuristics that help in understanding our surroundings by providing personal concepts and values, often in the form of normative and ontological beliefs (Oswald, 2019, p. 15). In short, frames guide human cognition (Oswald, 2019, p. 11). Framing is not always subliminal, but often done actively: Framing a problem means giving it a clear scope, a comprehensible reference that guides the further course of action (van Aken & Berends, 2018, p. 58). Framing constrains a problem defines the space, and gives it a shape. For Tim Brown constraints are one of the cornerstones of a Design Thinking project, and framed spaces nurture, not hinder solutions. “Without constraints design cannot happen, and the best design […] is often carried out within quite severe design constraints” (T. Brown, 2019, pp. 23–24).

Framing is not only about setting constraints. It is about identifying the problem, rendering it graspable (Adams, 2019, p. 35). One of the vital challenges for framing is to identify the right problem. The above-mentioned pre-existing personal frames that everyone has focus the perception. Problems are often framed through the scope of personal skills and available resources (Adams, 2019, p. 169). This is one of the reasons to create multidisciplinary design teams. If the team’s skill set is small, they will identify all problems as a type that fits their abilities (Collins, 2018). But even if the frame people define is wrong, if they believe the setting is true, they will think and act on it and create solutions for a non-existing problem space (Hofmann, 2019, p. 94). Liedtka et al. (2017, pp. 308–309) warn against the tendency to sort situations into dichotomous categories, “disruptive versus incremental, strategic versus tactical, long term versus short term” (Liedtka et al., 2017, p. 308), and ignoring the possibility of problems or solutions that fit in both or maybe neither category.

It is the task of the facilitator to be aware of possible misleading attitudes, to question the developed questions and to encourage leaving the comfort zone to find new perspectives (Sosa et al., 2017, pp. 485–486).

The concept of frames in design was already introduced by Robert Buchanan in 1992 as *placement*. Placement, like framing, gives the problem and the way to think about it a shape and direction that can always be reshaped when new insights arise that demand for an altered perspective (Buchanan, 1992, p. 11). The phases *Understand* as well as *Define* are dedicated to framing and re-framing the problem space in a Design Thinking project (Doorley et al., 2018; D. Kelley & Kelley, 2015, p. 99). But framing also takes place to frame the solution space, for example, to set the initiator's experiences and possible KPIs in the design brief (Liedtka et al., 2019, pp. 12–13), and sometimes during *Ideate* and *Prototype*, by setting deliberate constraints to spur creativity (Lewrick et al., 2018a, p. 168).

On the other hand, widening the frame helps to perceive new opportunities. The Blue Ocean Strategy, for example, questions the given practices of existing markets, inviting them to discover new areas of potential success. The strategy questions industry standards and alleged competitive advantages opening up for new markets (Barsch et al., 2019, pp. 34–37). Identifying the situations, people and research methods to investigate is also a type of framing. The Blue Ocean Strategy is also a good example for the demand of a frame that is not too narrow and includes nontypical elements. Observing Outliers is a valuable tool to achieve surprising insights (T. Brown, 2019, p. 50).

Framing is typically done by formulating the constraints with words – most relevant in Design Thinking with the creative question in *Define*. The right definition of the frame is crucial for the success of the project. "Words not only frame problems, they suggest where to go for solutions" (Dobson, 2018, p. 305). However, if the framing suggests just one type of solution everything outside of this type will be shunned. This problem is so prevalent that it is discussed in research as a distinct research area called framing effects. They occur when variations in the communication of a problem lead to different solutions (Kruger et al., 2017, p. 350).

Facilitators must always be aware of cognitive frames. They can enhance or hinder creativity, and are particularly ubiquitous in Design Thinking. To use them wisely needs sensibility and strategic thinking.

#### 4.2.5. Discussion and Conclusion to the Second Cycle's Results

Analysing the gathered information from the two projects of the second cycle left doubt about the concept of altering mindsets. Within the phases, the teams worked towards a certain goal, using different strategies to achieve them, but the observers did not recognise a distinct change of mind or of character. As the survey showed, the students felt a tendency to work more collectively or selectively, were drawn to analytical or visionary thinking, and switched from observant to experimental, but they did not change beliefs or opinions.

Dosi et al. (2018, p. 1992) defined the Design Thinking mindset as "the set of attitudes, opinions, beliefs and behaviours that characterize an individual, a group, or an organization, mostly developed by experience." This intricate definition shows the highly complex structure of a mindset. Dosi et al. identified 19 constructs that are substructures of the Design Thinking mindset. Some of them are complex in themselves like "Tolerance for - Resilience of - Being comfortable with Ambiguity - Uncertainty /Embrace Uncertainty" (Dosi et al., 2018, p. 1993). Similarly, other groups worked with a mindset comprising eleven or nine elements (Groeger et al., 2019; J. Schweitzer et al., 2016; Sobel et al., 2019). These research endeavours indicate two points: a) A mindset is an extremely intricate psychological construct that eludes clear definition and robust examination (see also French, 2016). b) There is an emerging need to identify and examine the substructures of mindset.

Furthermore, there are several schools with different definitions for mindset. As described in chapter 4.1.5, some authors define mindset as attitude. Others, namely in positive psychology, define mindset as *beliefs* (C. Dweck, 2017, p. 16; C. S. Dweck, 2019, p. 21). Following the cognitive psychology mindset theory of action phases (Achtziger & Gollwitzer, 2018), a mindset is a combination of cognitive procedures that is activated to facilitate a given task (Keller et al., 2019, p. 25). Especially in design oriented sources, mindset is used as a collective term for "design principles, thinking modes, creative behaviours and postures" (J. Schweitzer et al., 2016, p. 72). Calling it "The fuzziness of mindset conceptualization" (French, 2016, p. 683), French describes the incongruity of the actual schools, even doubting the mindset's aptitude for scientific research as long as there are no clearer definitions.

Still, the cognitive procedures, cornerstone in the mindset theory of action phases (Keller et al., 2019), appear in all mindset theories, typically as the way to think (C. Dweck, 2017; Mlodinow, 2018, p. 72; Zion & Crum, 2018, p. 155). Shepherd and Patzeld's definition "An engineering mindset represents a cognitive script for creative problem-solving" (2018, p. 118) is a good example for this structure.

"A detailed look reveals that even what are often described as the brilliant results of human genius are produced by basic cognitive processes operating together in complex ways to produce those results" (Anderson, 2019, p. 2). Psychology and Neuroscience already have deep insights in these fields. The findings should be the right approach to the basic riddle that stood at the start of this thesis: How should people think while working on a Design Thinking problem?

These findings fit with the survey. The design teams did not – consciously or subconsciously – strive to change their mindsets. As could be seen at IPAM, where the students were quite reclusive and insecure in the first tasks but found their confidence as they became more comfortable with the task, and understood better what was demanded. The same was also the case with the Dornbirn-Project. On the slow second day, the lecturers needed to explain the phases and tasks repeatedly. The students felt lost for a while, not knowing what to do (and think). But again, after feeling more secure about the task, they worked contentedly. The problem was always with the way they should reflect and act (acting being mainly a cognitive act in Design Thinking) on the task, not, for example, their belief in the issue.

Thus, the goal of the following research cycles will be to identify relevant cognitive processes and to examine their influence on the given tasks. This approach will not dismiss the concept of the second cycle but refine the broader (and fuzzy) mindsets to more precise cognitive processes. The author is aware that "it is not possible to clearly separate the thinking from the doing" (J. Schweitzer et al., 2016, p. 76), but to focus the research approach via the thoughts processes seems viable.

A review of the suggested opposed mindsets shows that the pairing do not properly fit together. *Analytical* is not opposed to *Imaginative*. In observing the Dornbirn teams, it was clear, that they were constantly analysing the acquired data while they devised solutions. The discussions showed this clearly in the iterative section, as proposed solutions were compared with the information and changed with the analysis of this information. In a much smaller amount this was also evident, when the IPAM students saw their results on the flip board and started to adapt the information.

Literature also confirms the observation that analytical is not in opposition to imaginative. It is particularly evident in iteration phases, where analysing the feedback often flows directly into ideation and changing the prototypes (Butler & Roberto, 2018, p. 49). Similarly, *Collecting* not directly opposed to *Selecting*. Even if the observer must completely concentrate on observing and collecting information without losing focus through premature interpretation (Osann et al., 2018, p. 42), she/he must still select the people and action to follow (T. Brown, 2019, pp. 49–50). Another example is ideation where non-judgmental collection is mandatory (de Bono, 2016b, pp. 132–133) but one still sometimes has to select the idea thread to work on for the next period of time (Stickdorn, Hormess, et al., 2018, p. 180).

*Observant* versus *Experimental* also did not really fit. The survey data shows that the students were least decisive with this dichotomy (see Table 20). The data for *Define* and *Ideate* had some especially significant outliers.

*Table 20*. Project Three – Spread of Survey Data for Observant - Experimental

| | 1. Diagnostic | 2. Observe | 3. Define | 4. Ideate | 5. Experiment | 6. Validate |
|---|---|---|---|---|---|---|
| Experimental | 0% | 0% | 6% | 19% | 19% | 0% |
| | 19% | 13% | 0% | 25% | 13% | 6% |
| | 6% | 13% | 25% | 19% | 31% | 0% |
| Observant | 31% | 25% | 31% | 31% | 13% | 38% |
| | 44% | 25% | 25% | 6% | 6% | 25% |
| | 0% | 25% | 6% | 0% | 0% | 6% |

Created by author on the basis of the survey conducted in Project Three

Remark: It is interesting and cause for deeper thought that the tasks at the so called Groan Zone - the change from diverge tasks to converging tasks (Lewrick et al., 2018b, pp. 37, 182), – namely *Analyse information* and *Select ideas*, which are quite different to the rest of the phase they are assigned to, did not get their own phase and are fairly neglected.

In short:
Deeper research into mindset revealed that the term mindset itself is in high dispute in the research community. There are several definitions that are too different to find a common basis. "The fuzziness of mindset conceptualization" (French, 2016, p. 683) prohibits to use it for further research. The one fundamental element that can be found with various importance in all mindset research is *cognitive function*. Further research will work with the element cognitive function as a basis.

## 4.3. Third Cycle

### 4.3.1. Third Cycle Concept

The relevance of cognitive functions in Design Thinking is recognized: "Design thinking is a form of creative problem-solving (CPS) that requires a specific set of thinking skills to address a problem" (Worwood & Plucker, 2017, p. 87). Creative thinking is well described as a cognitive dual-process model – often differentiating between idea creation and idea evaluation (K. C. Fox & Beaty, 2019, p. 124). Creativity is not just working through a set of tools, but activating the required way to process given information at the right time. It is the predominant task of facilitators to ease the way to this cognition by optimising the environment, providing the right tasks and guiding the team through the process (Worwood & Plucker, 2017, p. 87).

Amabile and Pratt (2017) extend this concept to all creative endeavours:

> *Creativity relevant processes* […] include cognitive styles, perceptual styles, and thinking skills that are conducive to taking new perspectives on problems, pivoting among different ideas, thinking broadly, and making unusual associations; personality processes, traits, and characteristics that lead the individual to take risks and eschew conformity; and persistent, energetic work styles. (Amabile & Pratt, 2017, p. 160)

Although Puccio et al. (2018, p. 2) focus on divergent and convergent processes they affirm, that every phase in CPS demands additional specific ways to perceive, experience, and deliberate.

Tim Brown (2019, p. 70) has described the variety of phases a Design Thinking project has to go through and how the mood in the different phases changes considerably, along with the thinking strategies that the team has to adopt over time[19]. Analytical and synthetical thinking is also essential for the Design Thinking process. After collecting information – be it through observation or by devising insights or ideas – the amassed data must be analysed and synthesised "into a coherent story" (T. Brown, 2019, p. 75).

These contradictory ways of thinking – no matter how important they are – lead to considerable tension. Notably, cognitive attitudes like analysis versus intuition and linear versus iterative conducts strain the team. Dealing with these stress factors as part and parcel of the creative process is a

[19] It is interesting to note, that Tim Brown does not use the term mindset when he writes about Design Thinking; not in his books (2009, 2019) nor in his seminal article (2008).

significant ability of designers (Prud'homme van Reine, 2017, p. 58). "The power of design thinking is in the tension between seemingly opposite ways of thinking" (Prud'homme van Reine, 2017, p. 75).

Research in creativity has shown that the creative process thrives with oppositional processes like focused and unfocused phases or analytical and spontaneous thinking (Mekern et al., 2019, p. 47). Dobson (2018) declares switching modes as "the most notable characteristic of creative behaviour"(p. 300). He is of the opinion that the shifts are erratic and unpredictable, a constant alternation between eagerness and restraint.

The second cycle data and discussions with active Design Thinkers revealed that shifting the mindset – the attitude and notably the belief towards something – is hard to do, particularly for people who never had to act or think like that before. This is also evident when comparing the two projects. The second class (Project Three), with four days for the project, felt positively about the class, but their most voiced complaint was about the speed of the project. In contrast, the students of Project Two (IPAM) were happy and did not feel the time pressure, expressing interest in learning more about Design Thinking. They wished they had more time for the class, but did not feel stressed. In Project Two, the instructions were such that the students got an introductory glimpse into the course and typical tasks of a Design Thinking project, while in Project Three the students were requested to dive deeply into the process and to act like Design Thinkers.

The concept of the third cycle extends and modifies the second cycle concept with the insights achieved from literature and observation to a set of five dichotomous cognitive processes that might influence the Design Thinking process. The difference is that a person does not have to be in a specific mindset, but just has to act and think according to the task. For example, instead of calling for an observant mindset, the task demands to perceive diligently what the senses provide.
This concept is in concordance with the creative cognition approach that strives to identify the mental processes that are included in ideation and problem-solving (Ward & Kolomyts, 2019, p. 176).

COLLECTING – ANALYTICAL

The idea behind this pairing is the mandate to collect observations and ideas without interpreting the data. Even more so, a good observation demands questioning our biases (Curedale, 2019, pp. 261–262) and making sure that we don't filter out information automatically (Gerstbach & Gerstbach, 2020, p. 31). Even automatic analysis is bad for the task. A little discussion that took place in the Dornbirn teams shows such a bias: Two students talked about brands of computers and one said that researching other brands besides Apple wasn't worth it, because Apple is the only real choice there is. The call not to analyse while collecting is also true for ideation. Bason and Austin (2019, p. 90) call it *unanchoring*; a process to let go of first thoughts in order to think laterally – or as they coin it, *sideways*. This also demands not analysing what is there, because analytical thoughts would unveil impossibilities and hinder wild ideation. For this, the author used Salvador Dalí as a role model, with an (even for him) intense and colourful portrait, and a small but inspiring introduction. This seemed to have worked well. The students were really daring and didn't interrupt to criticise.

OBSERVANT – ENVISIONING/IMAGINING

Design Thinkers must be able to observe diligently. Roger Martin (2009, p. 56) describes the importance of seeking *valid* information – in sharp contrast to reliable information. Seeking valid information call for observers who don't observe to find confirmation but to discover what really is there. Martin calls people who are able to do this "first rate noticers" (p. 56). This is not only true for the *Observe* phase with the advised beginner's mindset (see chapter 3.1.6.3), but also during *Test*, where the observation must reveal all weaknesses and strengths of the evaluated prototypes (Lewrick et al., 2018b, pp. 122–123).

Tina Seelig (2017) calls the dichotomy "Engage and Envision" (p. 21). She extends observation to engagement as "It requires actively immersing yourself, not just observing from afar" (p. 34). She regards engagement as the gateway to imagination (p. 34). Imagination is the creation of a mental version of something not currently or ever perceivable. It includes not only visual representations but also reproductions or creations related to other sensory inputs, motions, processes, and concepts (Gotlieb et al., 2019, p. 709). Imagination is not only relevant for the ideation and prototyping processes; To be able to visualize the whole problem and solution space of the current project in a holistic *gestalt* is identified by Micheli et al. (2019, p. 135) as one of the central abilities of Design Thinkers.

The students at IPAM showed how essential this gestalt view can be. By hanging their presentation posters on a pin board and being able to distance themselves from the work and thus get a better overview, both teams saw possibilities to improve the poster and added or changed some elements of their work.

DEVELOPING – JUDGMENTAL/SELECTIVE

To develop and to select is about the idea of generating possibilities (Riel & Martin, 2017, p. 137). The dichotomy seems to be close to divergent/convergent at first glance, but *Developing* should be present in the converging phases, searching for optimizations, synergies, and variations instead of rejecting possibilities too early in the process. In particular, creating insights is a developing – catalysing – process (Beghetto, 2019, p. 164). On the other side, while diverging, it is relevant to know when to let go of a thread and to reach for new lines of investigation or thought (Stickdorn, Hormess, et al., 2018, p. 160).

The developing effect could be observed in project 2 at IPAM where the students used the Windmill template to narrow down their ideas to a solution. The template helped them see that clusters and synergy effects are often a good path to a powerful solution. They not only selected a couple of solution segments, but developed them on the basis of the number of ideas created before.

SPONTANEOUS – REFLECTIVE

This dichotomy is grounded in the dual-process model of cognitive control. The dual-process model distinguishes between two types of thinking: Type[20] 1 is automatic, quick, and smooth, while Type/System/Mode 2 is deliberate, slow, and effortful (Benedek & Jauk, 2019, p. 208). With his book "Thinking, Fast and Slow", Nobel laureate Daniel Kahneman (2012) made the dual-process theory public outside of cognitive psychology (Kannengiesser & Gero, 2019, p. 1). Kahneman (2012) described: "The automatic operations of System 1 generate surprisingly complex patterns of ideas, but only the slower System 2 can construct thoughts in an orderly series of steps" (p. 21). System 1 is also a provider of information for System 2. It delivers not only perceptions and emotions but also plans and – notably – intuitions (p. 25).

To work creatively, people must iterate between those modes. Pringle and Sowden (2017) propose that creative personalities must be able to deliberately shift between the modes to reach maximum efficiency. The empirical research up to this point delivered no data for triangulation of this theory. As the concept of deliberate to spontaneous thinking is highly discussed in creativity research (Sowden et al., 2018) the author decided to include it in the concept.

EMPATHIC – WITHDRAWN / INTROVERTED

Empathy is one of the cornerstones of Design Thinking (Buehring & Liedtka, 2018, p. 139). In Tim Brown's (2008) view, empathic Design Thinkers "can imagine the world from multiple perspectives – those of colleagues, clients, end users and customers" (p. 87). The word 'imagine' in this statement already indicates that this act is not only needed while observing, but also as part of the envisioning phases. But there are times when immersing in other

[20] Literature also presents the dual-process theory with System 1 or 2 and Mode 1 or 2. To be consistent, the author will use Type 1 and 2 in this thesis.

people's needs and desires can be disturbing. Uebernickel et al. (2019, p. 244) describe a retreat space that is needed when Design Thinkers need to concentrate on a task that does not take on external influences.

In both projects, the facilitators proposed time spans where the students should use brainwriting, i.e. working alone and writing down the ideas. This is an often-suggested method (e.g. Firth, 2019, p. 7; Sawyer, 2017, p. 76), as only working in teams tends to suppress thoughts of quieter team members. Time for brainwriting was welcomed in the actual projects.

The theoretical model for the third cycle consists of the five dichotomous cognitive processes shown in *Table 21*. These processes are identified as relevant for the Design Thinking process and as prone to variable shifts between the two cognitions respectively.
A timeline of the shifts through the Design Thinking phases has been withheld to be assessed with the research of the following projects.

*Table 21*. Dichotomous Attributes for the Design Thinking Process

| | | |
|---|---|---|
| **Collecting** | ⟷ | **Analytical** |
| **Observant** | ⟷ | **Envisioning/Imagining** |
| **Developing** | ⟷ | **Judgmental/Selective** |
| **Spontaneous** | ⟷ | **Reflective** |
| **Empathic** | ⟷ | **Withdrawn / Introverted** |

Developed by author

The informal hypothesis for this cycle is: "A set of five complementary opposite pairs of cognitive modes can be demonstrated to correspond strongly with the fundamental phase structure of Design Thinking."

### 4.3.2. Project Four – FHV Dornbirn 2018

The course was an interdisciplinary elective course in the masters program for business, engineering and design students. The course had a duration of eight weeks with one four-hour lecture each of the first seven weeks, plus the presentation of the results on the last day. The project was conducted in two teams with six students each. The twelve students were all German native speakers, seven male and five female, and came from all three study fields. The class was conducted in German.
*Table 22* gives an overview to the research plan. The following subchapter provides information about the project. Further details see Appendices A.4. Documents of the observations made through the class can be found in the download area of the project.

#### *4.3.2.1. Description of the Project*

Four weeks before the first class, the students jointly selected the topic they wanted to work on and were assigned to use the time until the first class to familiarise themselves with the topic. The selected topic was 'modern living concepts'. During the first session, the students were split into two teams to work on separate problems ('homeownership for young mobile professionals' and 'living concepts for people with additional needs').
The classes consisted of short lectures and supervised practise work in two separate work areas.
After each phase, the students were asked to fill in a survey with a semantic differential to the cognitive pairs defined in the cycle's concept.
Warm-up games and role models were not implemented in every phase, but used selectively to intensify their effect. The role models were supported with images and storytelling. Leonardo da Vinci, for instance, was introduced with a background story about polymaths (Rana, 2018).

*Table 22*. Project Four – Research plan – Master class Design Thinking Dornbirn 2018

| IDEO phase | Tools/Tasks | warm-up exercises (w) / role models (r) | Research methods |
|---|---|---|---|
| Understand | 6 W Questions<br>Storytelling and Voting<br>Framing, Research plan | | Project observation & photography<br>Paper based Survey: Semantic differential<br>Working material |
| Observe | Autoethnography<br>Participant observation<br>Participant interview | R – The ethnographer | |
| Define | Need finding (core motto)<br>Speed-Storytelling<br>Affinity Diagram<br>Persona<br>2x2 matrix or life story<br>Point-of-View Mad Lib | R – Anti-Role model Henry Ford and his *Faster horses*<br><br><br><br><br>W – Candle challenge | |
| Ideate | Brainwriting / -storming<br>Quick prototyping<br>360° View | W – Chain story<br>(Ball throwing story)<br>R – Leonardo da Vinci | |
| Prototype | Clustering and Filtering<br>Portfolio<br>Idea presentation<br>Voting<br>Free prototyping | R – Thomas A. Edison<br><br><br>W – Marshmallow Challenge | |
| Test | Peer testing<br>Participant testing<br>Business model canvas | R – Richard Branson | Final presentation<br>Final evaluation |

Devised by author (n=12)

#### *4.3.2.2. Data Gathering*

##### *4.3.2.2.1. Project Observation & Photography*

Observation as well as photography was carried out by the author of this thesis who also led the class. The goal was to observe the performance of the teams during the Design Thinking project with a special focus on their reaction and the way they dealt with the tasks that were assigned to them. During the first session the students started with investigating the chosen topic to identify the problems they wanted to work on. For this task, the lecturer split the class randomly into two groups. Interestingly, these groups stayed together after the identification of the two problem-spaces, because they already felt like teams after the short but intense first session.

The teams stayed together for the rest of the course, working through all phases of a Design Thinking project. For the first sessions, they worked in separate rooms, with the supervisor switching from one team to the other. Later, they worked in one spacious room in separate areas, always meeting in a dedicated area for lecture sessions and mutual discussions. The teams served one another as first test groups and as sounding boards for their final presentation.

The student's reaction to the diverse role models was rather remarkable. The abstract ethnographer (presented with a short narrated profile extracted from 'The Ten Faces of Innovation' (T. Kelley & Littmann, 2016b)) was neither mentioned nor seemed to have any effect on the students. The other role models seemed to have a better effect. The observer tried to intensify the influence with A3-sized images that were hung on walls in order to always be visible to the team, and she observed some smiling glances at the posters. The highest impact was achieved through Henry Ford and his famous quote "If I had asked people what they wanted, they would have said: Faster horses" as this was an anti-role model.

The author used it to motivate the students to look behind the statements of the observed people, who only voiced their wishes and desires based on their horizon of experience. Later in the course, the 'faster horse' was also used to question the ideas of the teams to drive them to better ideas. The question "Is this just your 'faster horse'?" affronted them a bit but made them think again.

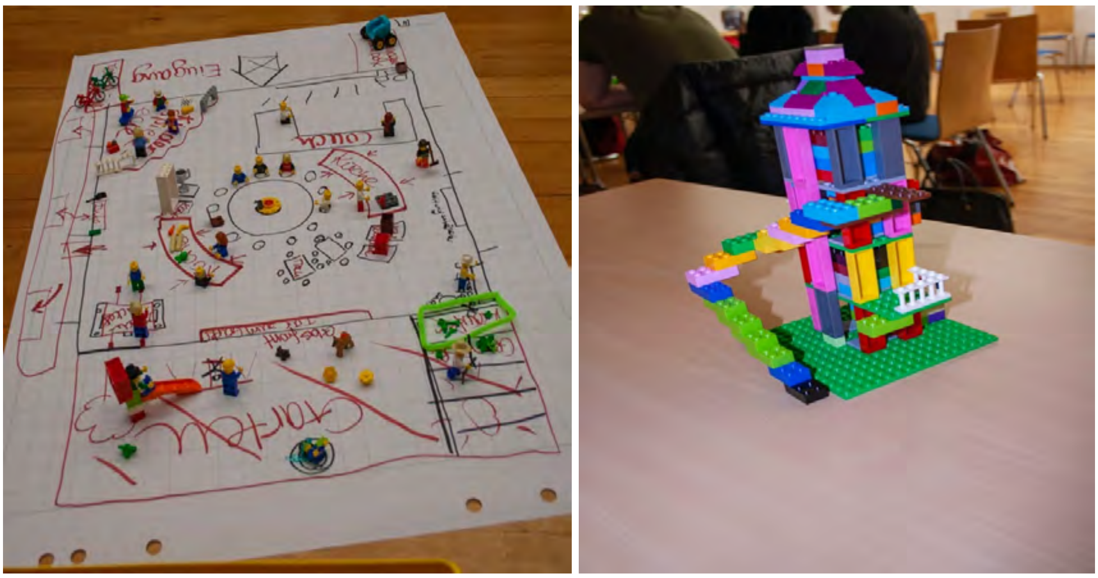



*Figure 73.* Project Four – Variants in Prototyping
Photography by author

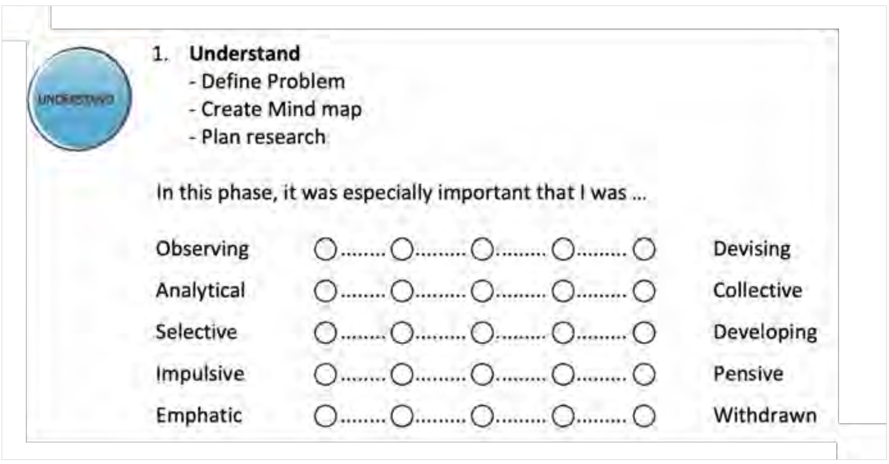
The student's reaction to the possibility of prototyping was rather remarkable. Team 1 especially didn't stop with modelling their solution but also tried to visualize its use. Team 2 created many variations until they felt content with the solution. While team 1 was busy talking about the interaction of people in their complex, team 2 discussed technical details. *Figure 73* shows the big differences in the way the teams used the material.

Most of the classes were held in a building where the students had never had lessons before. The observer had the impression that this was welcome and helped them to relax into the tasks. Especially prototyping worked very well, and the students dared to play but still with clear dedication to a perceptible result.

##### *4.3.2.2.2. Paper Based Surveys: Semantic Differential*

The Design Thinking teams were given a survey with the request to fill them in after each phase. The request was repeated at the end of each phase. Still, the participation was voluntary and the form was designed for anonymous answers.

As illustrated in *Figure 74* for the phase *Understand*, the survey consisted of a semantic differential that was repeated for each phase. The results are presented in chapter 4.3.5. and in the appendix A.4.


UNDERSTAND

1. **Understand**
   - Define Problem
   - Create Mind map
   - Plan research

In this phase, it was especially important that I was ...

| | | |
|---|---|---|
| Observing | O........O........O........O........O | Devising |
| Analytical | O........O........O........O........O | Collective |
| Selective | O........O........O........O........O | Developing |
| Impulsive | O........O........O........O........O | Pensive |
| Emphatic | O........O........O........O........O | Withdrawn |

*Figure 74.* Project Four – Excerpt of the Participant's Survey, Dornbirn 2018
Created by author

The author is aware of the small amount of survey data and that the results can only be regarded as a weak indication of support. Statistical methods to test distribution, skewness etc. do not make sense with the given amount of data. So, for this research, only tabulation and a heatmap for visual inspection were used to get an indication of possible results.

#### *4.3.2.2.3. Working Material and Final Presentation*

The relevant wallpapers and posters that were the platform for most of the tasks of the project were also documented. They give a good insight into the working attitude and development of the teams and their projects. They also give a revealing insight into different attitudes and team personalities of the two teams. *Figure 75* shows the POV-Companions (self-written posters with the Point of View that should be pinned on a wall, visible for the whole team, during all sessions after the *Define* phase).

While team 1 stuck to the creative question, team 2 needed additional information to be satisfied with the poster. Team 2's POV was relatively generic, so the add-ons enriched it fundamentally. Also, one example slide from each team's final presentation is shown in *Figure 76* – with the very factual, BMC-focused presentation of the one group and the prototype embracing, experience-focused approach of the second group.

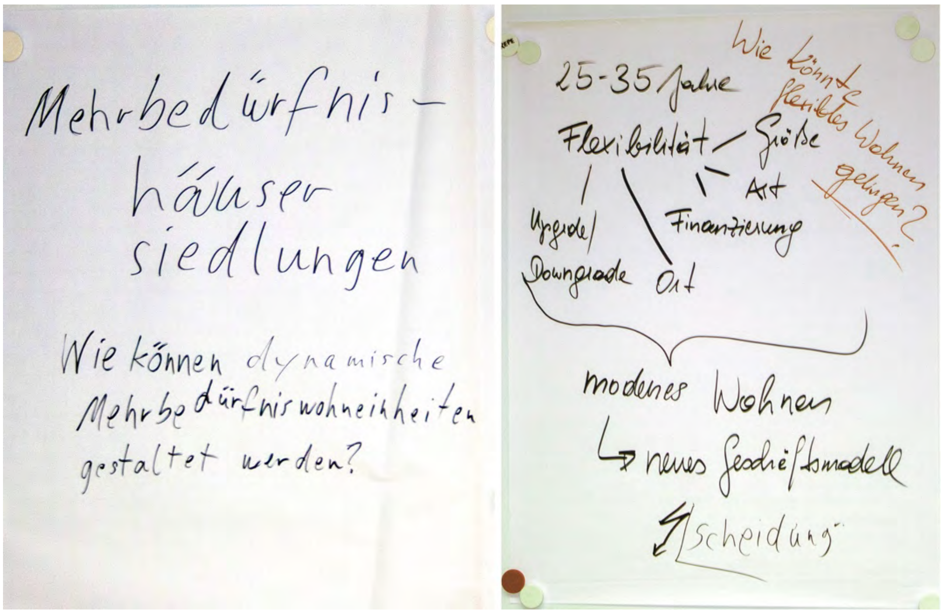



*Figure 75.* Project Four – Example for working material of the two teams – POV companion

Left: Team 1 used the POV only, right: Team 2 extended the POV with more information

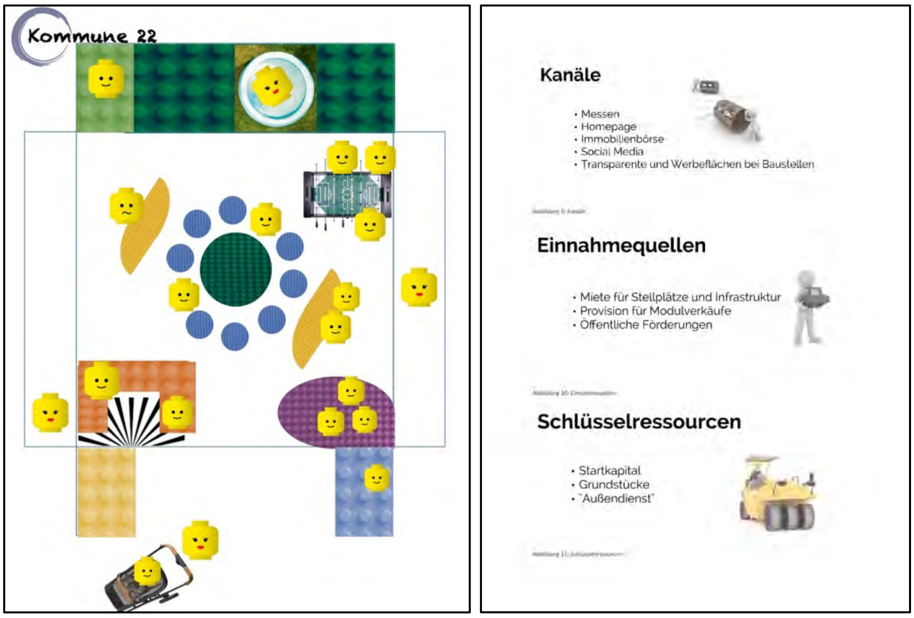



*Figure 76.* Project Four – Examples of Final Presentation Slides

Both examples are slides from their final presentation.
Additionally, both teams exhibited their prototypes.
Left: Team 1 presented a minimal graphic representation of their prototype
Right: Team 2 only presented the BMC data of their project

#### *4.3.2.2.4. Final Evaluation*

During the last session, the students were asked to complete a questionnaire with open text questions about their experience throughout the class. They were asked what they found difficult, what was easy, what they enjoyed the most and what inspired them. Additionally, the observer talked with the students about their experience.

The results showed that the class worked quite well. A point to consider is that the student's asked for examples of how to approach the assigned tasks. The challenge here is to provide examples that don't interfere with the Design Thinker's own ideas and lead them to a wrong area of thought. One possibility might be to use examples far from the area the Design Thinking team would work on. The observer had tried this with the problem 'soggy pizzas' for the 9-field task (see Appendix A.4). The students seemed to appreciate it without getting distracted from their task.

### 4.3.3. Projects Five – Three Short Project

During the third cycle, the possibility arose to conduct three short projects with a duration of two to four hours each. As the full Design Thinking process could not be carried out in this time, modifications of the Wallet Project (Both, 2016) were conducted.

The observation focus was on the interaction of the teams, the willingness to innovate, the irritations and positive surprises that the participants expressed. All three teams were fairly dissimilar and reacted differently.

#### *4.3.3.1. Project Five A – Computer Science Students in Digital Transformation*

Design Thinking is a regularly recommended method to overcome challenges with digital transformation (e.g. Atiker, 2017; Gerstbach & Gerstbach, 2020). The author included a short introduction in a course 'Digital Transformation' for computer science masters students to give the class an idea of how Design Thinking works. Their task was to develop the ideal work or school bag for their team partners.

This session was quite challenging as informatics students are used to working on computers only, with classical right or wrong problems and without much interpersonal communication. So, the first task was to activate and motivate the group. The author held a little 'pep talk' and used Hasso Plattner and SAP as the most salient example of why IT professionals should know how to do Design Thinking. The short project was structured with teams of two, where each person built the target group for their respective partner. It included reciprocal interviewing, scribbling solutions, and prototyping.

It was interesting to see that there were students who immersed themselves in the task and really tried to create something unique and innovative for their partners (see *Figure 77*). Others shied away from full participation and stuck to obvious ideas ('Provide online classes, then bags are futile') without even reflecting on how to make these ideas real. The results were astonishingly varied for the short project time, ranging from flying bags, over integrated charging devices and modular systems, to isolated compartments and liquid-stashes with flexible straws. The students showed remarkable creativity and empathy for their team partners.

Most students welcomed the class and appreciated the different tasks and work processes. They found the methodology exciting and appreciated the insight into the unfamiliar area. Some – typically those with professional experience – also saw the possible applications in their work life. Because of the unfamiliarity of the course of action, many found it difficult to analyse their thoughts and acts during the task. Some expressed that the interview tasks were the most challenging part of the class and that they enjoyed drawing and tinkering. Some of the scribbles showed remarkable quality and detail, as did the created prototypes.


*Figure 77.* Project Five A – Examples for Interaction and Prototyping
Photography by author

Some students did not see the reason for the Design Thinking session as they failed to do the transfer to a software project. A project with an at least partially technical background might fit better for this kind of class, as there is no time to do an intense reflection and transfer session. The author did not interfere much in the team conversations to see how they would proceed on their own but decided to change this strategy for following classes, as some guiding hints might have improved the experience considerably.

Because of the short project time and the newness of the topic for the participants, the author refrained from carrying out a survey in this project.[21]

[21] Additional data is provided in the download area for the jury

#### *4.3.3.2. Project Five B – Introduction to Design Thinking at IADE International Week*

This project was conducted as part of International Week at IADE in spring 2018. The class consisted of approximately 30 Portuguese bachelors students from a marketing/communications program. The challenge was the same as in Project Five A: create the ideal School/Work bag for your partner. The author agreed that the students could talk to each other in Portuguese to free them from language difficulties and to give them a relaxed mood. It was interesting to see that the students did not provide solutions with as many features and unconventional ideas as in Project Five A, but they tried to adapt the bag to the style their team partners preferred. They experimented with the provided materials and the author had the impression that with more time, space, and material, they would have started to be more inventive. Some students were astonished how much information they received from their partners. They did not expect the insights.

To create a relaxing atmosphere, the author played some music. She selected undemanding pop-music from the eighties with a positive mood and a nice beat. Several students appreciated the sound and were happy about the unusual educational environment. The author had the impression that the music contributed substantially to the open and active demeanour of the students.

Because it was not possible to get a written agreement from the students to use photos of the project, this part of the documentation cannot be provided. Also, a survey was not feasible[22].

#### *4.3.3.3. Project Five C – Introduction to Design Thinking for University employees*

The author offered an introduction in Design Thinking for colleagues as an element of the internal professional training program of the FH Vorarlberg, University of Applied Science. The colleagues asked the author not to take photos but were willing to fill in a questionnaire. The group consisted of twelve colleagues, lecturers, assistants and administrative staff with an age span from approximately 25 to 60 years old.

The author used the same task as with the students' project. It soon became apparent that the colleagues needed more time and had more difficulty to expressing their personal preferences and demands than the students had. The author gave them some extra minutes to talk, and with more

[22] Additional data is provided in the download area for the jury

time better results emerged. It was interesting to see that it was typically not the interview technique but the answers that needed more time to develop.

The author started the project with the same music as in Project Five B, but the group quickly started to complain. Switching to similarly undemanding classical music was welcomed by all, even the youngest participants.

The colleagues' participation was engaged as the students in the Five A and B challenge, but – as in the interview session – stayed more reluctant to being open and to show potential weaknesses. They started to loosen up with time, but as the course duration was limited, the increase in relaxation was only slight. The author is convinced that the group would have been more open and daring in a longer project. The result of the survey showed that most wished for more time for the project and for a reflection session afterwards.

The survey did not ask for reconciling the cognitive processes as the time for them to emerge was too short for reflected results. Instead, the participants were asked how difficult they perceived the different tasks to be and how comfortable they were with them (Likert-scale answers). Additionally, the survey provided open text fields to answer the following questions (plus some examples for answers)[23]:

- What corresponded to your usual way of thinking and working?
  - *Accept customer requirements - anticipate - agree (feedback) – build*
  - *Interview technique with follow-up*
- What contradicted your usual way of thinking and working?
  - *That the prototyping comes before the final feedback. In real life this can be expensive*
  - *To find a new perspective*
- What did you particularly like? What didn't you like at all?
  - *Interesting ideas arise in a short time*
  - *Negative: Skip situation analysis*
- Space for further remarks
  - *Good guideline for an introduction to the topic*
  - *What can I transfer as in lessons? Exciting question (here quite pragmatic)*

[23] The full feedback text, the survey form and a short analysis of the quantitative data is provided in the download area for the jury

The group was too small to provide sufficient data for statistical analyses, but the answers still offered some indications.

It was interesting to see that many found it most challenging and uncomfortable to receive feedback.

### 4.3.4. Third Cycle – Further Literature Review

#### *4.3.4.1. Information Gathering: Collecting – Analytical*

To work on a problem, Design Thinkers must build knowledge of a topic. Knowledge is created by gathering data and then integrating it into already existing knowledge (North & Kumta, 2018, pp. 35–36). Or as Tim Brown (2019) points out: "the data are just that—data—and the facts never speak for themselves" (p. 76). To be effective, the cognitive process of data/information collection and data / information processing must be separate. Analysis chiefly disturbs the observation (Liedtka et al., 2019, p. 49) and test process (Schallmo & Lang, 2020, p. 62), but it also affects the process negatively when analytic work is disturbed by the need to hunt down additional information.

Central cognition – the primary attention locus we are aware of – is restricted by a *bottleneck* that only allows serial processing; one cognitive process after the other (Anderson, 2019, pp. 73, 95). From this, it follows that people may only collect or analyse information. So, while working on a data collection task, it is vital to shut off the information handling attitude as much as possible. Reciprocally, while working on information, additional perceptual information hinders an effective process (Hirsch et al., 2018, p. 64). Serial processing is even more accurate when it comes to memory: to store information, people use representations of the same cognitive process. To store a route from place A to place B we either save a kind of map, thus using spatial information, or people trace the route with directional data ('straight ahead to the church, then left, after 200 meters turn right') reflecting action-based information (Anderson, 2019, p. 124).

The collection phase should be done without interference – no other thoughts should disturb the process, neither those related to the task nor other reflections about other issues (Maisel, 2018, p. 58). The openness also includes being detached from the given problem of the project and the accomplishments oneself or the team has already made. Every new element is welcome and appreciated. This attitude provides space for impressions that can be sorted out in a subsequent step (Berglund & Leifer, 2017, p. 614).

Buehring and Liedtka (2018, p. 143) also call for collective cognition when the team members interact. Embracing the information given by a fellow Design Thinker instead of defending their own standpoint might lead to *emergence*: Possibilities arise from the collaboration that were unthinkable before the joint conversation. The often called beginner's mind (e.g. Curedale, 2019; Doorley et al., 2018) – an attitude of knowing nothing about the subject – helps to be more open and not to analyse when collection is demanded (Lewrick, Link, et al., 2020, pp. 73, 135).

Analytical thinking is a biphasic process: First, examining the given information, sorting, selecting and structuring it; Second, recognising relationships and constructing insights from the structured data (Nuroso et al., 2018, p. 776). Worwood and Plucker (2017, p. 93) describe how the two cognitive processes are used in testing: First, data is gathered through testing, then the results must be thought through, considered from different standpoints, and fashioned into new, better solutions.

Collective and divergent phases are not parallel. Ideation, for instance, creates new data (i.e. ideas) which should not be consciously collected but deposited to make space for new ideas (Runco & Acar, 2019, p. 236). In contrast, the next step towards prototyping demands absorbing all ideas to be able to combine them into good solutions (Coco et al., 2020, p. 2).

##### *4.3.4.2. Perception: Observant - Envisioning/Imagining*

Observing means perceiving a situation. Perception not only includes the visual sense but all human senses that provide interesting data that might offer insights and inspiration for the process. "The sensory immersion is why people still fly to other parts of the country for face-to-face meetings with clients, customers, and colleagues, even in the information age; why phone or video conferencing often does not do it" (T. Kelley & Littmann, 2016a, p. 31). Imagination is the "ability to conjure up images, ideas, impressions, intentions and the like" (Abraham, 2020, p. 1).

The creative process only thrives through the interplay of both *Observation* and *Imagination*. Mental imagery builds upon the information people perceived before, so the imagination process must always include both: Sensing what is there and then envisioning what could be (Seelig, 2017, p. 58). Cognitively, these activities demand first external and passive attention – paying attention to the information provided by the senses – then internal and active attention – conscious creation of mental representations (Benedek, 2018, p. 180).

Robert McKim (1980, pp. 6–7) proposed a trichotomy for visual thinking adding *Drawing* to *Seeing* and *Imagining*[24]. He stressed the interactive and iterative structure of those three modes which support each other towards solving the problem at hand. Kim and Park (2020) adapted the model for Service Design and Design Thinking, again stressing the importance of iterating between the modes and the supportive function each of the three have for the other. For practised creatives, *Imagining* and *Drawing* often blend into one act. *Drawing* helps to transform received as well as imagined information to make it more easily accessible for the person drawing and for the team members (Kim & Park, 2020).

Perception is highly important for human beings. As Beau Lotto (2018) describes it:

> The death that we all fear is less the death of the body and more the death of perception, as many of us would be quite happy to know that after "bodily death" our ability to engage in perception of the world around us continued. This is because perception is what allows us to experience life itself … indeed to see it as alive. (p. 3)

Anderson (2019, p. 105) states that some of the most creative human actions are visual imaginations ("mental imagery"). At the very basic level, mental imagery is just the recall of past sensory impressions of real or made-up objects, events or sensation (Berger, 2020, p. 258), but it can be enriched by newly generated sensual elements (Benedek, 2018, p. 187). Even without an external trigger, humans build phantasmagorias and are able to use them for highly abstract concepts. The complexity of imagination becomes obvious in Anna Abraham's (2020) overview chart of classifications of imagination (*Figure 78*).

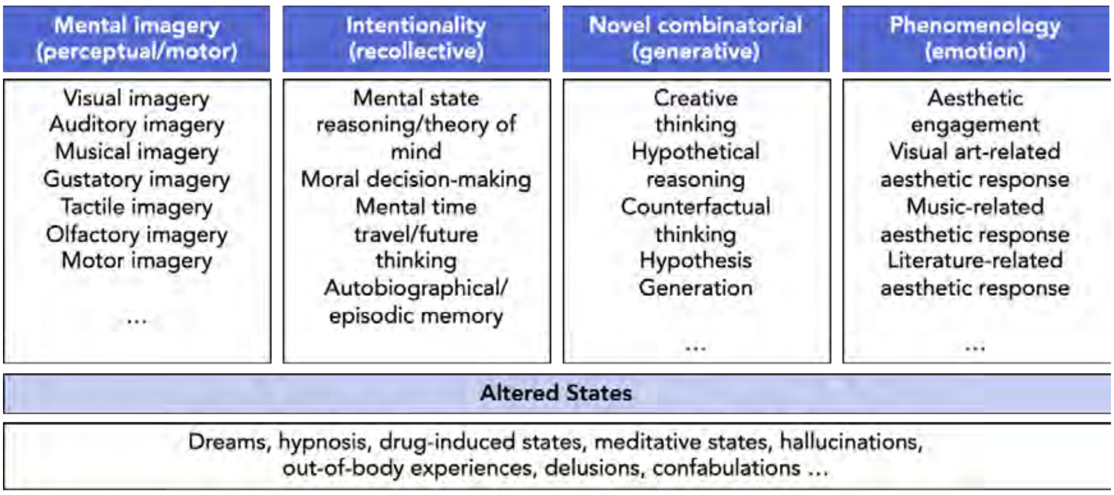



*Figure 78.* A Neurophilosophically Informed Classification of the Imagination – After (Abraham, 2020, p.7)

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[24] McKim (1980, p. 8) might be the inventor of the Marshmallow Challenge explained earlier in this thesis. He proposes the 'spaghetti cantilever' exercise to discover the relation of seeing and imagining.

Moholy-Nagy already stressed the importance of what he called inner visualization: "the ability to visualize the wholeness of the task in its corporeal solution before it is executed so that it can be evaluated with lightning speed. … The vividness of this inner visualization is a measure of the designer's ingenuity" (Moholy-Nagy, 1947, p. 57). But not only vision is relevant for creativity. Kolko (2018, p. 75) stresses that auditive information is significant in the observation stage. He uses the technique of transcribing the observables "because it embeds the participants' collective voice in our heads" (p. 75). Glăveanu (2017, p. 124) even describes creativity itself "as a dialogue between different, sometimes unexpected or even opposed perspectives" where perspectives can be multisensory as well as related to different persons or even objects. The brain combines the impact of all exterior senses to create a multifaceted, holistic experience of our environment (Lupton, 2017, p. 142).

Another multisensory technique is the immersion with objects that are linked to the problem a Design Thinking team works on. This direct contact can support a brainstorming session activating inspirations through bodily contact. Using a short observation session as a warm-up or examining old solutions or associated objects are also well-honed method to stimulate the imagination (T. Kelley & Littmann, 2016a, p. 60).

Visualisation is not just one homogeneous style, there are at least two substyles identified: (a) object visualisation is the ability to imagine objects and its properties, and (b) spatial visualisers can envision the relation of objects in space and analyse object details (Aggarwal & Woolley, 2019, p. 3). Research among students showed that fine arts and psychology students preferred object visualization while engineers were more into spatial imagery (Pérez-Fabello et al., 2018, pp. 135–136). This distinction shows how important it is for the facilitator to know their team members deeply so they are able to lead the team in the best way to reach their goals.

It is important to be aware of the fact that perception is never a subjective process: "Your mind is a grand collaboration that you have no awareness of. Through construction, you perceive the world not in any objectively accurate sense but through the lens of your own needs, goals, and prior experience" (Barrett, 2017b, p. 157). The information perceived is personal and – importantly so – a person is able to use different inner personas to regard an object or a situation (e.g. the creator of an object or the detached spectator) to draw different information and inspiration (Vlad P. Glăveanu, 2017, p. 126) Prior experiences are also part of the inner self, that primes actual perception and our imagination: "Memory helps project the situation into the imagined future and lets us envision the consequences" (Damasio, 2018, p. 11).

No matter if observing or envisioning, people must be able to sense what there is to perceive outside or inside their head. But sometimes there are obstructions that impede access to the information. James Adams (2019) lists and explains perception itself, emotion, culture and environment as well as intellect and expression as possible sources for blockades. For example, the pursuit of stability and security can block (in-)sights: "It is often uncertainty that stimulates the search for and generation of creative ideas, but it is also our fear of uncertainty that renders us *less* able to recognize creative ideas" (S. B. Kaufman & Gregoire, 2016, p. 171). On the other side, people tend to recognize what fits their wishes and goals while ignoring everything else. They render biased results and miss what might have helped to solve the problem (Liu et al., 2019, p. 4). As Seelig (2017) summarizes: "We so often listen but don't really hear, touch without really feeling, look without really seeing" (p. 28).

Implicit motivation controls what we are able to perceive. As this happens subliminally, people are not aware of this fact. Triggering the right emotions can help to be aware of selected stimuli (Chlupsa, 2017, p. 16).

Some methods and tools are available to the experienced creative person to facilitate observation and imagination. Charles Dobson (2018) recommends metaphors and analogies to further imagination. The idea is to add a normally unrelated concept to the given problem space to spur new ideas. The classic example here is biomimicry: Using features from nature to find new solutions in science and technology[25]. Dobson claims that metaphors help to perceive reality in a much more dynamic way and that cross-fertilization happens with ease. Interestingly, experienced professionals embrace this technique willingly, while beginners fail to abstract the given instruction and cannot make use of it (pp. 305-306).

Physicist and Nobel laureate Richard Feynman early realised the effect of a shifted perspective, seeing that getting a bit crazy is sometimes helpful. He described the research towards quantum mechanics: "Working out another system to replace Newton's laws took a long time because phenomena at the atomic level were quite strange. One had to lose one's common sense in order to perceive what was happening at the atomic level" (Feynman & Zee, 2014, p. 5).

Both allowing oneself to be a bit crazy or working with metaphors are examples for priming the mind. As explained in chapter 4.2.4.3.1, priming helps to direct thought and imagination as it shapes our model of the world. But it also helps to direct perception. Total perception of all sensory inputs the body receives is impossible. The amount of data is so vast, that it is *mathematically impossible* to process it all (Lotto, 2018, p. 61). The brain selects the signals that fit best with the actual situation, or – to be

[25] Examples are the lotus effect or wind turbines shaped after the fins of a whale

more precise – to the model the brain creates about the actual situation (Wilkinson et al., 2019, p. 102). What people consciously perceive is only a fraction of all sensory signals, and priming influences the filtering process (Anderson, 2019, p. 72).

#### *4.3.4.3. Assessment: Developing – Judgmental/Selective*

The interplay of developing and selecting information is most evident in the phase between ideation and prototyping. First there is typically a judgmental task, eliminating the absolute not utilizable information. Willemien Brand (2018) calls this "Select and eliminate" (p. 111) and splits the information into 'Yes', 'Maybe', and 'No'. One should be very careful with dedicating information to the No-stack, as each negatively judged element might include the seed for a great solution, but only if it stays with the considered data (Riel & Martin, 2017, pp. 70–71). Still, bad ideas must be identified and deleted. This is hard if there is not enough data – a problem that arises for instance, if the team did not follow the instruction to generate many ideas (Pijl et al., 2018, p. 129). After the first sift through the data, a clear development phase arises. This is not only true for the task after ideation but also for observation data that must be developed into insights (Amabile & Pratt, 2017, p. 159). It is relevant to note, that these tasks are mapped in the convergent areas of the creative processes but still undeniably are highly creative and idea generating (Bathla, 2019, p. 96; Liedtka et al., 2019, p. 28).

Finally, the team has to decide which insights to follow or which prototypes to create, so they are back to *Selective* (Doorley et al., 2018, pp. 38, 46). Judgmental processes should always strive to be objective and democratic within the team. Techniques like dot-voting or card-sorting (Hanington & Martin, 2019, p. 36) help to convey the attitude of equality. But still, emotions are part of the evaluative factors in Design Thinking and must be considered. Storytelling, for instance, has proven a potent method to impart the affective value of a concept to a team and to render it open to discussion and evaluation (Beckman, 2020, p. 148).

Arnold (2016, p. 129) distinguished between the decomposing analysis process as opposed to the unifying synthesis process. He taught both thinking methods as highly relevant qualities of creative persons. Martinich (2017, p. 26) follows this distinction and sees in the consistent alternation of the two thought processes as the ideal method for generating innovation. Brown (2019, pp. 75–76) calls analysis and synthesis the "natural complements to divergent and convergent thinking" (p. 75). Similar to Arnold's approach described above, Brown defines analysis as the judgemental process that dissects information, and synthesis as the developing process. Both thinking modes help to comprehend a problem and to create new solutions. The task is to discover patterns, interesting facts, and insights in gathered information. Sometimes the analysis is supported through technical means but the synthetical part always needs a human brain to find the *story* the data tells (T. Brown, 2019, pp. 75–76).

Unfortunately, synthesis is often disregarded in the design process as it does not lead directly to assessable solutions and often delivers only partial, vague or non-communicable pre-concepts that even the creator him-/herself is hard pressed to realise. To share the result is even harder and thus often shunned (Dewit, 2019, p. 228). Sternberg (2019, p. 91) identifies the (re-)definition of a problem as synthetic thinking and as a crucial part of creative skills. Therefore, he also deplores the instability creative people feel with synthesis as a real loss for the process. Prud'homme van Reine (2017) even proposes to regard Design Thinking as a whole as a method of synthetic thinking rather than analytic or descriptive thinking (p. 59).

Integrative thinking holds the developing process in high esteem. It is listed as one of the essential personality traits of Design Thinkers (T. Brown, 2008, p. 87). Integrative thinking is a method to combine two contradictory (either/or) choices to a problem and find a way to create a synergistic solution by taking the best of both and shifting them into an optimal solution (Riel & Martin, 2017, p. 9). It is the ability to "bring divergent possibilities into a convergent reality or analytical detail into a synthetic whole" (T. Brown, 2019, p. 90). Integrative thinking also embraces complexity, perceiving it as a challenge that really demands creativity but also gives the opportunity and space for it (T. Brown, 2019, pp. 90–91). Riel and Martin (2017, p. 65) propose a four step process for integrative thinking that could easily be mapped in the Design Thinking process. Ney and Meinel (2019, p. 36) see it the other way around: Design Thinking is the tool to enable people to solve wicked problems with integrative thinking. So, Tim Browns' required trait (i.e. integrative thinking) seems to emerge with the process.

De Bono (2016a) presents a similar process called the explorative mode. He contrasts this mode with a pure judgement mode that assesses every piece of data in the moment it arises. The explorative mode, in contrast, works with *possibilities*, giving every piece of information the chance to evolve and to merge with other facts. Nevertheless, this chance-giving does include constant observation.

A fact is not judged as being bad or good, but as potential that might be pruned if it proves hindering. This explorative mode demands a constant iteration between the developing and the judging processes (de Bono, 2016a, pp. 119–121).

Hypothetical thinking is a method that includes strong developing but also judging elements. It "involves imagining possibilities and exploring their consequences through a process of mental simulation" (Ball, 2020, p. 514) The method includes a systematic review process that should help to avoid rejecting or advancing possibilities because of mental biases or design limitations, striving for 'bounded rationality' (Ball, 2020, pp. 515–516).

In sum, these methods all lead not to a selection of insights or ideas but to an emergence out of the amassed data. Cross (2018a, p. 379) even describes the materialisation of a problem-solution pair after a period of exploration where both spaces are unstable. Laypeople especially tend towards premature judgement. Since this is particularly harmful during brainstorming, facilitators must prevent the criticizing attitude. Warm-up games at the beginning of the ideation phase with elements of fun and team spirit help to quell hierarchies and the urge to profile, thus giving more freedom to play without critique (Gerstbach, 2017, pp. 191–193).

Creative insights are created through the combination of stimuli that are often antithetical and come from different domains. This happens as a strategy to resolve a disruptive experience that leaves us irritated. Striving for a state of ease, insights are pursued using abductive reasoning (Beghetto, 2019, p. 165). Ward and Kolomyts (2019, p. 186) also promote the process of conceptual combination. Objects or information that are seemingly irrelevant can inspire or build in synergy valid solutions.

Developing is relevant to gaining insights. Gary Klein (2017, pp. 238, 242) describes how important it is to stick relentlessly to hunting down an insight, how questioning everything and finding new variants leads to new paths to follow that eventually lead to valuable comprehensions. Mindfulness helps reach the cognitive flexibility needed for this conduct (Byrne & Thatchenkery, 2018).

##### *4.3.4.4. Responsiveness: Empathic / Open - Withdrawn / Introverted*

Empathy and openness to the environment are core elements in Design Thinking and a Design Thinker's proudest characteristic (Micheli et al., 2019, pp. 133–134). Openness is the first of the Big Five Traits of creativity (see chapter 3.3.2.1). However, being highly perceptive should not always be the goal of a creative person. Concentrating on thought is crucial for concept development and humans are able to consciously select the channels they want to attend to (Verschooren et al., 2019, p. 469). Creative people are often found to be open to experience but still tend to introversion (Plucker et al., 2019, p. 50), and this has valid reasons: As discussed above (see chapter 3.2.3) mind-wandering is beneficial to creativity.

Mind-wandering needs to be a withdrawn process: "An important functional mechanism involved in MW [mind-wandering] is the disengagement of attention from perception (known as perceptual decoupling): when the mind wanders, the attention is internally directed and the processing of sensory input is strongly decreased" (Vannucci & Agnoli, 2019, p. 247). Fox and Beaty (2019) even propose that mind-wandering and creative thinking are highly related, that they use the same cognitive functions and neural networks (p. 128).

Even when the mind does not wander, the insulation of the mind provides freedom to concentrate on the given cognitive action without external diversion (Vannucci & Agnoli, 2019, p. 247). The effect becomes apparent when people engage in laboratory tests on divergent thinking. After a given task, people perform for a considerable period of time without needing more information, as they generate what is needed within themselves (Benedek, 2018, p. 181).

Abraham (2018) differentiates mind-wandering as "a state of 'unguided attention'" from the "internally oriented guided attention" when people muse or are deeply absorbed in thought (p. 38). The human brain also decouples perception when providing spontaneous thought, like an inspiration. It is believed that this is done to preserve the integrity of the process (Smallwood et al., 2018, p. 77).

Flow, the state of mind that is highly cherished and aspired by creatives, is an extreme example of internal attention. People are so highly concentrated on their thoughts that they lose track of time and environment (Finley & Csikszentmihalyi, 2018, p. 86). In flow, the environment disappears from the consciousness of creative people as they are totally immersed in thought[26] (Dietrich, 2019, p. 8). In a smaller amount, this also happens when a person focuses their attention on the task at hand, musing for instance about the problem and the facts that are provided. This concentration is important, as people are much less able to do or think as many things simultaneously as commonly believed (Bachrach, 2017, pp. 140–142).

The withdrawn phases are relevant to be able to focus on a demanding task that suffers through perturbations. A maximum reduction of mental noise enhances the space for complex cognition (Maisel, 2018, p. 129). Designers who work in an open environment, like an open-plan office with cubicles, were found to build 'caves' that totally close off their workspace with cardboard on top and on all open sides to safeguard their creativity (Elsbach & Stigliani, 2019, p. 23). Stickdorn et al. (2018, p. 399) recommend safe spaces for the design teams for specific tasks in the process, where they even look the door and obscure the windows, to make sure the team cannot be overlooked and will not be disturbed.

Still, empathic and open perception is important for creativity. Ivcevic and Hoffmann (2019, p. 274) describe openness as a central quality of a creative person and as openness to the facts and events happening but more so to the emotional signals of the people they design for. Sometimes it is hard for the team to develop the needed empathy for the stakeholders of their project. This is particularly true for Design Thinking novices who are also often novices into observing other people deeply and being

[26] It is interesting that people typically recall the flow state as a state of happiness and contentedness.

aware of their feelings and needs (Dzombak & Beckman, 2020, p. 576). Buehring and Liedtka (2018) observed that novices and also experienced team members thrive with supportive tools like the job-to-be-done framework (Klement, 2018) or journey mapping (Brandão & Wolfram, 2018) to get a better feel of the needs and behaviours of the affected people (Buehring & Liedtka, 2018, p. 142). But even simple observation must be learned. Sitting in well-familiar places and simply watching what happens can be revealing for non-designers. “In this receptive mode, you’re ready to start actively searching out inspiration” (D. Kelley & Kelley, 2015, p. 79).

The alternating open and closed cognitive functions allows for fluent internal concept generation and external evaluation and enrichment. It is also valuable in team work where alternating internal processing and external sharing leads to effective teamwork using solitary contributions and team performance (Worwood & Plucker, 2017, p. 91). Nevertheless, switching is time consuming and effortful – even if it happens subconsciously – and should not be triggered too often so as to avoid premature weariness (Verschooren et al., 2019, p. 470).

##### *4.3.4.5. Thinking Fast and Slow: Spontaneous – Reflective*

Creativity demands for both Type 1 and Type 2 processes. The associative, effortless Type 1 thinking and the deliberate Type 2 processes are needed while in idea generation. When the generated ideas are explored and merged into solutions Type 2 is prevalent (Sowden et al., 2018, p. 45). Khadilkar and Cash (2019) deepen the definition of Type 2 by distinguishing algorithmic and reflective thinking within Type 2: “The Algorithmic mind thinks causally, using strategies and generation of hypothetical situations. This brain employs logical and probabilistic reasoning” (p. 1867). Reflective thinking questions assumptions and goals, pondering deeper relations and beliefs (Khadilkar & Cash, 2019, p. 1867).

Against common belief, most human thought is Type 1 related as this way of thinking is much more comfortable and comes naturally (Kahneman, 2012, p. 64). Our brain must be efficient and thus tries to simplify data to more easily manage the information. Detecting patterns in a small data set and applying it to the situation is a common strategy for Type 1 thinking (Valerio, 2019, p. 21). It is also essential to be aware of the power of emotions. As described in chapter 0, emotions trigger behaviour. Emotions also can activate Type 1 thinking, overriding deliberation and decision making, and thus leading to resolutions that are far from rational (Adolphs, 2018, p. 7; Häusel, 2019b, p. 48).

The dual-process theory provides structure for many issues in creative thinking. Cash et al. (2019) propose to create a framework for creativity based on Type 1/2 thinking. They see a basis for many cognitive processes like reasoning and inspiration as well as perception and attention and many more (p. 1377). Both types are able of creative thinking. Neuroscience has even shown that they can even work synchronically, providing each other with information. Executive Type 2 thinking reflects on the given problems, analyses them and draws logical inference. Spontaneous Type 1 thinking uses the results for associations, that again in Type 2 are evaluated and refined (Benedek & Jauk, 2018a, pp. 292–293).

Surprisingly, two contradictory beliefs to Type 1/2 thinking are commonly accepted: Many people believe that they are thinking deliberately when they are solving a problem, as this takes some time and is relatively strenuous. Especially in design projects that take a long time, slow thinking seems to prevail. However, even in an intense thinking session, Type 1 is often active and tends to overrule Type 2 (Kannengiesser & Gero, 2019, pp. 4–5). On the other side, creative thought was long thought of as the spark of inspiration that comes automatically, thus being sourced in Type 1 thinking.

Creativity comes easily to those who are gifted (see also chapter 3.2.1). Nevertheless, recent studies show that creativity needs contemplative thinking processes as well as spontaneous ones (Pennycook, 2018, p. 94). Sassenberg et al. (2017) consider Type 1 thinking to be too cursory, and point out: "In order for ideas to be new and original, they must go beyond the usual associations activated through prior knowledge" (p. 128). With the ability to focus on specific problems, to think things through, to compare and combine facts with prevalent or memorized information, to draw conclusions and other high-level cognitive functions, Type 2 thinking provides a whole toolset of possibilities to work on a given problem and to device solutions (Dietrich & Haider, 2017, p. 5). Still, Type 1 thinking provides intuition, which is an indispensable basis for problem-solving. Intuition can be derived from experience or 'gut feeling' coined associative intuition (Taura & Nagai, 2017, p. 135).

Experiential intuition is considered an excellent way to get to quick results. However, the strategy to use previous concepts as a basis for new products readily leads to 'design fixation', to not being able to step away from the first experience idea and consider other solutions. Design practitioners still often use this shortcut, preferring rapid results over time-consuming reflections (Kannengiesser & Gero, 2019, p. 6). This hunt for speed is often economy driven but dangerous. Even if design fixation does not set in, the process fails to produce quality. For one, the first idea, if evaluated promptly after creating it, is accepted, as long as it is *satisficing* and there is no apparent reason that speak against it. This is not only true for ideas but all steps of the process. Sticking to trodden paths is dangerous (Ball, 2020, p. 518). It is proven that even if the number of ideas decreases with the time invested in ideation, the quality of the ideas and concepts increases significantly. This 'serial order effect' also provides evidence that Type 2 thinking is capable of generating ideas with a high originality factor (Barr, 2018, p. 95).

An unbiased and developing assessment of information mainly demands Type 2 thinking, as Type 1 is harder to control and might be contorted through beliefs and attitudes (Bonnefon, 2018, p. 114). There are several possibilities to activate Type 2 thinking for a design team: a thorough design brief, the attitude for objective appraisal, and sufficient mental and temporal space help to use slow thinking to perform a preferably objective evaluation (Evans, 2018, p. 155). Nevertheless, Type 2 thinking is no safeguard to biased reflection. On the contrary, reflection can even bolster beliefs and pseudo-rationalise concepts (Bonnefon, 2018, p. 116). This is another good reason for interdisciplinary teamwork as the diverse perspectives help to weed out contorted attitudes.

In summary, creative cognition requires the implication of slow and fast thinking modes to be beneficial. Kannengiesser and Gero (2019) demonstrate the alternation with the example of brainstorming that starts with the formulation of the point of view in Type 2 mode, switches to Type 1 for spontaneous ideas and comes back to Type 2 for assessment and refinement (p. 16).

### 4.3.5. Conclusion of the Third Cycle

In this cycle, the evaluation of the cognitive process-pairs was paramount. Additionally, the observer tried to discern which element of each pair was predominant in each Design Thinking phase. This demanded more literature review for each of the cognitive pairs. In the projects, the author observed the behaviour of the participants and aspired to watch the application of the thinking modes. This chapter documents the triangulation and inferences of this scheme. The author decided to structure the conclusion along with the cognitive process-pairs and not along the Design Thinking phases, as, at this stage, the focus of the research is to evaluate if the cognitive processes are vital for creative projects.

INFORMATION GATHERING: COLLECTING – ANALYTICAL

This cognitive pair is about the acquisition of information and discerns between the gathering of data and its inspection and classification.

*Understand* starts as a rather passive phase while the participants receive information about the given task and its constraints. However, to reach the mandatory mutual comprehension of the challenge, the design team must be activated and stake out the first impression of the problem space (Lewrick, 2018, p. 46). The big wallpaper with the almost ridiculously small starting point for the mind map seemed to have successfully stimulated the teams in Project Four to engage appropriately with the *Understand* task. The amount of information showed that collective processes were relevant here, and the fact that they questioned and discussed many points indicated analytical thinking, too. In *Observe*, Design Thinking demands an anthropological view of the stakeholders. In these stages, the naïve newcomer status is valued higher than the knowledgeable pro, who tends to analyse and filter information in an untimely manner while losing track of what is happening around them (Prud'homme van Reine, 2017, p. 62).

*Table 23.* Project Four – Survey Results as Heatmap – Example: Analytical-Collective

| | | 1 UNDERSTAND | 2 OBSERVE | 3 DEFINE | 4 IDEATE | 5 PROTOTYPE | 6 TEST |
|---|---|---|---|---|---|---|---|
| Collective | 5 | 17% | 8% | 0% | 17% | 8% | 0% |
| | 4 | 33% | 17% | 0% | 17% | 17% | 18% |
| | 3 | 25% | 8% | 8% | 25% | 25% | 18% |
| Analytical | 2 | 25% | 42% | 58% | 42% | 33% | 45% |
| | 1 | 0% | 25% | 33% | 0% | 17% | 18% |

Devised by author (n=12)

The survey results of the students in Project Four were interesting (again, the small number of twelve participants allows first indications only).

The pair Analytical – Collective was very definite (see *Table 23*). Surprisingly, the students rated the *Observe* task as more analytical than selective. The observer assumes that they connected the phase more with the work they did in class, which was the sorting of the data, creation of personas, etc. than with the real observation in the field. *Define* was clearly analytical, *Test* less so, but still with an obvious tendency towards analysis. Only *Understand* was rather collective, but not decidedly so.

That the students did not see the two main divergent phases, *Observe* and *Ideate* as collective is interesting but explainable. Gathering information for Design Thinking does not only consist of collecting it. Each collection must be followed by a process of assessment and integration, and in short, the data must be transformed into information. The two processes should be fairly separate even if they are dedicated to the same phase, as both are cognitively demanding and interfering.

Furthermore, the term 'analytical' does not really fit as antagonism to 'collective' as intended in the concept. The idea was to distinguish between the mere data gathering and the processing of the data to transform it into information.

Thus, the naming should be optimised to INFORMATION ACQUISITION: *Collecting* – *Processing*

Deduced prevalence of the acquisition processes through the Design Thinking phases: The *Observe* and *Ideate* phase are rather collective (if only the first part of the phase), *Define* and *Prototype* are processing information, *Understand* and *Test* both start as collective then switch to processing.

PERCEPTION: OBSERVANT - ENVISIONING/IMAGINING

Paying attention to the outside world or to internal, imaginative activities use different cognitions that demand concentration, so much concentration that one should not try to do both at the same time, but stick to one of them (Seelig, 2017, p. 37). Full perceptive attention – mindfulness – has shown to be a vital element for creative processes (Shamas & Maker, 2018, p. 130). Mindful attention to our environment, people, their actions, and their interactions provides the exploration space for new information (Tom Kelley in Coyle, 2018, p. 125). The focussed internal attention provides the possibility of having a good look at what one is able to envision, or – as Gary Klein (2017) points out – "opening the gates to insight also means opening ourselves to insights – being able to track and unpack them" (p. 225).

During *Understand,* the Design Thinking team gets information about the alleged constraints of the project that later often prove to be wrong. Nevertheless, knowing about the *perceived constraints* helps to understand the problem in a profound fashion (T. Kelley & Littmann, 2016a, p. 6). The mind map wallpaper for Project Four was filled diligently. As most of the information was not provided right in that moment, mental imagery (i.e. recalling information from memory. See Berger, 2020, p. 258) played an important role.

Most answers to the question "What was particularly inspiring?" in the survey of Project Five were in the perception area: Several students mentioned the prototypes as highly inspiring, as they delivered new perspectives, while others enjoyed the work in the diverse team and the different view they received there. Worwood and Plucker (2017, p. 94) recommend particularly rapid prototyping to get quick shifts in perspective to gather new insights. This effect was also easy to observe in Project Five's scribbles that developed quickly through the course. Even in these short two to three-hour projects, the advancement of the bag design from the first impersonal concept to the bag that was directly dedicated and bespoke to the partner was considerable.

The students of Project Four were part-time students. They arrived in the Design Thinking sessions directly from full-time jobs and were sometimes agitated and absent-minded. The lack of attention was not only observed by the author but the students themselves complained that it was hard to stay focused late in the evening after a stressful day. The effect was particularly palpable during engaging phases like *Ideate*.

The impression of the active attention was quite definite and was geared towards the outside for only *Understand* and *Observe* and towards the inside for the following phases (see *Table 24*).

*Table 24*. Project Five – Survey results to the cognitive pair Observing-Devising

| | | 1 UNDERSTAND | 2 OBSERVE | 3 DEFINE | 4 IDEATE | 5 PROTOTYPE | 6 TEST |
|---|---|---|---|---|---|---|---|
| Devising | 5 | 8% | 0% | 17% | 25% | 67% | 18% |
| | 4 | 17% | 8% | 50% | 50% | 25% | 64% |
| | 3 | 17% | 0% | 8% | 17% | 8% | 9% |
| Observing | 2 | 25% | 25% | 8% | 8% | 0% | 9% |
| | 1 | 33% | 67% | 17% | 0% | 0% | 0% |

Devised by author (n=12)

Summary: Perception is more than just *looking*. Design Thinkers need to use their complete senses to perceive all there is in the world for their projects. But there are times when perception must be directed inwards. Conscious awareness of the emotions towards the problem/solution, and most of all, concentrating on imagination without interference gives freedom to real creativity. As Design Thinking is based on team work, the envisioning phases must be intermittent with team exchange.

As of now, the naming of the perception pair seems to be fitting.
Deduced prevalence of the perception functions through the Design Thinking phases: Through the Design Thinking phases the external senses should be prevalent in *Observe* and *Test*, *Ideate* and *Prototype* need to be strongly envisioning, *Understand* and *Define* are iterating between the two processes, the dominance is dependent on the team interaction.

## ASSESSMENT: DEVELOPING – JUDGMENTAL/SELECTIVE

Data, information, and ideas must be assessed and filtered in a Design Thinking project because the process is prone to gathering more than could be handled (Beckman, 2020, p. 154). Nevertheless, without development, connecting given information and creating something new, unveiling synergies and hidden strengths, nothing new would arise from the process (Dzombak & Beckman, 2020, p. 579).

In the *Define* phase, Kolko (2018, pp. 74–78) jumps from a selective phase with sorting and rejecting information to a developing phase that starts with hunting for answers for why-questions over creating observation-related insights, to phrasing provocative statements with a generalized, activating attitude.

*Table 25.* Project Five – Survey results to the cognitive pair Judging-Developing

| | | 1 UNDERSTAND | 2 OBSERVE | 3 DEFINE | 4 IDEATE | 5 PROTOTYPE | 6 TEST |
|---|---|---|---|---|---|---|---|
| Developing | 5 | 17% | 17% | 8% | 33% | 33% | 0% |
| | 4 | 42% | 8% | 25% | 42% | 25% | 9% |
| | 3 | 17% | 33% | 17% | 25% | 25% | 36% |
| Judging | 2 | 25% | 42% | 33% | 0% | 17% | 36% |
| | 1 | 0% | 0% | 17% | 0% | 0% | 18% |

Devised by author (n=12)

Students in Project Four stated that it was hard not to stay in their normal behaviour and perspective ("Not to think in one direction from the beginning", "Consider other views", "Why should we question this?"). The 'Faster Horses' (see chapter 4.3.2.2.1), i.e. questioning if they really tried to be open to new thoughts and ideas, stirred them up to leave their trodden paths. Assessment had not left an intense impression with the participants of Project Five. As *Table 25* shows, they perceived a tendency towards development in phase *Ideate* and *Prototype,* and towards judging in *Test* and surprisingly *Observe.* In *Understand* and *Define* they were rather undecided.

Summary: At first glance, these processes seem to be the same as divergent and convergent thinking. But converging segments can also develop ideas or insights. This is obvious in *Prototype*, where several ideas are merged to a concept that is much stronger than as the single elements. On the other hand, observers often need to select which line of action and which person they follow.

Optimisation of the naming: ASSESSMENT: *Developing – Judgmental/ Selective.*

Deduced prevalence of the Assessment functions through the Design Thinking phases: *Understand* is developing, *Observe* is sometimes selective but should never be developing as this would interfere with the observation, in *Define* and *Prototype* both selective and developing processes are needed, *Ideate* is developing, *Test* is rather judging.

RECEPTIVENESS: EMPATHIC / OPEN - WITHDRAWN / INTROVERTED

Buehring and Liedtka (2018, p. 142) declared Receptiveness as an essential factor of the *Understand* phase, and the students in Project Four showed this in their empathy for one another and building of connections and sense of belonging. That they decided to stay in the randomly assigned preliminary teams is a good indicator for the empathic development. The highest empathy level is typically assigned to the phase *Observe*, as it is mandatory to gear perception to external sensations. The task is to collect information as unbiased and unfiltered as possible (Curedale, 2019, p. 247). Unbiased openness is difficult to achieve for beginners. For example, the students stated in the written feedback to the question "What was hard?": “Not to think in one direction from the beginning: so ‘stay open’”, “Take the blinkers of”.

Interestingly, the employees (Project Five C) rated ‘To get a new perspective’ (second *Observe* task of the guide) as the most pleasant (but not the easiest) task of the project. This fits the observations in the projects. The author had the impression that the second round of interviews was easier for most participants than the first round, as they had time to build some connection to their partners. The affinity method (*Observe*) used in Project Five also indicates empathy. For instance, group 1’s findings reveal very personal fears of the observed people regarding the housing situation. Examples: Fear of loneliness, poverty, discrimination, loss of autonomy. The affinity diagram of the other group also shows the complexity of the concerns they revealed (The desire to have stable, affordable housing collided with a multitude of career-related, social and economic issues).

The *Define* phase should end with a statement that is geared outward towards the stakeholders of the problem space and not inward to the design team or the mandate (T. Kelley & Littmann, 2016a, p. 57). The team members must withdraw during the ideation process to think about their own ideas but also take care not to miss any ideas of fellow team members to be able to grow with them (Paulus et al., 2018, p. 2). In team ideation, one must also consider the time a team member needs to explore and develop an idea – which needs withdrawn thinking – and the production, i.e. communication of the idea to the team – which needs open, empathic thinking (Barbot, 2018, p. 4). It might be one of the problems of brainstorming that ideation itself should be withdrawn, while teamwork constantly demands being empathic and switching between these two modes is arduous.

On the other hand, openness for the ideas of the fellow team members can trigger new inspirations (Royalty et al., 2020, p. 53). When the actual prototype is built, *Prototype* demands for seclusion, but as soon as there is a palpable object, the mind should open to discover new insights and optimizations (T. Kelley & Littmann, 2016a, p. 103).

The instant optimisation was obvious in all four projects of the cycle, especially in Project Four as the participants had sufficient time to inspect and work on their products. The author observed intense discussions and significant optimisations. The team that built a combination of Lego and drawn floor plan used the Lego figures to run through the utilisation of their solution. During intense discussions they created an optimised prototype even before the first official test. The process referred to the empathic insights the team made, but wouldn't have been possible without the team being focussed on each other.

*Table 26* shows that the participants in Project Five never felt to be withdrawn through the process, even when the observation yielded considerable reclusive time spans. Part of it might be the fact that the survey asked for Empathic versus Withdrawn/Introverted, and introversion has a bad reputation (at least in German language).

*Table 26.* Project Five – Survey results to the cognitive pair Empathic – Withdrawn

| | | 1 UNDERSTAND | 2 OBSERVE | 3 DEFINE | 4 IDEATE | 5 PROTOTYPE | 6 TEST |
|---|---|---|---|---|---|---|---|
| Withdrawn | 5 | 0% | 0% | 0% | 0% | 0% | 0% |
| | 4 | 0% | 17% | 17% | 0% | 17% | 0% |
| | 3 | 25% | 8% | 17% | 25% | 33% | 18% |
| Empathic | 2 | 42% | 33% | 50% | 42% | 17% | 36% |
| | 1 | 33% | 42% | 17% | 33% | 33% | 45% |

Devised by author (n=12)

Summary: With Empathy named one of the central traits of Design Thinkers, the cognitive pair seems nonsensical. Nevertheless, to be efficient, creative people need time where they are in a secluded space shielded from additional demands from the outside. This is true for the whole Design Thinking team that needs time to interact and think without external interference, but also for the individual who must withdraw to think deeply. The challenge for the facilitator is to enable individual reclusiveness even during team work.

Optimisation of the naming: RECEPTIVENESS: *Empathic – Withdrawn*.

Deduced prevalence of the Receptiveness functions through the Design Thinking phases: Empathy should be dominant in *Understand*, *Observe* and *Test*. *Ideate* and *Prototype* should be carried out with withdrawn, *Define* needs both empathic and reclusive times.

AWARENESS: SPONTANEOUS – REFLECTIVE

"Both behavioral and neuroscientific evidence reach the same conclusions regarding the necessity of understanding both associative and executive processes in creativity" (Barr, 2018, p. 100).

Cash et al. (2019) offer the significant advantage of the dual process theory. As it is well recognised in many business areas, from managers, to entrepreneurs and innovators, it might provide a lingua franca to render Design Thinking more accessible to non-designers and present an easier way to explain cognitive processes needed for an effective Design Thinking project (p. 1379).

Kolko (2018) demands introspection in the final tasks of the *Define* phase. He advises activating it through asking *why*-questions (e.g. "Why do students develop résumés to find jobs?" (p. 77)) on the basis of the observables: "And the key to the whole process is that we answer these questions even though we don't know the answer for sure" (pp. 76-77). Typically, people don't have a conscious strategy for problem-solving, which leaves them ineffective and dependent on chance inspirations. To guide the team to good deep reflection, the facilitator must provide tools and strategies to work on the problem and given data (Benedek & Jauk, 2018a, p. 291).

The observer's experience is that defining a good point-of-view is a hard task. Not because a team cannot find a creative question easily, but because it is very hard to reject the first, obvious, clear to follow question and look for one that is more to the point but needs a lot of digging, thinking, and sense-making. Project Four started with the *Define* phase in one session and completed it in the session the following week. The teams came back to the second session deeply convinced that they already had a good POV. To unsettle this security, the author used the candle-on-the-wall warm up (message: Always question what you have – the box was not only for holding the matchsticks but also to support the candle), Henry Ford's 'Faster Horse' (message: Are you trying to look beyond what is obvious for you? Are you only thinking of your own 'faster horse' solution?) and the core-elements wallpaper. With this, they started to think more deeply and to develop better insights.

The three short groups did not have much time for deliberation, but the change in their bag designs showed that they thought differently about the needs of their 'client' and reflected about an optimal the solution. Being spontaneous and generating ideas was the point that most students in all groups mentioned as the most pleasurable point in Design Thinking. One student also mentioned how she/he enjoyed delivering contributions, “when the ‘flow’ was there.”

Kelley and Littman (2016a) recommend emptying the mind with small Zen-related exercises as means to be more spontaneous in the ideation mode (p. 60). In contrast, Kolko (2010) describes the designer deep in thought in the process of generating innovative ideas (p. 16). Similarly, Tan (2017) explains how the experience of the “freedom of contemplation” leads to insights and solutions on the basis of random thoughts and feelings that need deliberation to allow for the emergence of great ideas (p. 80). Dietrich (2019, p. 7) proposes a threefold model with *flow* as the third thinking mode. The feedback of the other team in Project Four also activated considerable reflective mode in the students who used the information diligently to optimise their solutions.

In the survey (results see *Table 27*), the students were discordant where to put the cross for *Understand* and *Prototype*, but they noticed the rather spontaneous way in *Ideate*. *Observe* and *Test* was mainly rated neural to pensive. The observer assumes that the passive, if possible not thinking, observation was judged as pensive.

*Table 27.* Project Five – Survey results to the cognitive pair Impulsive - Pensive

| | | 1 UNDERSTAND | 2 OBSERVE | 3 DEFINE | 4 IDEATE | 5 PROTOTYPE | 6 TEST |
|---|---|---|---|---|---|---|---|
| Pensive | 5 | 17% | 0% | 0% | 8% | 8% | 0% |
| | 4 | 33% | 42% | 25% | 8% | 17% | 36% |
| | 3 | 17% | 42% | 17% | 17% | 33% | 45% |
| Impulsive | 2 | 33% | 8% | 50% | 50% | 25% | 9% |
| | 1 | 0% | 8% | 8% | 17% | 17% | 9% |

Devised by author (n=12)

Conscious control is never absolute. The human brain has too much power to rein it in. This holds especially true for Type 2 thinking. If, for instance, associations arise, Type 1 comes forward, at least for a short time-span. This uncontrollability is not necessarily detrimental as mental leaps often lead to interesting insights and exceptional ideas (Benedek & Jauk, 2018a, p. 291). This is also observable in practise, where one can see a participant sitting still, obviously pondering, then suddenly sit up with wide eyes and start writing.

Summary: Astonishingly, the cognitive pair that the author only reluctantly added to the analysis shows a lot of potential. Research is very active in the area of creativity-/problem-solving and dual process theory. The question how to guide team members to one of the two thinking modes and how to devise prevalence in the Design Thinking phases still is challenging.

Optimisation of the naming: AWARENESS: *Spontaneous – Reflective*.

Deduced prevalence of the Awareness functions through the Design Thinking phases: *Ideate* needs spontaneous and reflective thinking, *Define* must dominate deliberate thoughts. as must *Prototype*. Deducing the prevalence in the other three phases is rather challenging, so the definition is tentative: *Understand* needs team members that follow the received information and refine and enrich it for the *Observe* phase. This can be assigned to pensive. During *Observe,* thoughtfulness should be averted, so prevalence can be set to Type 1. The same can be said for *Test*.

Summary of the Conclusion to the Third Cycle:

This research cycle showed that all five cognitive process pairs are promising as relevant for Design Thinking and other creative processes. All are discussed and refined in the current research and could be identified in the Design Thinking projects:

- Data acquisition consists of collection of data and transforming it into valuable information.
- Perceptual Attention can be geared outward to sight, hearing, smell, taste, and touch or inward to our bodily sensations and to our thoughts and imagination.
- Information assessment can be judgmental, i.e. filtering and discarding, or developing.
- Receptiveness refers to paying attention to other people and their needs and feelings, versus ignoring external interference and concentrating on the given task.
- Thoughts can be quick and automatic, or conscious and voluntary. Both modes are needed in creative thinking, because flashes of inspiration create creative results, as does intense reflection.

The suggested ascendancy within the dichotomies is backed with research literature but needs more observation and survey results to be considered as having some evidence. The foci of the cognitive processes will be the main task in the following research cycles, flanked by deeper research in cognition to substantiate the above findings.

## 4.4. Fourth Cycle

### 4.4.1. Fourth Cycle Concept

The dichotomous cognitive pairs devised in the preceding research build the basis for the next projects:

- INFORMATION ACQUISITION: *Collecting – Processing*
- PERCEPTION: *Observant – Envisioning/Imagining*
- ASSESSMENT: *Developing – Judgmental/Selective*
- RECEPTIVENESS: *Empathic – Withdrawn / Introverted*
- AWARENESS: *Spontaneous – Reflective*

The hypothesized switch of focus for the cognitive pairs during each Design Thinking phase is delineated in Figure 79.

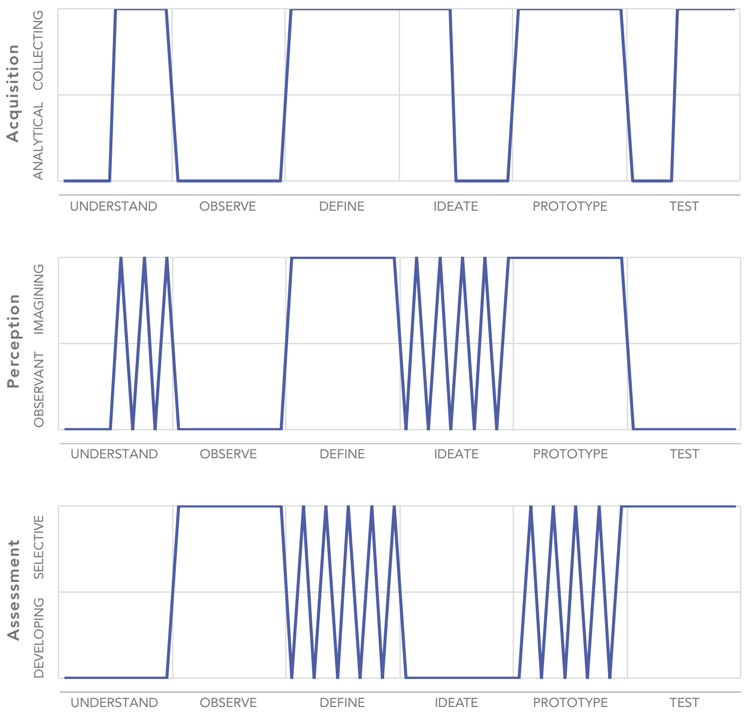



*Figure 79.* Assumed Focus Switches for the Dichotomous Cognitive Pairs – Devised by author

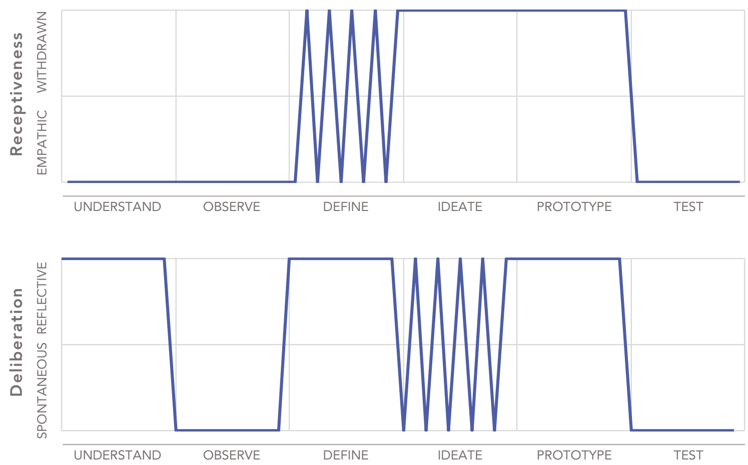



*Figure 79.* continued

The research task in the following research projects is to observe if these cognitive processes arise as hypothesized and if the assumed foci can be documented.

### 4.4.2. Project Six – Antwerp 2018

The project took place with a group of second year bachelors students from a business program during a business management class. In this class, teams of five to seven students worked on real life projects, solving problems sent in by Belgian companies.

The class consisted of 104 students split by the administration into three groups: Group 1: 29 students, Group 2: 24 students, Group 3: 51 students, ages ranging from twenty to twenty-five, and approximately evenly distributed by gender across the teams. The lecturer was the author of this thesis.

The Design Thinking lecture supported a big project, helping the students deal with a partial problem from their task. The lecturer took advantage of having three groups by assigning one as a control group and the other two as having project role models. Of the role model groups, one group was given an abstract role model and the other an identifiable role model known from media and/or history.

The project started in October and began with written assignments for the students. The sessions on premise were held over two days with the class split into three groups, and in December 2018 each group was again given two hours of individual attention from the lecturer. *Table 28* provides an overview of the research made for this project.

*Table 28*. Project Six – Research plan – Bachelor Class in Entrepreneurship Antwerp 2018

| IDEO phase | Tools/Tasks | Role Models for Group 2 and 3 | Research Methods |
|---|---|---|---|
| Understand | Create task<br>Frame the problem | | Project observation<br>Photography<br>Online Survey |
| Observe | Participant observation<br>Participant interview | 2 – The researcher<br>3 – The TV show detective | |
| Define | Empathy map<br>Jobs-to-be-done framework<br>Observation-insight-challenge funnel | 2 – The analyst<br>3 – Henry Ford<br>2 – The anthropologist<br>3 – The doting admirer | |
| Ideate | Brainwriting / -storming<br>Redefine challenge | 2 – The creative pro.<br>3 – Leonardo da Vinci | |

Developed by author

#### 4.4.2.1. *Description of the Project*

The project was conducted outside the Hogeschool grounds in an experimental building serving as a greenhouse, bar and connection space for sustainable technologies (see *Figure 80*). Being drawn out of their normal learning environment supported the students' independence and willingness to improvise. The class started with a short lecture about Design Thinking and quickly switched to focus on practical tasks for the students.

The lecturer coached the students during their tasks by walking from table to table. Whenever a task was concluded another impulse lecture was held, and new instructions given for the next task.
The second day was similar. The project was too short for *Prototype* and *Test* phases to occur, but the lecturer provided instructions on how to conduct those two phases independently if the students wanted to proceed with them.

On the second day, a construction company was working in the same spaces as the class took place, disturbing the lecture considerably. The students took it lightly and just switched places in the building when the construction action was too disquieting.

*Figure 80.* Project Six – Working Environment for Project Six Antwerp 2018
Photography by author

#### *4.4.2.2. Data Gathering*

As the students mainly spoke Dutch, the observation was restricted to body language and the dialogue between students and lecturer. After the lecture, the students were asked to fill out an online questionnaire.

The author had the impression that the unfamiliar environment was positive for the conduct of the classes. The atmosphere was open and friendly and the students did not hesitate to ask questions or show results. The most important result of the class was the research from the survey.

The quantitative survey only covered four phases, as *Prototype* and *Test* were not part of the project. *Understand* and *Observe* were merged into one phase. 54 Students answered the survey.

When regarding the whole class the results seemed quite indecisive. Then, by splitting the data into the three groups, interesting data emerged. As shown in *Table 29*, the role model seemed to have led the students towards a thinking mode. Interestingly, the students who worked with the abstract role model selected more specific preferences for cognitive modes than the students with the concrete role models. The chosen preferences were mostly along the foci suggested in the cycle's concept.

*Table 29.* Project Six – Quantitative Results for the Three Groups

| | Group 201: no role model | | | Group 202: abstract role model | | | Group 302: concrete role model | | |
|---|---|---|---|---|---|---|---|---|---|
| **Thinking mode** | | | | | | | | | |
| Collecting | 6% | 65% | 47% | 38% | 77% | 92% | 58% | 50% | 50% |
| Neutral | 35% | 24% | 24% | 31% | 0% | 8% | 13% | 21% | 29% |
| Selecting | 59% | 12% | 29% | 31% | 23% | 0% | 29% | 29% | 21% |
| **The way to watch** | | | | | | | | | |
| Observant | 41% | 29% | 35% | 31% | 31% | 23% | 54% | 58% | 33% |
| Neutral | 24% | 35% | 35% | 15% | 0% | 23% | 17% | 8% | 21% |
| Envisioning | 35% | 35% | 29% | 54% | 69% | 54% | 29% | 33% | 46% |
| **The way to react** | | | | | | | | | |
| Impulsive | 18% | 41% | 47% | 38% | 54% | 62% | 4% | 21% | 29% |
| Neutral | 24% | 29% | 24% | 15% | 15% | 23% | 25% | 25% | 33% |
| Reflective | 59% | 29% | 29% | 46% | 31% | 15% | 71% | 54% | 38% |
| **How I perceive** | | | | | | | | | |
| Empathic | 35% | 47% | 53% | 85% | 46% | 69% | 67% | 50% | 54% |
| Neutral | 29% | 35% | 35% | 0% | 0% | 15% | 21% | 38% | 21% |
| Introverted | 35% | 18% | 12% | 15% | 54% | 15% | 13% | 13% | 25% |
| | 1_Unders. Observe | 2_Define | 3_Ideate | 1_Unders. Observe | 2_Define | 3_Ideate | 1_Unders. Observe | 2_Define | 3_Ideate |

Devised by author

Using all data, the number of entries was big enough to perform a statistical test to evaluate the skewness of the entries. The procedure was equivalent to the analysis performed for the Social Media Survey. For technical details see chapter 4.5.3.1. The critical value for rejecting the null hypothesis, i.e. confirming the skewness, is 33 for this survey.

*Table 30.* Project Six – Result of the Skewness Test for all Survey Entries

| | 1_Unders. Observe | 2_Define | 3_Ideate |
|---|---|---|---|
| **Thinking mode** | | | |
| Collecting | 27 | 37 | 38 |
| Selecting | 27 | 17 | 16 |
| **The way to watch** | | | |
| Observant | 29 | 27 | 24 |
| Envisioning | 25 | 27 | 30 |
| **The way to react** | | | |
| Impulsive | 15 | 26 | 30 |
| Reflective | 39 | 28 | 24 |
| **How I perceive** | | | |
| Empathic | 38 | 33 | 37 |
| Introverted | 16 | 21 | 17 |

Devised by author

The red border identifies skewed segments with the red number indicating the predominant side of the cognitive pair

The participants were also asked which phase they liked the most. The supervised phases *Define* and *Ideate* were selected almost equally, with 22 votes for *Define* and 24 votes for *Ideate*, while unsupervised *Understand/Observe* only received eight votes.

In the open text feedback, the 15 positive statements were about creativity and five about brainstorming. Others wrote positively about the change of perspective and insights (e.g. "…to think from different points of view", "Other view on the project", "It gave another perspective on how to think about creative situations"). Some felt that the class improved their teamwork.

On the negative side, students complained about the short time frame and the demand to develop many ideas in fast succession. Some criticized the theory input of the lecturer and the environment – both points that were also remarked on positively.

The regular lecturer for the class remarked that the students spoke positively about the Design Thinking Project Six class and that it mostly improved their degree projects. The attitude towards stakeholders and questioning the project framing held through the rest of the semester.

### 4.4.3. Project Seven – FHV Dornbirn WS 2018-2019

The course for Project Seven was, as with Project Four, an interdisciplinary elective course in the masters program for business, engineering and design students. The course had a duration of eight weeks, with one four-hour lecture each of the first seven weeks plus the presentation of the results on the last day. To give the students a better feel for Design Thinking, the lecturer decided to conduct a short introduction project during the first two sessions and a longer one over the remaining six weeks. The class consisted of fourteen students in their mid-twenties to mid-thirties, seven male and seven female. The class was conducted in German by the author of this thesis. Only the last session was conducted by the guest lecturer Pieter Sprangers, who introduced the implementation methods of a solution.

*Table 31* gives an overview of the research plan with the following subchapter providing information about the project. For further details see Appendices A.7. Documents for the observations made through the class can be found in the download area of the project.

*Table 31*. Project Seven – Research plan – Master class Design Thinking Dornbirn WS 2018/19

| IDEO phase | Tools/Tasks | warm-up exercises (w) / role models (r) | Research methods |
|---|---|---|---|
| **Short project:** | | | Project observation & photography; Online Survey: Semantic differential; Working material |
| Understand | Framing | | |
| Observe | Online research,<br>Peer interviews | | |
| Define | Observation-Insight-POV | | |
| Ideate | Brainwriting / -storming<br>Idea communication sheet | | |
| Prototype/Test | Rapid prototyping | | |
| **Big project:** | | | |
| Understand | Mind map + Coding<br>Project commitment<br>Research plan | | |
| Observe | Participant observation<br>Participant interview<br>Body storming<br>What – How – Why | R – The Child | |
| Define | Speed-Storytelling<br>Empathy map<br>Laddering<br>9-fields-method<br>Job-to-be-done<br>Point-of-View | R – Anti-Role model Henry Ford and his *Faster horses* | |
| Ideate | Brainwriting / -storming<br>Visual brainstorming<br>360° View<br>Inspiration portfolio | Meditation<br><br>R – Leonardo da Vinci | Project observation; Online Survey |
| Prototype | Clustering and Filtering<br>Voting<br><br>Free prototyping | R – Thomas A. Edison | |
| Test | Formalised Peer testing<br>Participant testing<br><br>TRIZ and SWOT for optimization loop | W – Marshmallow Challenge | |
| Integration | Business model canvas | | Final presentation; Final evaluation |

Devised by author

#### *4.4.3.1. Project Description*

The author had gained the impression that it was disturbing for the flow of the project when every step was new for the students. To mitigate this, she conducted two projects in this class: A short project to introduce all phases and some exemplary tools, followed by the main project.

For the first project, the problem space ("The information filter bubble") was predefined by the lecturer. For the second project, the students could propose and elect their own topic. It was interesting to see that the randomly assigned teams put together for the initial *Understand* phase not only stayed together for the first project, but also for the second. As usual with this type of course, the students hardly knew each other before the first session. As a topic for the second project, the students elected "exclusion of older people through digitization".

Instead of a warm-up exercise, the lecturer conducted a meditation session at the beginning of the *Ideate* phase. This ten-minute awareness priming had a very positive effect on the students. They were calmer and more focused. Asked how they felt, most of them lauded the small exercise as beneficial for their wellbeing.

During the classes, the students could choose between several classrooms or more informal work areas. The class took place during the less frequented hours for the university, so many areas were free to choose from. In most of the cases, the students chose the informal areas, preferably a small sitting room and a sitting area, with high backs as shown in *Figure 81*. Both granted some seclusion, and at the same time, the freedom of informality.

*Figure 81.* Project Seven – FHV Dornbirn WS 2018 – Preferred Working Spaces – Photography by author

It turned out that two projects were a bit too much for the class. The introductory effect of the first project was very positive, but the time was missing in the second and bigger project. For the following session, the lecturer planned a shorter introduction similar to the shopping-bag challenge used in the Projects Five classes.

#### *4.4.3.2. Data Gathering*

##### *4.4.3.2.1. Project Observation & Photography*

The data of the observation can be inspected in the appendix of this thesis (extract) and in the download area for the jury. The author of the thesis simultaneously coached and observed the students during their tasks.

During observation, the lecturer introduced coding techniques (colours, coloured borders, dots, scribbles, etc.) for mind maps. The goal was to initiate deeper reflection and to think more intensely about the mind map objects. The students not only used this for the mind maps, but transferred it to other tools where they brought it to good use (see *Figure 82*).

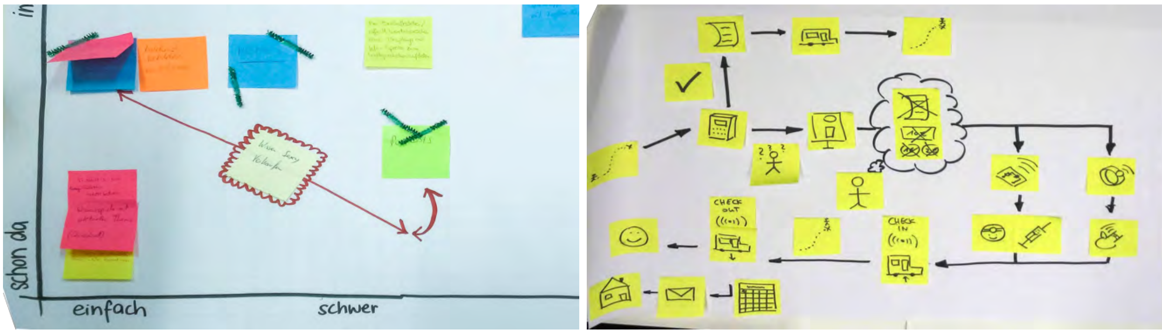



*Figure 82.* Project Seven – Examples for the use of mind map coding in other tools
Photography by author

After the brainstorming-sessions, the author coined the resulting ideas 'idea roughs' that need refinement and combination. The synergetic effects creating the solution concept. This led to almost ridiculous stacks of ideas, as they tried not to lose any information for later. Still, the method worked well (image shown in A 7.5).

Despite the time pressure, the students worked diligently on their prototypes. One of the groups created a media- and communication-station for elderly people and tried to build it as usable as possible. They also organised feedback from stakeholders to optimise the right usability. Robust control buttons, clear symbols and an old-fashioned handset were the results (see *Figure 83*).


*Figure 83.* Project Seven – Prototype for a communication and entertainment device for elderly people – Photos by author

The other group worked on barrier free methods to achieve travel tickets for elderly people and were quite risky with their solution that included implanted chips. But the feedback they received was astonishingly positive, so the solution has real life merit.

#### *4.4.3.2.2. Online Survey*

The author had the impression that the terms identified in the previous research include too many concept variations and thus led to misunderstandings. So, the survey for this research cycle asked with descriptions rather than terms, and a 5-step Likert scale from 'totally agree' to 'totally disagree'.

The questions for one phase are (translated from German)[27]:

In the phase Understand…

...I gathered information
...it was important to analyse and systematise the information
...it was important to monitor the situation
...my imagination and powers of imagination were particularly demanded
...I evaluated, grouped and selected information
...I developed things/information
...spontaneous thought and impulsiveness were important
...I've been thinking a lot about things
...it was important to be empathic and open to others
...I made the best progress when I withdrew into myself

[27] The full survey form for one phase can be found in appendix A.7.

With the questions not positioned as two either/or extremes respectively, the prevalence of one cognitive function was only visible in extreme phases, where only one of the modes of one pair was needed. The survey served to determine if the participants recognized the described cognitive function as relevant, and confirmed the relevance of all presented modes except the withdrawn mode. All questions besides "...I made the best progress when I withdrew into myself" received a Median at the level "agree" or "strongly agree" for not less than three of the six phases.

Additionally, the participants were asked if they found this phase positive and interesting and if they had the impression that they were successful in fulfilling this task. Both statements received uniformly positive answers.

The online survey was much less successful, as the paper survey that was used in Project Four. The students did not fill out the forms as often as this was the case with a paper survey. Participation count varied from sixteen to only six participants. With this, the results must be considered as very weak. Still, some (stronger) results are considered in the conclusion of the cycle.

##### *4.4.3.2.3. Additional material*

As listed above, the wallpapers, final presentations, and written feedback to the project are available for analysis. Examples are accessible in the appendix; all available material is accessible in the download area.

The students provided rather extensive written feedback which was transcribed and translated.
They liked the class, the creativity and the various methods. The team work with students from other study programs was much appreciated, as was the direct implementation of the theoretical lecture in practical work. The time pressure was considered problematic, as it sometimes cut the team's creative processes. Likewise, the students criticised the time frame of the class, as it was held for three to four hours on Thursday evenings, and the long evenings were trying and didn't further the student's productivity.

### 4.4.4. Fourth Cycle – Further Literature Review

Storytelling is an often-used tool in Design Thinking that was already mentioned in this thesis. The observation in this research endeavour showed that storytelling has high potential. So, it seems sensible to use it as an example for the tools a facilitator can use in Design Thinking. As there are frequent references from cognitive psychology to neuroscience, it seems sensible to touch on this subject, if only superficially. The literature review proved so relevant for creativity, that the author decided to give a precis to current research, fully aware that this can only be a small overview to a subject with tremendous depth and complexity.

#### *4.4.4.1. Storytelling*

Human beings think in images and stories, and therefore they should be part of every Design Thinking project (Gerstbach, 2016, p. 247). Storytelling has at least three fruitful functions in Design Thinking: (1) it can be used by the facilitator to guide the team members through the tasks of the project; (2) the participants can tell stories to convey their observations and ideas to their teammates; and (3) storytelling can be used as part of the prototypes created (Buehring & Liedtka, 2018, p. 144; Micheli et al., 2019, p. 134).

As storytelling helps create mental images, it spurs phantasy and inventiveness (Micheli et al., 2019, p. 136). Vivid narratives can change the attitude of the audience. The stories connected to a role model give it more substance and convey the exemplary function they hold (Maio et al., 2018, pp. 148, 255). Tina Seelig (2017, pp. 169–170) names storytelling as the best inspirational tool that entices people and enhances their productivity and creativity. "Storytelling is often the best way to create emotional connections to new ideas, innovations and new strategies" (Liedtka & Kaplan, 2019, p. 6).

Stories can support the Design Thinking process from the very beginning. They help to understand complex situations: "Narratives are the processes by which we create, recognize, assume, and believe in the stability and wholeness of the world. Understanding is the calling up of a narrative of explanation and then finding it sufficient" (Lissack, 2019a, p. 235). Moreover, the story told in *Understand* affects how the team observes, as the preceding narrative influences the perception (Lissack, 2019b, p. 328). Storytelling makes sure that observations made by one team member are experienceable for everybody listening (Lewrick, Link, et al., 2020, p. 129). But even before that, while observing, the best insights can be found, when the observer gets the observed person to tell stories. These experiences often reveal deep emotions and motives that stay otherwise hidden (Gerstbach & Gerstbach, 2020, p. 86). The sense-making process in *Define* is best made as a team-dialogue based development of a story that condenses the observed information into a vivid story that highlights the challenge the Design Thinking project deals with (Beckman, 2020, p. 148).

Co-narration unites and helps to master individual differences (Price et al., 2018, p. 189). Liedtka (2020, pp. 55–56) also recommends storytelling for *Prototype/Test* because of its power as a translation medium between the creative team and the testing people. Storytelling renders concepts palpable and tangible, thus enabling more detailed and precise feedback. It also serves as a strong supporting element during implementation as its power to visualize the solution provides vivid examples of how the innovation might come to life. This effect enhances the chance to convince decision makers from the new ideas (Phillips & Phillips, 2018, p. 14).

Good stories follow a few simple rules. "The stories must be easy to understand, have a surprising element, and be both believable and emotionally charged" (Seelig, 2017, p. 171). It is often hard for Design Thinking novices to tell and listen to stories. Warm-up games like the ball-throwing story, a-truth-a-lie, or back-to-back-stories help to overcome the barrier and to prime for narrative experiences (Osann et al., 2018, p. 49). Facilitators should set a good example with a personal narrative that breaks the ice.

Stories have great power (even self-induced ones): "The key is this: *the stories we imagine change us profoundly*. Through imaging stories, we can create perceptions, and thus alter our future perceptual-based behaviors" (Lotto, 2018, p. 122). In other words, people can change the way they perceive and act through self-invented stories. Consciously used, this effect can be beneficial, but it might also demotivate, disquiet, and discourage.

Ellen Lupton (2017) stresses the great power that design and storytelling have in combination with psychology. She demands "Like doctors, designers should pledge to do no harm and use the amazing power of language and design to advance the common good" (p. 140).

##### *4.4.4.2. Neuroscience and Creativity*

Research on creativity in neuroscience strives to build an understanding of the very functions in the brain that are needed for creativity. The goal is to map the creative mind to discover its biological basis (Beaty & Kenett, 2020, p. 219), and with this, to build a deeper understanding for creative cognition (Vartanian, 2019, p. 148).

As discussed in chapter 0, creative processes consist of at least idea generation and idea evaluation. These two phases are often connected with divergent and convergent thinking. It is still fairly common, even in scientific literature, to assign divergent thinking to the right hemisphere and convergent (i.e. logical) thinking to the left hemisphere of the brain. Neuroscience provides evidence that this model is wrong (Barbot & Eff, 2019, p. 132). The brain's functions are not split in two, and, as is intensely discussed in this thesis, creativity needs much more than just two cognitive processes (see also Amabile & Pratt, 2017, p. 106). Today, most of the higher cognitive processes are associated with large-scale neural networks. These are mappings of the areas of the brain that work together to achieve specific functions. As the name indicates, they are typically widely distributed in different regions of the brain (Abraham, 2019, p. 90).

Four networks are specifically relevant for creative cognition: the Executive Control Network (ECN), the Default Mode Network (DMN or DN), the Salience Network (SN) and the Visual Network (VN) (Beaty et al., 2019, p. 24).

The Executive Control Network is active when the perception of the external senses and conscious thinking and acting is required (Beaty & Jung, 2018, p. 276; Kenett et al., 2018, p. 79). The Default Mode Network was first thought to be a functionless system that is only active when the brain is idle. In fact, people in periods of rest do not think of nothing but linger most often in autopoietic thoughts (Abraham, 2019, p. 90). The default mode network is activated in both Type 1 and Type 2 cognitive processes. For instance, it is activated in reasoning about one's own personal state, remembering or imagining events, or moral evaluation (Abraham, 2018, p. 42). The DMN is crucial for imaginative thought and was observed as active in both creative thought processes and performances by artists (Beaty & Jung, 2018, p. 276). Typically, ECN and DMN are counteractive. While daydreaming, the ECN is deactivated, and when a complex cognitive task demands the attention, the DMN is silent, presumably to not interfere with idling thought (Dietrich & Haider, 2017, p. 5).

The coordination of the two networks is performed by the Salience Network who acts as a mediator, activating the essential network according to the stimuli it receives. It might activate, for instance, the ECN when a person is mind-wandering and an unusual sound can be heard, but it may also attenuate external stimuli lest not to disturb deep thought (Vartanian, 2019, p. 156). It was also found that the SN brings mind-wandering-ideas – created in the DMN – to consciousness through signalling them to the ECN (Beaty et al., 2018, p. 1087). The salience network seems to present all ideas that come to mind, including every day and uninteresting ideas. Trained creatives, though, are able to attenuate the SN messages, thus concentrating on more interesting and unusual ideas (Beaty & Jung, 2018, p. 281).

The counteractivity of ECN and DMN is always effective except for creative processes. There, the Default Network seems to play the role of a storyteller while the Executive Control Network evaluates the result and transforms it "into a coherent and realistic mental representation to be implemented in the external world" (Beaty & Jung, 2018, p. 276). Research also indicates that creative professionals use this interaction more intensely as creative novices or laypeople (Lazar, 2018, p. 4). These findings fit with the theory that shifts between the evaluative and the developing mode are essential for creative production (Barr, 2018, p. 102). Dobson (2018, p. 300) states that creative professionals use exactly this process with rapid fluctuations to reach high productivity.

Furthermore, neuroscience also shows that experienced creatives are better able to control mind-wandering, i.e. deliberately directing thoughts like future planning towards the intended goal. This ability is enabled through a productive interaction between the involved neural networks (Golchert et al., 2017, p. 233). Without guidance, mind-wandering tends towards thoughts about very personal topics, past events, future planning or personal goals. Creatives can day-dream other dreams (Abraham, 2018, p. 38; Vannucci & Agnoli, 2019, pp. 247, 250). Based on this knowledge, it does not surprise that deliberate mind-wandering has shown a positive correlation to the production of a high level of original ideas (Agnoli & Vannucci, 2020, p. 172). Sonalkar et al. (2020, pp. 159–161) also stress cognitive control. They do not see deliberate and spontaneous thinking as two dichotomous modes but construct a continuum from intense reflexive (controlled through SN) to intense reflective (CEN-controlled) mode. To them, creative thinking is a rather deliberately controlled way of thinking, with only Goal-oriented thinking under stronger conscious control.

The progress neuroscience has already made in creativity research is vividly illustrated through the statement of Beaty and Kennett (2020): "We could reliably estimate a person's creative thinking ability just by knowing the pattern of their brain network connections" (p. 222). To generate novel and useful ideas, creative people possess the ability to control the mind's facilities for creating new thoughts, either by talent or by training. The processes used by amateurs and professionals are the same, but the efficiency of creative people is much higher (K. C. Fox & Beaty, 2019, p. 128).

Why is the knowledge outlined in this chapter relevant for Design Thinking? To understand how creativity works and how different levels of creative experience generate ideas helps to guide the teams according to their demands, and to understand why some tools are fashioned the way they are. The demand, for instance, to create as many ideas as possible helps to overcome the salience network's characteristic to offer obvious and mundane ideas. As laypeople – other than creative professionals – can't suppress these ideas, the tactic of writing them down provides space for new and better ideas.

### 4.4.5. Conclusion of the Fourth Cycle

To get an overview of the research findings, this chapter first follows the Design Thinking phases and compares the concept of this cycle, the findings in both projects, and the literature review. Finally, cross-phase considerations are presented. The author used the project to test some tools and the reaction to it. The findings are included into the first part of the conclusion.

UNDERSTAND

> The introduction of mind map coding in Project Seven served its purpose. The students discussed intensely about the map and seemed more reflective than before. All students who filled in the survey for the observation phase stated that they thought deeply about the discussed points.

In Project Seven, and also in earlier projects, the researcher discovered that the participants were eager to mention ideas they already had. She heard comments like "I already know what we should do", "Why can't we start now?", especially when the team was very committed. Telling them that it is important to go through the process step by step and that there will be a right time for their ideas left them a bit demotivated. With the knowledge from chapter 4.4.4.2, it is clear that the salience network offered these premature ideas and that the Design Thinking novices could not dismiss them. As a countermeasure, the author will implement a 'treasure box' in subsequent project, where the participants can collect written down ideas for the following steps.

OBSERVE

Even if some students complained that there was not enough time for observation, most survey entries voted it as a success (15 of 16 entries in the first two fields) and as an enjoyable task (15 of 16 entries in the first two fields).

Topic for the main project was "Elderly people and digital transformation", and so the author presented bodystorming as a tool to discover more insights into the target group (see *Figure 84*).


*Figure 84.* Project Seven – PowerPoint chart to bodystorming (translated version) – Devised by author

Inspired by bodystorming, some students tried using the electric toothbrush and sunglasses as handicaps while they used a smartphone app. The results led to the big interface elements and the large screen shown in *Figure 83* (page 250). Motivated by the author/facilitator they enhanced their sensibility for the problem space and gained new perspectives for the challenges elderly people have to meet.

DEFINE

It is interesting to see that the students in Project Seven voted almost all cognitive functions as lower (if mostly still in the ‘agree' area) than in the other phases. Only "...it was important to analyse and systematize the information" and "...I developed things/information" received full agreement. The Antwerp students unanimously voted the collecting function as high. but showed a mixed result for the other questions. Looking at the data for the Project Seven groups, those assigned the abstract role model ‘the analyst' declared the experience to be more envisioning and impulsive in *Define*, while the group assigned Henry Ford as a role model stated it to be more observant and reflective in *Define*. The data of the control group was blurred. This result shows that the role models had an effect and deserve and demand deeper investigation as the two models lead to distinctively different results.

In *Define* the author introduced the job-to-be-done framework (Klement, 2018) in both projects to activate deep thinking to analyse the target group and already as an evaluation tool for the solutions. It turned out that the tool needs more facilitation/guiding than the author could provide with three simultaneously working teams. The framework is powerful but needs time and thought to implement.

IDEATE

In the ideation phase of the short project, the lecturer introduced visual brainstorming images (Marc Heleven, 2015) to activate imagination. The tool was already there for other projects and the lecturer introduced it regularly when presenting the tool-boxes. This time she spread the images on some tables – nudging the students to use them. The result was a discussion asking if the lecturer prepared this sample specially for the "information bubble" task, because so many of the images were inspiring. For the big project, the author did not have to spread the images herself, the students fetched them autonomously. The function of the brain-storming images is to show various aspects of a situation. They are rather symbolic and it is interesting to see how they can inspire in totally different problem spaces. The author perceives them as action stoppers and disturbers because they do not deliver an inspiration directly, but curb the action and give participants time to think.

As described above (chapter 4.4.3.2.1), the author implemented meditation at the start of the *Ideate* phase. The result was so promising that the author decided to include some literature review for the topic of mindfulness in this thesis, as she had the impression, that it improved the cognitive performance of the team.

PROTOTYPE

> Storytelling helps novices optimise their solutions. The solutions for elderly people thrived after the students heard stories about the ways people could use the product, as well as real life stories about relatives who struggled with the same problem that led them to fantasize about "How would Grandma deal with this?". The stories changed the perception from seeing what was physically built from cardboard, Lego and cloth to the object it symbolised.

One of the problems with defining the dichotomous pairs is the identification of the phase that sorts, selects and combines ideas to find a solution. The idea generating process must be withdrawn and free of judgement, while the assessment demands for selection, development and openness (Dobson, 2018, p. 300). A similar problem arises between *Observe* and *Define*.

The fact that both teams scored high with spontaneous *and* reflective thinking fits to the literature review: "Creative thinking is best conceived as a dynamic interaction between autonomous and controlled processing" (Barr, 2018, p. 99), and "This suggests a more nuanced view, implying that spontaneous and controlled processes show actual simultaneous interaction, but their respective predominance may vary across time and individuals" (Benedek & Jauk, 2018a, p. 292). Creative thought needs both times of spontaneity and times of deep reflection. The former is mostly easy, the latter might need some guidance and nudges to rethink the given problem.

The survey results in Project Six showed the effects of storytelling, as the groups with role models more decidedly selected the thinking modes as the control group. An interesting detail: The written assignment for the teams included only a role model without a backstory. For the group with the abstract role model the survey results were diffuse, for those with the concrete role model the results were similar to the other phases. The author presumes that the instruction "imagine you are the top-notch detectives like in your favourite crime show" implied the story and thus nudged the student's attitude.

The five dichotomous pairs of cognitive processes are not totally independent. Developing processes, for instance, tend to be deliberate and thus happen in the Type 2 mode. But an insight sometimes arises as spontaneous thought ascended from Type 1 thinking (Valerio, 2019). So, the connection is not absolute. The author hopes that the social media survey conducted in the next cycle will show if the cognitive pairs are all relevant and separately needed.

A topic that is often discussed is if Design Thinking is something that should be left only to designers, or if the method is perfected enough that anyone can do it. In this cycle, the author tried to look more deeply into that question. Both Project Seven teams consisted solely of Design Thinking novices, and members of both groups even said (without being triggered by the lecturer) that they were so happy, that they finally had the chance to be creative, because no other class permitted this. Some of the students had a hard time with creative cognition. Examples: “Thinking of new ideas got me a bit intimidated”, “I didn't really see the point”, “Nice class but totally not my thing”.

The author frequently discovered the difficulty to motivate laypeople to rethink their creative question. Cross (2018a, p. 386) claims that designers are open to this task. They even deliberately enhance the difficulty to come to better solutions. Although Tim Brown legitimately states: “Design is now too important to be left to designers” (T. Brown, 2019, p. 43), the research shows that designers – that is people talented, trained, and practised in creative thinking and acting – are indispensable for Design Thinking projects (Beaty & Kenett, 2020; Lazar, 2018). In other words, at least some of the members of a Design Thinking team need to be trained creatives for the project to be most effective.

In this research cycle the author predominately tried to answer the question “Sub-Question F.5: Can facilitators guide Design Thinking team members to activate these cognitive functions?”.
The author used priming and framing with the help of role models and storytelling with significant effect. Meditation also showed considerable success, as did visual brainstorming tools and formal peer testing. So, the answer to this question is affirmative.

Because some of the facilitation tools showed substantial power and the research in this dissertation on this topic is only explorative, it is crucial to deepen and formalise the investigation into this area. In fact, the results of this thesis are moot without further research on how to implement them in Design Thinking.

## 4.5. Fifth Cycle

### 4.5.1. Fifth Cycle Concept

The five cognitive pairs are modified as follows

- Acquisition of data: COLLECTING – PROCESSING
- Alignment of perception: OBSERVANT – ENVISIONING/IMAGINING
- Assessment of information and ideas: DEVELOPING – SELECTING
- Focus of Attention: EMPATHIC – WITHDRAWN / INTROVERTED
- Awareness of thought: SPONTANEOUS – REFLECTIVE

The difference to the concept of cycle four might seem minimal, but it is relevant. For instance, to be aware, that the first pair is about data and not information changes the way one interacts in these phases. That the observer or tester does not have to understand what exactly is happening in the given line of action reduces the stress and allows for more openness. To be aware that perception can be geared towards external or internal impressions can help similarly to switch consciously.

In this cycle the five cognitive pairs will be evaluated in a bigger survey conducted through diverse social media. In Project Eight the author will observe her own metacognition and the application of some tools in the Design Thinking project. The goal is to identify aids like warm-up games, avatars, and storytelling can be according to the main *nudges* they can provide.

### 4.5.2. Project Eight – Dornbirn SS 2019

The course for Project Eight was an eight-week course in the cross-programme offering for masters students. The class consisted of fifteen students in their mid-twenties to mid-thirties, five female and ten males. The class included two projects, one shorter introductory project followed by one big project. Other as in Project Seven, the lecturer used less tools and optimised the time management. The course was conducted in English by the author of this thesis. *Table 32* gives an overview of the research plan with the following subchapter providing information about the project. The possibility for iteration was given more focus in this project, past data showed that the solutions prospered in these loops.

For further details see Appendices A.8. Documents for the observations made through the class can be found in the download area of the project.

*Table 32*. Project Eight – Research plan – Master class Design Thinking Dornbirn SS 2019

| IDEO phase | Tools/Tasks | Extras (E) | Research methods |
|---|---|---|---|
| **Short project:** | | | Project observation & photography<br>Online Survey: Semantic differential |
| Understand<br>Observe | On-site research,<br>Project commitment,<br>Research inventory<br>Observe-watch-interview | | |
| Define | Observation-Insight-POV | | |
| Ideate | Brainwriting / -storming<br>Idea portfolio<br>Idea communication sheet | | |
| Prototype/Test | Rapid prototyping | | |
| **Big project:** | | | |
| Understand | Mind map + Coding<br>Project commitment<br>Research plan | | |
| Observe | Participant observation<br>Observe-watch-interview-participate<br>What – How – Why | E – Mindfulness talk | Working material, Final presentation |
| Define | Speed-Storytelling<br>Empathy map<br>Laddering<br>9-fields-method<br>Job-to-be-done<br>Observation-insight-POV | E – Treasure box<br>E – Story Telling<br>E – The Groan Zone | |
| Ideate | Brainwriting / -storming<br>360° View<br>Inspirational images<br>Inspiration portfolio | E – Meditation | |
| Prototype | Clustering and Filtering<br>Free prototyping | | |
| Test | Participant testing<br>TRIZ and SWOT for optimization loop | E – Formalised First Test<br>E – Quality Loop Lecture | |
| Integration | Business model canvas<br>Social BMC<br>Triple BMC | | Final evaluation |

Devised by author

#### *4.5.2.1. Project Description*

The first project of this course was conducted during the first two class sessions and left enough time on the second evening to prepare the observation phase for the second session. The task given for the first project was to think about the vending machines at our university. The task was open enough for different approaches and reachable enough for the short time of the project.

The students selected 'SMOMBIES', smart phone zombies, as their challenge area for the second project. They later split in two groups one working media competence for children and the second on smart phone addiction.

There were several special elements in this project, tailored to guide the thinking process:

- Mindfulness talk: The Observe phase started with a short speech on mindfulness, giving the students tips how to keep their mind on observing and suggesting a little exercise. The goal was directing the perception towards external senses, to enhance a collective mode and reduce information processing.
- Story Telling: Story telling was introduced with a short lecture and some examples how to tell about the observations the students made. The goal here was to enhance imagination and to develop data towards information.
- Treasure box: To keep the students from pondering on premature ideas, they got a 'Treasure box'; a silver carton with a silk ribbon where they could deposit their ideas to keep it for the *Ideate* phase. The goal was to keep their mind on the actual phase and to prevent early discussion of solutions.
- The Groan Zone: The explanation of the zone with a positive attitude towards chance and development. The lecturer tried to reduce the stress of the zone and to encourage the students to see the potential in their data.
- Meditation: To enhance mindfulness and to calm the students, a meditation sequence started *Ideate*.
- Formalised First Test: Instead of just suggesting that the students should help each other to evaluate their prototype, this time the lecturer set precise time slots and a team rota to make sure, that every student tested and evaluated another prototype and that the tested team used protocols to document the findings.
- Quality Loop: On the basis of Figure 85 the lecturer explained in more depth than in former projects why the loops are so important. She tried to motivate the students to a positive, optimisation seeking attitude.

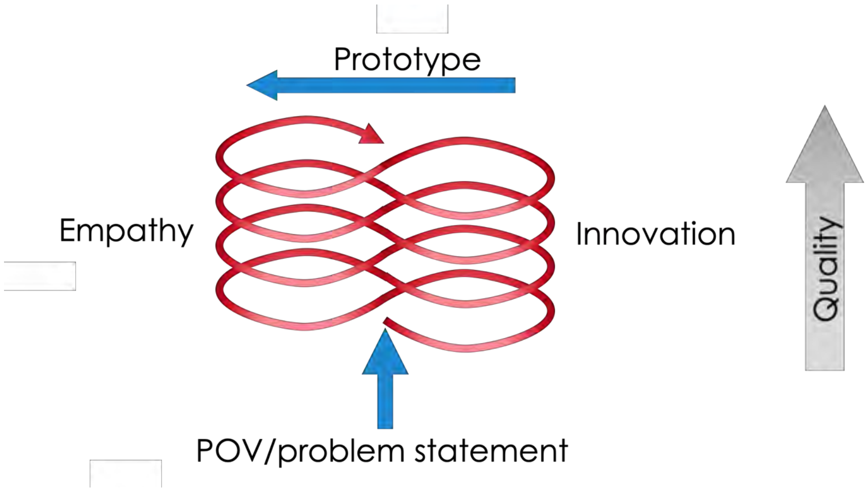



*Figure 85.* The Quality Loop – Devised by author

#### *4.5.2.2. Data Gathering*

##### *4.5.2.2.1. Project Observation*

The observation focussed on the second project, as the first was mainly to get a first impression of the process.

- Mindfulness talk: It was interesting to see, that the research results were much richer than in other Design Thinking projects. However, the students complained later, that the workload for the class was too high. So, they took the talk as an order and engaged heavily. But the results were also interesting regarding the insights. The game for the children, for instance showed high sensitivity for the demands of the age group.
- Treasure box: Was taken as a kind of relief. The discussions about solutions during *Define* stopped entirely but there was regularly a new piece of paper finding its way in the box.
- Story Telling: Did not work as well as expected. The students still did not dare or know how to narrate about their experiences.
- The Groan Zone: The introduction seemed to help a bit, but not as much as desired. The students still seemed worried and strained.
- Meditation: The 12 minutes meditation session was openly welcomed and calmed the students considerably. In the feedback, the students also mentioned it regularly.
- Formalised First Test: This worked extremely well. The students were astonished about the insights they can get when they take the *Test* seriously.
- Quality Loop lecture: While former groups rather saw the loops as a waste of time, in this project they accepted the process and really worked on the improvement of their products. In combination with the Formalised first test, the results were considerably optimised.

##### *4.5.2.2.2. Online Survey*

The online survey asked for all cognitive modes separately with a seven step Likert scale. As described above, it is still a subject of research if all the cognitive pairs are equally relevant through the phases. Except for the first phase, the participation was be quite low. So only weak inference can be drawn from the data. The data can be found in the appendix. The author draws on some information in the conclusion of the cycle.

The students also provided free text feedback that is also listed in the appendix.

### 4.5.3. Social media survey

As a final research project, the author conducted an online survey within the greater Design Thinking communities. She used several contact points that promised good connection to those interested in Design Thinking and who probably have some experience in the field. The following contact points and potential participants listed in *Table 33* were utilised:

*Table 33.* Social Media Survey – Social Media Channels and Potential Participants

| Medium | Details | Potential Participants / Group Members in 2019 |
|---|---|---|
| LinkedIn | Design Thinking Group ID 37821<br>Design Thinking ID 2057541 | ~120.000<br>~65.000 |
| Facebook | Design Thinking for Business<br>Service Design, Design thinking, Service Innovation, UX, CX<br>Friends with Design Thinking experience, tagged in a request | ~7000<br>~20.000<br>160 |
| XING | Design Thinking - Innovationskultur, Kunden-USP und Change-Management neu gedacht | ~4.200 |
| Coursera | Members of a Design Thinking course team | 13 |
| eMail | Personal contacts to Design Thinking course leaders | 8 |

Devised by author

The above-mentioned platform portfolio promised a worldwide reach for the authors survey request to people with at least an affinity for Design Thinking. It can be assumed that active community members were more likely to take the survey than passive ones. While this produces a certain self-selection bias, there was no indication in the data of systematic bias. The issue of sample representativity in the Design Thinking community is outside the scope of this analysis.

The survey was viewed by 292 people, started by 125, and completed by 56 entrants. Regarding the potential of the social media groups, this number was far below the expectations of the author. However, with up to 34 answers per survey and only few answers left out, the set contains 1661 data points. For the exploratory purposes of this analysis, the quality of the data can be considered high; the missing answers do not result in complications.

One of the goals of the preceding studies was to determine a survey structure that provides as much valuable information to the research topic as possible. The survey was again grouped by the Design Thinking phases and used the cognitive pairs as differentials with seven options (see *Figure 86*).


*Figure 86.* Social Media Survey – Extract of the Survey Form – Section Understand
QuestionPro survey created by author

The survey was conducted in a single questionnaire. All respondents therefore gave their information in the form of a holistic, punctiform assessment of five different cognitive functions during the phases of the Design Thinking cycle. The data includes both the respondents' ages and their level of experience with Design Thinking methods.

The empirical data analysed here was gathered with a view to a) its exploratory nature and b) the fact that all information gathering on sensitive issues such as someone's state of mind during creative processes tends to interfere with the research subject itself. Because of the former, no detailed hypotheses as to concrete patterns in the data can be stated with any degree of certainty at this point of time – nor would be desirable to do so.

This concerns in particular:

- the relationship between phases
- the quantitative distribution of cognitive functions

Because of the latter, all empirical data gathering had to be designed in as unobtrusive and un-interfering a fashion as possible. A laboratory setting or a concomitant study was therefore out of the question. Accordingly, the data must be assumed to contain extraneous behavioural factors. All in all, the survey must be considered a snapshot-type cross-sectional study which does not control for a bevy of possibly relevant psychological determinants, or behavioural factors such as recollection bias, consistency bias, recency bias or peak-end rule effects in particular. Such issues could only be addressed in a much more formalized laboratory setting with an entirely different study design. At this point of the inquiry, they must be considered extraneous variables.

While it appears unlikely from the standpoint of construct validity (see below), that these extraneous factors result in strongly confounding effects, the possibility cannot be excluded. Therefore, all data analysis has to be based on conservative assumptions.

#### *4.5.3.1. Statistical analysis*

The study gathered information for each cognitive pair (variable $C_n$) in each phase (variable P) of the Design Thinking process. Research on knowledge-based processes in general suggests that age and experience level play a role in a practitioners' performance. So, this information was collected in control variables. In sum, the data model is strongly multivariate:

| | |
|---|---|
| – cognitive pairs $C_1$, $C_2$, $C_3$, $C_4$ and $C_5$ | ordinal |
| – phase of the Design Thinking cycle (P) | ordinal |
| – age of respondent (A) | numerical |
| – experience level of respondent: role ($L_1$) | ordinal |
| – experience level of respondent: # of sessions ($L_2$) | numerical |

While the sample of 56 survey respondents is quite satisfactory in absolute terms, it is clearly insufficient for analysing a nine-dimensional multivariate model, not least because seven of the nine variables are categorical and require much more data for analysis than numerical variables would. Accordingly, the analysis below aims at a broad outline for a theoretical model and focuses on a limited number of hypotheses which can currently be stated with confidence.

Two key questions can be posted on the given model:

- Can anything definite be said about the distribution of the values for each cognitive pair?
- Can any associations between the variables be determined?

The analysis of the data demands for a step by step process through several hypotheses:

H1 The values of the $C_n$ are not uniformly distributed

H2 The distributions of values of the $C_n$ change from phase to phase

H3 The distributions of values of the $C_n$ are predominantly monomodal

H4 The distributions of values of the $C_n$ are predominantly asymmetrical, the type of skew correlated to the phase of the Design Thinking cycle

H5 There is an association between the observed values of each of the $C_n$ and the phases of the Design Thinking process P as a whole

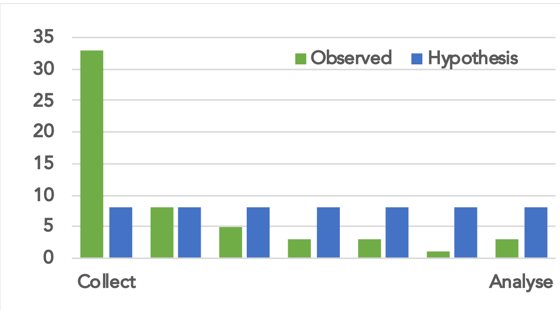
H6 The skewness of each of the distributions of the $C_n$ is statistically significant in at least some of the phases of the Design Thinking process

H7 There is an association between the observed values of at least some of the pairs ($C_n$, $C_m$) of cognitive processes

The control variable's *age* and *experience* are omitted in the analyses as the amount of entries would not deliver reliable results.

#### *4.5.3.1.1. Chi Square test of the data distribution*

To test this hypothesis is only possible for each $C_n$ in each phase. As will be demonstrated in the next section, the hypothesis is verifiable through visual inspection. The formal test will only be shown with the example 'Collect information – analyse information' and the *Understand* phase. The test is a version of the $\chi^2$ test called 'a goodness of fit test'. The null hypothesis it tests is: "The sample shows a discrete uniform distribution." The visualisation of the null hypothesis and the calculated results are shown in *Figure 87*.




| One-Sample Chi-Square Test Summary | |
|---|---|
| Total N | 56 |
| Test Statistic | 94,750[a] |
| Degree Of Freedom | 6 |
| Asymptotic Sig.(2-sided test) | ,000 |

a. There are 0 cells (0%) with expected values less than 5. The minimum expected value is 8.

*Figure 87.* Social Media Survey – Visualisation of the Null Hypothesis Versus the Observed Data, and SPSS Results – Devised by author

#### *4.5.3.1.2. Tabulation and Visual Inspection of the Data*

The plausibility of Hypotheses H1 to H4 can best be checked through visual inspection and tabulation for the exploratory purposes of this analysis. The complexity of the data collected in the survey calls for separate inspection for each cognitive pair. The data is therefore first cross tabulated for each of the pairs ($C_1$, P), ($C_2$, P), ($C_3$, P), ($C_4$, P) and ($C_5$, P) and then re-coded for a visual synopsis.

Here, only the results for 'collect information – analyse information' are presented. Additional data can be found in the Appendix. As shown in *Table 34*, the data was again coded using a heatmap to provide quick visual results.

*Table 34.* Social Media Survey – Tabular Results for Analyse – Collect

| | Understand | Observe | Define | Ideate | Prototype | Test |
|---|---|---|---|---|---|---|
| Collect | 33 | 26 | 0 | 5 | 1 | 16 |
| | 8 | 14 | 1 | 3 | 1 | 6 |
| | 5 | 2 | 1 | 3 | 1 | 0 |
| Analyse | 3 | 3 | 7 | 17 | 16 | 4 |
| | 3 | 2 | 8 | 7 | 7 | 1 |
| | 1 | 6 | 13 | 12 | 11 | 4 |
| | 3 | 2 | 26 | 8 | 18 | 25 |

Devised by author

For visual inspection, a diagram view might also be helpful. The amount of data demands for a three-dimensional view. As the information value is rather lower than with the heat mapped table, this visualisation is omitted from further analyses.

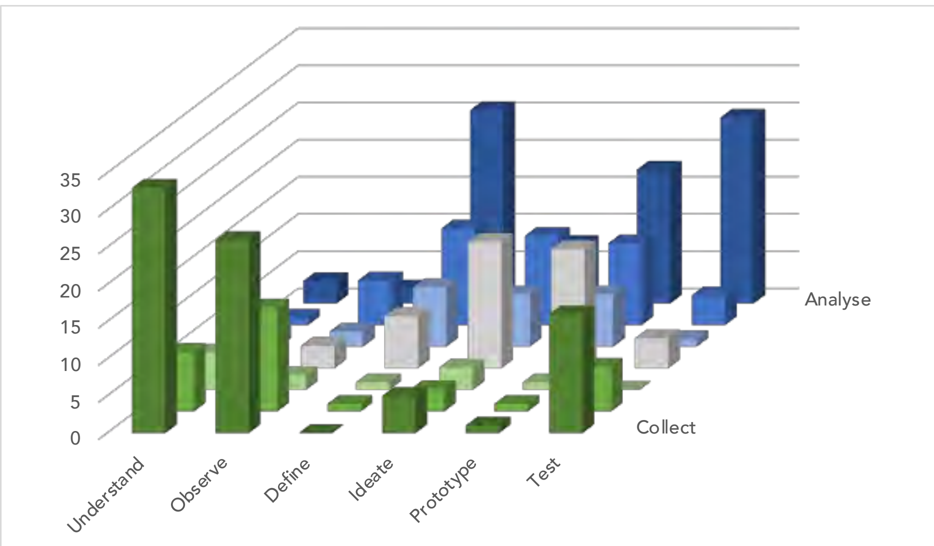



*Figure 88.* Social Media Survey – 3D Diagram for Analyse – Collect

Devised by author

The previous analysis has already shown visually that the survey's respondents both experience the phases of the Design Thinking process as quite distinct, and clearly articulate differences in their perception of the five different cognitive processes. This fact can be further clarified through a synopsis of the result. An additional source of clarification rests in the observation that a) in every combination of cognitive pair and Design Thinking phase, respondents' answers tended to cluster either in the left side, the middle or the right side of the semantic differential, and b) the resolution of semantic differentials as measurement devices is not very high.

It is therefore instructive to group the results of the survey into the three bins:

– Left side of the semantic differential.......................values 1, 2 and 3
– Neutral segment .......................................................the middle value 4
– Right side of the semantic differential ...................values 5, 6 and 7

Table 35 shows the synopsis. It quickly becomes evident that Hypotheses 1 to 4 can be easily visually assessed.

*Table 35*. Social Media Survey – Tabular Synopsis of the Survey Results with Grouped Values

| | Understand | Observe | Define | Ideate | Prototype | Test |
|---|---|---|---|---|---|---|
| Collect | 46 | 42 | 2 | 11 | 3 | 22 |
| *Neutral* | 3 | 3 | 7 | 17 | 16 | 4 |
| Analyse | 7 | 10 | 47 | 27 | 36 | 30 |
| Observe | 39 | 51 | 10 | 4 | 11 | 44 |
| *Neutral* | 8 | | 16 | 6 | 6 | 4 |
| Imaginge | 7 | 5 | 29 | 46 | 38 | 7 |
| Select | 24 | 24 | 19 | 7 | 10 | 18 |
| *Neutral* | 11 | 13 | 6 | 15 | 7 | 10 |
| Develop | 20 | 18 | 30 | 33 | 39 | 28 |
| Spontaneous | 20 | 24 | 6 | 26 | 12 | 11 |
| *Neutral* | 10 | 11 | 8 | 4 | 11 | 10 |
| Reflective | 25 | 20 | 42 | 26 | 32 | 34 |
| Empathic | 50 | 48 | 17 | 30 | 24 | 27 |
| *Neutral* | 3 | 4 | 17 | 11 | 16 | 15 |
| Withdrawn | 3 | 4 | 21 | 14 | 15 | 14 |

Devised by author

In essence, surprisingly distinct patterns emerge for all combinations of Design Thinking phases and cognitive pairs[28]. It is obvious at a glance, that all segments have a unique visual signature. This suggests very strongly that there is both an association between the phases of the Design Thinking process and each of the variables, and that no cognitive pair is a full corollary of another. In addition, the plausibility checks of the four hypotheses H1 through H4 have been successful.

#### *4.5.3.1.3. Association and Skewness Test*

The following analysis finally tests the core hypothesis H5 and H6 for the research data: Is there an association between the cognitive pairs and the Design Thinking phases and is a skewness detectable?

The binomial test demands a grouping into two areas. For this, all responses are grouped into the left and the right half of the semantic differential. In order to achieve a conservative test result, the neutral value is split down the middle. If it is an uneven number, the fractions are added to the minority score.

With this even split of the responses, the Binomial Distribution can be calculated as B (56, 0,5) for 56 trials and a probability of 50% for each response to fall in one of the groups. This results in the cumulative distribution function graph as shown in *Figure 89*. The critical value for rejecting the null hypothesis, i.e. confirming the skewness is 34.

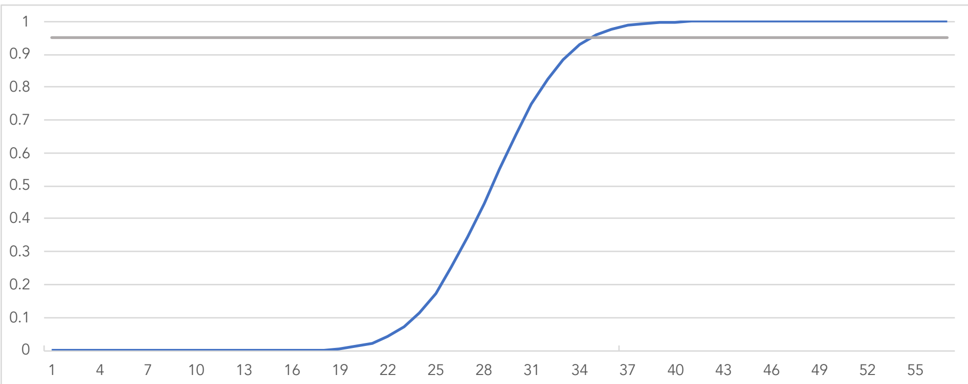



*Figure 89.* Social Media Survey – Cumulative Binomial Distribution Graph for 56 Trials and p = 0,5 – Devised by author

Table 36 shows the synopsis for all cognitive pairs and all phases.

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[28] In the following, ‚segments' for short

*Table 36*. Social Media Survey – Result Skewness analysis – Overview to all Results

| Cognitive Pair | Phase | Test Result for Null Hypothesis | Skew | ML-Estim. Exp. Value | ML-Estimator for Variance | Confidence Lower Limit |
|---|---|---|---|---|---|---|
| Collect - Analyse | Understand | rejected | positive | 83,93% | 0,13489 | 74,11% |
| Collect - Analyse | Observe | rejected | positive | 78,18% | 0,17058 | 67,04% |
| Collect - Analyse | Define | rejected | negative | 89,29% | 0,09566 | 81,02% |
| Collect - Analyse | Ideate | rejected | negative | 63,64% | 0,23140 | 50,66% |
| Collect - Analyse | Prototype | rejected | negative | 80,00% | 0,16000 | 69,21% |
| Collect - Analyse | Test | not rejected | none | 57,14% | 0,24490 | 43,92% |
| Observe - Imagine | Understand | rejected | positive | 79,63% | 0,16221 | 68,67% |
| Observe - Imagine | Observe | rejected | positive | 91,07% | 0,08131 | 83,45% |
| Observe - Imagine | Define | rejected | negative | 67,27% | 0,22017 | 54,62% |
| Observe - Imagine | Ideate | rejected | negative | 87,50% | 0,10938 | 78,66% |
| Observe - Imagine | Prototype | rejected | negative | 74,55% | 0,18975 | 62,80% |
| Observe - Imagine | Test | rejected | positive | 83,64% | 0,13686 | 73,66% |
| Select - Develop | Understand | not rejected | none | 52,73% | 0,24926 | 39,26% |
| Select - Develop | Observe | not rejected | none | 54,55% | 0,24793 | 41,12% |
| Select - Develop | Define | not rejected | none | 60,00% | 0,24000 | 46,79% |
| Select - Develop | Ideate | rejected | negative | 72,73% | 0,19835 | 60,72% |
| Select - Develop | Prototype | rejected | negative | 75,00% | 0,18750 | 63,43% |
| Select - Develop | Test | not rejected | none | 58,93% | 0,24203 | 45,78% |
| Spontaneous - Reflective | Understand | not rejected | none | 54,55% | 0,24793 | 41,12% |
| Spontaneous - Reflective | Observe | not rejected | none | 52,73% | 0,24926 | 39,26% |
| Spontaneous - Reflective | Define | rejected | negative | 82,14% | 0,14668 | 71,91% |
| Spontaneous - Reflective | Ideate | not rejected | none | 50,00% | 0,25000 | 36,64% |
| Spontaneous - Reflective | Prototype | rejected | negative | 67,27% | 0,22017 | 54,62% |
| Spontaneous - Reflective | Test | rejected | negative | 70,91% | 0,20628 | 58,66% |
| Empathic - Withdrawn | Understand | rejected | positive | 91,07% | 0,08131 | 83,45% |
| Empathic - Withdrawn | Observe | rejected | positive | 89,29% | 0,09566 | 81,02% |
| Empathic - Withdrawn | Define | not rejected | none | 52,73% | 0,24926 | 39,26% |
| Empathic - Withdrawn | Ideate | rejected | positive | 63,64% | 0,23140 | 50,66% |
| Empathic - Withdrawn | Prototype | not rejected | none | 58,18% | 0,24331 | 44,88% |
| Empathic - Withdrawn | Test | rejected | positive | 61,82% | 0,23603 | 48,72% |

Devised by author

Transferring the results back to the Tabular Synopsis with binomial data illustrates the results of the analysis (see *Table 37*).

*Table 37*. Social Media Survey – Tabular Synopsis of the Skewness Analysis

| | Understand | Observe | Define | Ideate | Prototype | Test |
|---|---|---|---|---|---|---|
| Collect | 47 | 43 | 6 | 20 | 11 | 24 |
| Analyse | 9 | 12 | 50 | 35 | 44 | 32 |
| Observe | 43 | 51 | 18 | 7 | 14 | 46 |
| Imagine | 11 | 5 | 37 | 49 | 41 | 9 |
| Select | 29 | 30 | 22 | 15 | 14 | 23 |
| Develop | 26 | 25 | 33 | 40 | 42 | 33 |
| Spontaneous | 25 | 29 | 10 | 28 | 18 | 16 |
| Reflective | 30 | 26 | 46 | 28 | 37 | 39 |
| Empathic | 51 | 50 | 26 | 35 | 32 | 34 |
| Withdrawn | 5 | 6 | 29 | 20 | 23 | 22 |

Red borders indicate confirmed skewness in the segment,
Red numbers indicate the dominant cognitive function

Devised by author

Ten of the 30 segments show no statistically significant skewness. Two thirds of the segments therefore show a skew which is significant at the 95 percent confidence level. Note that in some of the other cases, there appears to be a skew in the numbers as well. It simply does not reach the level of significance required here. The skewness of the other segments is clearly patterned but shows no repetition of the pattern, indicating that the cognitive pairs are independent.

The devised patterns per cognitive pair are interesting and basis for further thought. Collect-Analyse and Observe-Imagine are well understood and clearly assigned to the phases. But, the participants never saw 'selecting' as a dominant function in the assessment-pair, and they likewise rejected spontaneous thought as their leading way to think. As true Design Thinkers, the idea of not being empathic was not an option.

#### *4.5.3.2. Free text results and additional data*

Most participants also provided their age and experience with Design Thinking. This information is helpful to evaluate the quality of the entries. Age and gender are only relevant as they provide the information that there might be a gender bias in Design Thinking and that the age is widely dispersed. 64% of the entrants are male, the average age is 44, with the youngest 22 and the oldest 70.
32% are facilitators, 40% team members or core team members. 28% stated the have experience with more than 30 sessions, 17% participated in 11 to 30 sessions. This data shows well that most entrants claim to be experienced Design Thinkers and that the registered data can be rated as good, reliable information.

The survey offered a free text field for further remarks. Only ten participants took advantage of this option and provided some thoughts. Nevertheless, this feedback includes interesting thoughts that will be referred to in the cycle's conclusion.

### 4.5.4. Fifth Cycle – Further Literature Review

The last literature review to first examine mindfulness, as the author has observed that this subject is mentioned in various sources in both Design Thinking and psychology. Then, the cognitive pair: 'Receptiveness: Empathic – Withdrawn' needs additional consideration and consulting of research literature. The findings are presented in the chapter 4.5.4.2 Attention and Creativity.

#### *4.5.4.1. Mindfulness*

Mindfulness is mentioned in many Design Thinking sources (e.g. Beckman, 2020, p. 148; Meinel & Leifer, 2020, p. 5; Shapira et al., 2017, p. 286; Thompson & Schonthal, 2020, p. 89).

In the Design Thinking literature, mindfulness is identified as part of the mindset (Lewrick, Link, et al., 2020, p. 6), it is often mentioned in the *Observe* phase (Dzombak & Beckman, 2020, p. 576), the *Ideate* phase (Doorley et al., 2018, p. 44 card 16) and also in *Prototype/Test*. "If only embraced and analyzed with an open mind, failures are expected to aid learning, ultimately in the service of even greater creative achievements" (Thienen, Meinel, et al., 2017, p. 5).

"Mindfulness is the experience of being fully engaged in the present moment" (Shamas & Maker, 2018, p. 130). Agnoli and Vannucci (2020, p. 168) identify three components of mindfulness:

(1) attention: "the individual engages in a clear observation of his or her moment-to-moment experience (e.g., thoughts, emotions, and bodily sensations)" (p168).
(2) intentionality: the observation is conscious and purposeful.

(3) attitude: the observer is detached, free of judgement and curious. As shown in Table 3, page 32 a distortion-free perception needs mindfulness. "Being mindful, the practitioner is aware of her pattern of intention, thinking, feeling and actions moment by moment without distortion (Johns, 2017, p. 8).

Mindfulness helps shift perception, thus providing the ability to regard the environment through different points of view. Compton et al. (2019, p. 123) refer to Ellen Langer, a pioneer in mindfulness research, who stated that mindfulness provides the possibility to create new categories of perception. This concept aligns Langer's theory with Lisa Feldman Barrett's Theory of Constructed Emotion discussed in chapter 5.1.2. It follows that mindfulness requires creativity, as the conception of new categories is a creative act that is obligatory to establish order in multifarious environments (Agnoli & Vannucci, 2020, p. 169).

Shamas and Maker (2018, p. 131) discern between mindfulness of thought, coined *thoughtfulness,* and mindfulness of the senses, coined *sensationality*. Thoughtfulness implies a focus on cognitive processes including memory recalls, imagination and deep reflection, and the disregard of external and internal senses. Sensationality, as used by Shamas and Maker, is the mindfulness towards all senses while obtaining "mental silence" (p.131). Both *thoughtfulness* and *sensationality*, or the internal and external focus, are fundamental for the creative process when alternating with each other (Shamas & Maker, 2018, p. 141). The awareness of attention enables a meta ability: attention regulation. A mindful person is able to regulate the direction of her or his attention (Wheeler et al., 2017, p. 1474). However; the switch from internal to external attention and back is effortful and needs certain dedication (Verschooren et al., 2019, p. 484). As discussed in chapter 4.4.4.2, being an experienced practitioner eases the change towards levity.

Meditation is a common method to enhance mindfulness. Schootstra et al. (2017) researched the effectiveness of meditation and found that after only ten to twelve minutes of meditation, students achieved higher levels of creative variability than the control groups, and were also in a more positive and more relaxed mood. In contrast, a study on the effects of long-term meditation found positive effects on problem-solving in convergent and but not in divergent tasks. The same research found that experienced practitioners have enhanced insight abilities after a meditation session targeted to also better their mood (Colzato et al., 2017, p. 14). Baas (2019, p. 265) also supports the positive effect of mindfulness training on creativity enhancing moods. Rieken et al. (2019) performed similar research with engineering students, and also found, that fifteen minutes of mindfulness meditation can enhance divergent thinking skills. Openness, curiousness and kindness were the most relevant sub-factors to for gaining better divergent thinking scores. Subsuming these three elements to the ability to observe, other studies confirmed these findings (Agnoli et al., 2018, p. 43).

Mind-wandering and mindfulness seem to be opposing phenomena. But it has been shown that people with high scores in both mindfulness and mind-wandering – specifically deliberate mind-wandering – achieve high values in creativity (Agnoli et al., 2018, pp. 48–49).

It's easy to see that mindfulness is helpful during *Observe* and *Ideate*. As a mindfulness meditation with a positive mood can induce a more detached attitude, described as “effortless” and “non-grasping” (Colzato et al., 2017, p. 15), it might be worth a try to practise mindfulness meditation before a *Test* phase to enhance acceptance of critique.

#### *4.5.4.2. Attention and Creativity*

The author was considering to reject the cognitive pair ‘Receptiveness: Empathic – Withdrawn’, as many surveyed people indignantly turned away from the idea of not being emphatic. Surprisingly though, literature research and observation showed considerable parallels with the social media survey. Furthermore, the research findings showed a gap without the attention modes. The author had the assumption that the terms she used in the surveys were badly chosen. As Lissack (2019a) states: “Meaning is given by sets of objects and associations that are invoked when a term is used” (p. 240). Further literature review revealed a better fitting nomenclature in spring/summer 2020. As there was no possibility for an additional survey, the author decided to refine the concept with a literature triangulation in Design Thinking research, cognitive psychology and neuroscience. Additionally, there is proof in the given empirical data that will be explained at the end of the chapter.

One of Csikszentmihalyi’s (2013) ‘Contradictive Traits of Creative People’ (see *Table 16*, page 177) is Introversion – Extroversion. He describes the creative person as someone who thrives in contact with others, needing the shared experience and input of other people’s thoughts. On the other side, creative people sometimes need seclusion to perform their tasks and to produce outputs (pp. 65-68).

Openness is one of the traits that is steadfastly linked to creativity (Plucker et al., 2019, p. 50). This openness manifests as high sensitivity, and broad or ‘leaky’ attention that is very aware of the environment and all inputs that can be received from it (Zabelina, 2018, pp. 162–163). Because of this trait, Martin (2013, p. 56) talks of “first rate noticers”. On the other hand, “in order to create a highly original thought or product, people have to focus and persist in the task at hand” (Zabelina, 2018, p. 164).

Creativity needs both focused and unfocused attention, the ability to flexibly switch between an open mind that notices as much as possible and a highly concentrated mode where nothing counts but the task at hand (Zabelina, 2018, p. 165).

Focused phases don't have to be purely reflective, i.e. geared inwards. The attentive mind coordinates the focus towards internal and/or external information. The goal can, for instance, be to diligently perceive a certain action. Enhanced attention reduces the amount of information that is filtered automatically through *irrelevance processing*. So, the filtering of information can happen to a higher degree consciously and the human decides what might deliver clues (Vannucci & Agnoli, 2019, pp. 250–251).

The human mind is not able to simultaneously keep and work with more than five to seven independent items. This number is far too small to be holistically aware of a given situation and the mind must filter what it should be cognitively aware of to the limit it can handle (Lissack, 2019a, p. 237). Humans are able to multitasking but only on a very basic level. The more concentration one task demands, the less other functions can be fulfilled (Hofmann, 2019, p. 47). To work intensively on a specific topic, the person must focus on this topic and withdraw from other influences.

Only deeply concentrating on one topic might be detrimental, because without changing perspective, people tend to confirm their belief towards the given subject of focus and harden their attitude if the timespan in concentration is too long. Subsequently, they cease being able to create new ideas with the subject matter (Bengal et al., 2018, p. 375). Zabelina (2018, p. 167) created a Model of Creativity and Attention (MOCA) in which she shunned fixed attention and implemented flexible attention (i.e. the ability to frequently select the level of attention), thus avoiding the problem of a hardened focus. It might be advisable to think about flexibly focused instead of focused. Still, there is a big difference between volitional change and disturbing interruption. When just following a though thread, a disturbance, no matter if it is a telephone call or a stray thought, can be extremely detrital (Mlodinow, 2018, p. 149).

There is evidence that de-focusing, i.e. not thinking about the given problem and allowing for incubation, can be helpful for the creative process, especially when the mind is diverted with distracting tasks (Ward & Kolomyts, 2019, p. 185). This connects not-focusing with mind-wandering as discussed above with the same strategy of giving the mind 'time to play' to subconsciously reach results (Agnoli et al., 2018, p. 42). This unfocused cognition is Type 1 related and the processing is associated with the Default Mode Network (Abraham, 2018, p. 42).

Bilevicius et al. (2018) show that the neural networks that are highly associated with creative cognition, namely the Default Mode Network (DMN), the Central Executive Framework (CEN), and the Salience Network (SN) (see chapter 4.4.4.2), are connected with the attentional component of mindfulness. CEN and SN are active in "attention to moment-to-moment experiences" (p. 44). The research of Bilevicius et al. (2018) also showed the link between the DMN and mind-wandering and its negative correlation to mindfulness, but there was slight correlation to those parts of the DMN that are associated with deliberate mind-wandering (p.45). To keep the concentration to one task, the mind must learn not to react on salient impulses or to select the signal it follows deliberately (Lotto, 2018, pp. 264, 267).

In her research, the author observed the students trying to find quiet places for their work, because, as they stated, they wanted to concentrate. This was rather easy for the projects that took place at FHV Dornbirn (e.g. see *Figure 81*, page 248) but posed a problem for Project Six in Antwerp, especially on the second day when construction work distracted the students considerably. This distraction was one of the main complaints those students voiced. It became clear that all students felt it was important to be able to focus on the given task. In both projects (and many others), the author observed students sitting at their places with closed eyes or staring into nothingness, lost in thought.

#### *4.5.4.3. The Groan Zone*

The experience of the author with the Groan Zone was one of the reasons for the topic of this thesis. As a member of a Design Thinking project, she and her teammates felt lost in the Groan Zone (not knowing at that time what it was) and had the impression that the facilitators felt similarly and just wanted to get over with it. In the Groan Zone, the instructions that had always been helpful and to the point became cursory and unclear.

According to Lewrick et a. (2018b, pp. 36–37), the Groan Zone is the transition area between divergent and convergent thinking. Living up to its name, the Groan Zone has a bad reputation, is called a "'Creaking' hinge" (Fleischmann et al., 2020, p. 166), "where the group experiences feelings close to despair" (Kuuluvainen, 2018 para 7), and "when the team feels at odds what is going on" (Kun et al., 2019, p. 349).

The term "Groan Zone" was coined in the 1990's by Sam Kaner et al. (2014) for the "struggle in the service of integration" (p.18) in the process of participatory decision-making. The description they deliver is fierce:

> Struggling to understand a wide range of foreign or opposing ideas is not a pleasant experience. Group members can be repetitious, insensitive, defensive, short-tempered – and more! At such times most people don't have the slightest notion of what's happening. (Kaner et al., 2014, p. 19)

Approximately at the same time, John Gero (1996) introduced the term *Emergence*, explaining:

> Emergence allows for the introduction of new behaviours and new functions and is the equivalent of a designer refocusing his or her attention and/or reinterpreting the results of his or her actions so far. (Gero, 1996, p. 444)

Emergence happens at the same time as the Groan Zone but with a dramatically different attitude, concentrating on the potential of the phase instead of the problems (Kun et al., 2019, p. 349).

Even if the Groan Zone is distinctly different from divergent and convergent thinking, it is included in phases with other totally different 'zones', while it often stays unclear if it is the previous divergent or the following convergent phase the Groan Zone belongs to (Curedale, 2019, pp. 202–205). Kaner (2014, p. 21) and Lewrick (2018b, pp. 37, 182) both emphasise the importance of the facilitator being aware of the Groan Zone, but that it is often also beneficial to explain it to the team. As the Design Thinking models do not help here, it is up to the facilitator to recognise when the Groan Zone appears. However, some facilitators advise to minimise and ignore it (Kuuluvainen, 2018). Others strongly advise against it, as it can lead to real problems (Kaner et al., 2014).

The Groan Zones are the times in the Design Thinking process when the team can draw on abundant resources, be it the information and insights from observation or the mass of ideas from ideation (Gerstbach, 2016, pp. 77, 96; Liedtka et al., 2019, pp. 22, 28). The amount of data can be intimidating, but it provides the basis for exploration (Kun et al., 2019, p. 355), for the emergence of implicit ideas, insights and solutions that derive from the synergy of the fullness that is now attainable for the team (Gero, 1996, p. 438).

The author suggests it is time to think differently about the dreaded zone.

#### 4.5.5. Conclusion of the Fifth Cycle

The Social media survey confirmed the basic concept of this thesis. The five cognitive pairs are acknowledged by the participants of the survey. All participants completed the questions and assessed the cognitive pairs. One entrant (with experience in over 30 projects) stated: "all design thinking is placed in one page". Several commented that there are Design Thinking phases that need both modes of a cognitive pair, which conforms the findings in literature review and project observation.

It is interesting to see, that the important attitude of Design Thinkers was also mentioned from a highly experienced entrant: "Design Thinker would never be constrained by being 'withdrawn to own thoughts'". As literature review and project observation showed, this is most probably not true, but the question was not well posed, as it directly confronted this core element of the trade.

The statistical analysis provided data that can be compared with the predominance concept presented in chapter 4.4.1. *Figure 90* shows the predominance of both concept and survey data. The zigzag areas only indicate that there is no predominant function. In some segments this means the functions work alternately in rapid succession, like deliberate and automatic thinking in *Ideate* (or more precisely in a brainstorming session in ideate). In other segments the cognitive functions might just both be not very important. The author presumes this for 'appreciation of information' and the *Observe* phase. Here the observer shouldn't think about the information, neither judging nor selecting, because this would hinder her/his observational skills.

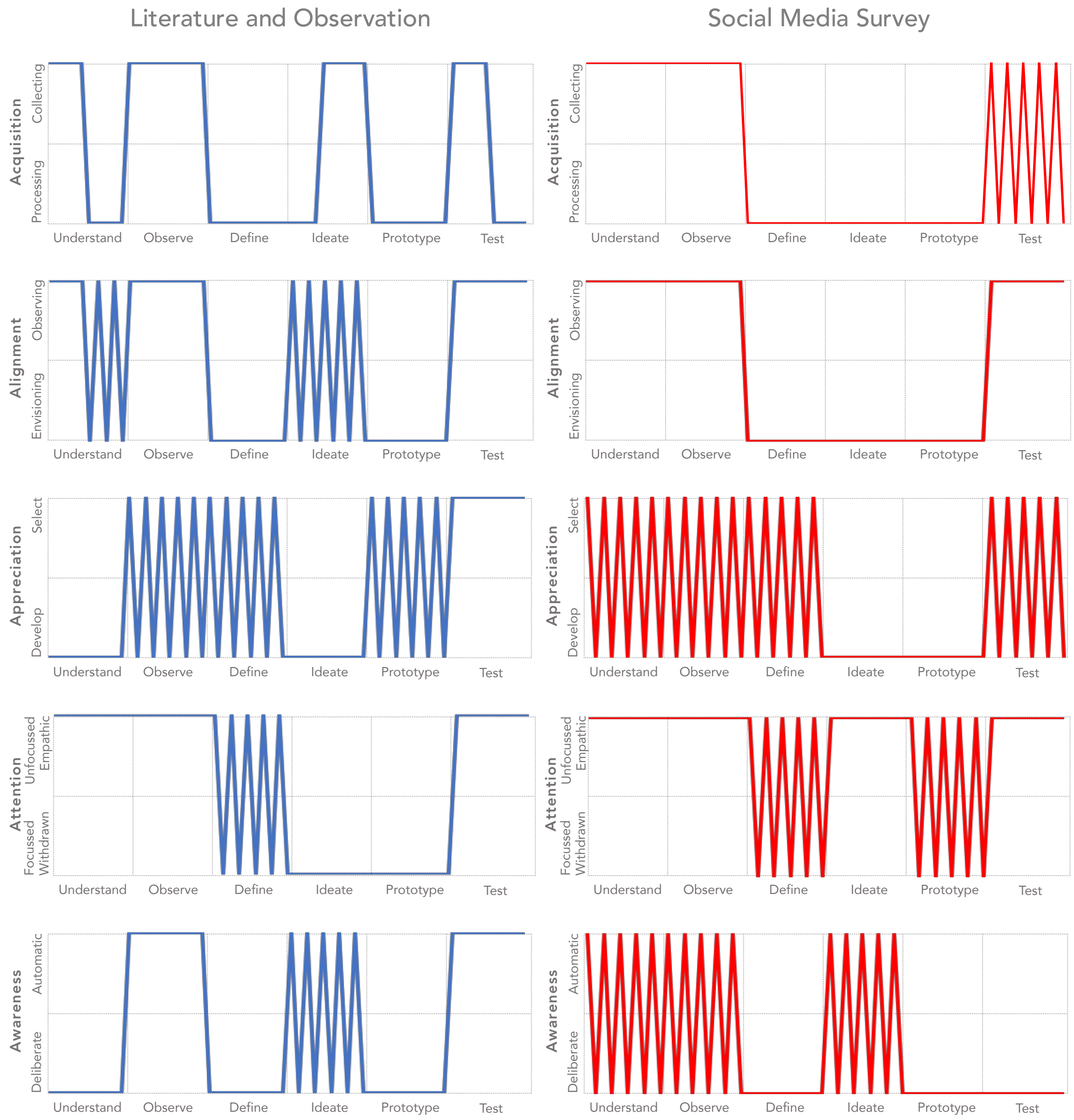


*Figure 90.* Comparison Concept and Survey Results - The Cognitive Mode Activity Profile – Devised by author

The mindfulness model of Shamas and Maker (2018) aligns with the cognitive pair *Alignment of Perception:* OBSERVANT – ENVISIONING/IMAGINING of this thesis. Being observant aligns with sensationality while envisioning fits to their thoughtfulness mode. Similar to Schootstra et al. (2017), the author of this thesis led a ten minute instructed meditation prior to the ideation phase in Project Eight. The students willingly participated in the exercise and mostly welcomed the calming effect. Some shared personal experiences with meditation and appreciated the possibility "to find a better focus". The author observed a certain composedness and a good level of concentration during the following exercise.

A final refinement of the *Assessment* set renames SELECTING to JUDGING. This follows the literature findings and project observations, that there might be a potential chance in every existing element. Besides, it has shown in through project observation, that the team members find it easier to cluster and rate facts – especially ideas - than to reject it definitively.

Pringle and Sowden (2017) declare that shifting between cognitive modes can be deliberate. For deliberation, metacognitive awareness is indispensable. They found that trained creatives are better able to switch modes, but that they use mode switching only in professional circumstances. Pringle and Sowden (2017) deduce from this that shifting cognitive modes can be learned. Even the intensity in which the selected mode is applied can be controlled. Vannucci and Agnoli (2019, pp. 249–250) point out "that spontaneous and deliberate MW [mind-wandering] are different cognitive experiences and that different cognitive mechanisms might play a role in prompting the arising of these two types of MW experiences".

The facilitator has a significant responsibility in the Design Thinking process. Their task is to enhance creativity in their teams. "They do this by providing bold challenges, that stretch others' imagination, creating a culture of constructive debate, and giving ownership and credit to those who contribute" (Seelig, 2017, p. 170).

It is important that the Design Thinking facilitator is aware of the mental states she/he and the team is in. Self-awareness has two virtues. First, it helps oneself to a more active way to guide one's thoughts and strategies. Second, it helps guiding the team as the awareness of the personal state provides a good standpoint to observe the state of the team members and to find leverage for change (Kasperowski, 2018, pp. 17–18)

The Groan Zone's usefulness suffers because of its bad name. It is essential to be aware of the zone because it is not an easy phase and to ignoring it can lead to disaster (Kaner et al., 2014). Nonetheless, as illustrated in chapter 4.2.4.3.2, framing alters attitude and action, so to perceive the Groan Zone not as an area of suffering (Kuuluvainen, 2018), but as an area of chance and development might change the progress that is possible in the given project. The author tested the perception shift for the Groan Zone in Project Eight and experienced a substantial change in the team. The author didn't deny the awkward mood when the divergence phase ended, and instead explained the reason for it and emphasised its potential as a phase of development and chance. The students took this at face value and fought through the struggle to reach remarkably good results. Bestley and Noble (2018, pp. 27–28) name the transition between divergent and convergent phases *transformation*, and Kun et al. (2019, p. 348) call it the zone of *emergenc*e, representing potential, and not the threat, of the Groan Zone.

In short, the author suggests renaming the Groan Zone to Growth Zone and to work with it accordingly. The suggested name keeps a resemblance with the old one, making it easier to recognise for veterans. The Growth Zone might not even need its own phase under these circumstances as the attitude fits with the divergent phases, *Observe* and *Ideate*, it should belong to.

This cycle showed, the five cognitive pairs are relevant and useful for Design Thinking. Sometimes, one function of the cognitive pair dominates, but in some phases the iteration between the functions is relevant for a successful project.

## 4.6. Final Cycle

### 4.6.1. Final Concept

The last cycles showed, that the five cognitive pairs have their merit. With several rounds of refinement and after the worldwide survey they can be considered valid:

– Acquisition of Data: COLLECTING – PROCESSING
– Alignment of Perception: OBSERVING – ENVISIONING
– Assessment of Information and Ideas: DEVELOPING – JUDGING
– Attention to a specific task: UNFOCUSSED – FOCUSSED
– Awareness of the cognitive process: AUTOMATIC – DELIBERATE

The dominance of one of the cognitive functions in a Design Thinking phase respectively is not always clearly defined. There is evidence, that in some the cognitive pair is less relevant – like *assessment of information and ideas*, in *Observe*, and that in other phases the cognitive functions alternate, like develop and select in *Define* and *Test*. Some phases are clearly split, with the dominance switching inside the phase. An example for this is *Ideate* where data must be used as analytic basis for ideation and then collected to find the solution. Determining the exact dominance and importance in each segment is beyond the scope of this thesis and should be researched in subsequent projects.

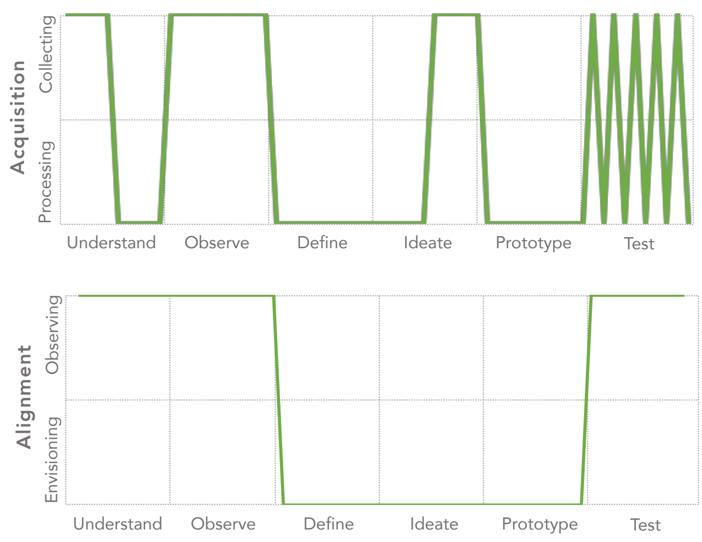


*Figure 91.* Final Concept – Cognitive Mode Activity Profile – Devised by author

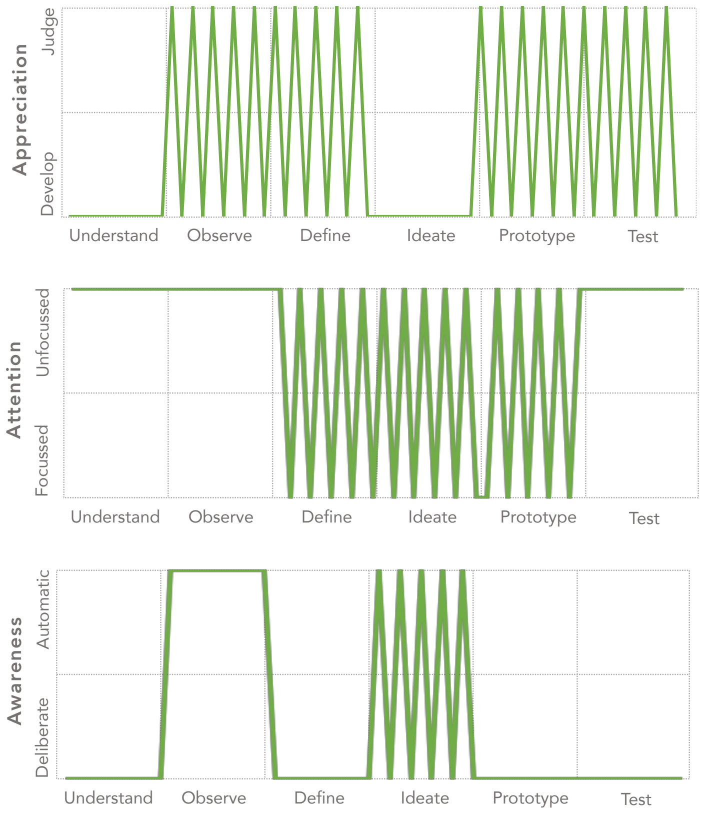


*Figure 91.* Continued

#### 4.6.2. Project Nine – IFS Vorarlberg, Institut für Sozialdienste, Institute for Social Service

The IFS is an institution that provides social services everywhere in Vorarlberg. Their topics range from consulting people in dire situations, over helping people with disabilities or learning difficulties, to active support in abusive and violent situations. The field is vast, the tasks of the employees are demanding and unsettling. Goal of the Design Thinking project was to investigate into the current trends in the social issues attended by the IFS and to discuss a potential repositioning of the institute to fit to the new development in their work area.

There were 20 participants (including two team members that supported the project) from diverse working areas of the ifs and with various professional experiences. The age went from early twenties to late fifties, fourteen participants were female, six were male.

*Table 38* shows the course of the project. As it was a final project, the research was reduced to observation and photography.

*Table 38.* Project Nine – Project plan – IFS Vorarlberg

| | Group 1 | | Group 2 | |
|---|---|---|---|---|
| **IDEO phase** | **Tools/Tasks** | **Extras** | **Tools/Tasks** | **Extras** |
| **Kick-off session:**<br>Understand | - Presentation of up-to-date information on the state of social problem fields affecting the IFS.<br>- Discussion of the fields<br>- Voting for the most important ones<br>- Splitting into groups<br>- Task for everybody to investigate into her/his field in their work space (Introduction to Observe-watch-interview-participate) | | | |
| **Workshop 1** | | Ball-throwing game | | Ball-throwing game |
| Understand | - Topic collection<br>- Topic selection | One truth/one lie | - Topic collection<br>- Topic selection | One truth/one lie |
| Observe | - Storytelling<br>- What–How–Why<br>- Human needs<br>- Persona | | - Storytelling<br>- What–How–Why<br>- Persona | |
| **Workshop 2** | | Candle-on-the wall | | Candle-on-the wall |
| Define | - Client journey<br>- Laddering<br>- Observation – Insight – POV | | - Systems map<br>- Observation – Insight – POV | |
| Ideate | - Brainwriting / -storming<br>- Inspirational images | Back-to-Back story | - Brainwriting / -storming<br>- Inspirational images | Back-to-Back story |
| **Workshop 3** | | Blind portrait | | Blind portrait |
| Define | - voting for sub-topic | | - voting for sub-topic | |
| Ideate | Split in 2 Teams:<br>- Brainwriting / -storming | POV-Companion | Split in 2 Teams:<br>- Brainwriting / -storming | POV-Companion |
| Prototype | - Clustering<br>- Voting<br>- Free prototyping | Marshmallow-challenge | - Clustering<br>- Voting<br>- Free prototyping | Marshmallow-challenge |
| Test / Prototype | - Short test with second team<br>- Refinement | | - Short test with second team<br>- Refinement | |
| **World Café** | | | | |
| TEST | Presentation of the project and the prototypes for peer feedback | | | |

Devised by author

#### *4.6.2.1. Project description*

The project was conducted in 5 sessions: A kick-off to identify the topics that should be discussed in depth, 3 workshops (4 hours each), and a world-café to present the prototype solutions to the colleagues at the IFS for testing and feedback. Further workshops were possible if needed.
The group was split in two teams working in separate time slots on different topics.

In the Kick-off session, all participants worked together to identify the topic they wanted to focus on. After the identification, the split at their own choice into two teams that worked in separate time frames during the three workshops. As shown in *Table 38*, the two teams needed different tools as the topics and the work progress differed.

#### *4.6.2.2. Observation*

The project was quite challenging as all participants were non-designers and as the problem space was vast. Two contact persons had already Design Thinking experience and supported the author throughout the project.

The observation showed that the thinking processes fit in such a setting. However, the team was harder to guide, especially for *Observe*, as their profession is very demanding and distracting. Their profession made the team members good observers, but they tend too quickly to draw conclusions. They came to the workshop not with observations facts but with their personal conclusions. Story-telling helped to go back to the observed points.

Team One worked on IFS-internal issues, Team Two on more external points. This led to rather different discussions and work methods. Even with the same tool, the questions were different. For instance, the personas the teams developed, were in Team Two for the IFS-clients, where Team One modelled IFS-employees. Later, it was important for Team One to understand the interdependencies in the IFS System. Team Two needed to get better insights into the customer journey. They worked with wool threads to combine the elements of the journey. This technique was quite successful, as the team was very flexible while planning and tried various variants.

The project rooms included huge blackboards that were extremely helpful, as they provided ample space and the flexibility to mix Post Its with chalk drawings. All in all, it transpired that the time for the project was too ambitious and the problem spaces of the teams too big to handle properly in the short time given.

Nevertheless, the teams created four interesting prototypes for concise topics and were proud of it. Unfortunately, the author was not able to convey that the world café was a test session that was not designed to present final results, but to initiate a new iteration. This led to too high expectations and to some frustration.

A concluding conversation revealed, that the prototypes will not receive further development, but that several issues and solutions were brought to awareness to the management of IFS with this Design Thinking project and will be implemented – if not directly, so still in a highly influencing way.
For the research of this thesis, the projects showed that the cognitive pairs were well applicable and that the guides (role models, games, storytelling) worked satisfactory.

#### 4.6.3. Project Ten – Antwerp 2019

The project was held for fifth semester bachelors students in a business program during an entrepreneurship course. In this course, teams of five to seven students worked on real life projects, solving problems from Belgian companies. The Design Thinking project supported them in solving the problems. The project started in October with written assignments for the students. The class on premise was held over two days with the class split into three groups and with two hours individual attention for each group and day in December 2019. As this is the final project, the focus was set on observation (see *Table 39*).

*Table 39*. Project Ten – Project Plan – Bachelor Class in Entrepreneurship Antwerp 2019

| IDEO phase | Tools/Tasks | Role Models for Group 2 and 3 | Research Methods | | |
|---|---|---|---|---|---|
| Understand | Create task<br>Frame the problem | | | | |
| Observe | Participant observation<br>Participant interview | 2 – The researcher<br>3 – The TV show detective | | | |
| Define | Empathy map<br>Jobs-to-be-done framework<br>Observation-insight-challenge funnel | 2 – The anthropologist<br>3 – The doting admirer | | | |
| Ideate | Brainwriting / -storming<br>Redefine challenge | 2 – The creative pro.<br>3 – Leonardo da Vinci | Project observation | Photography | Online Survey |

Devised by author

The class had the same structure as Project Six and the researcher decided to stick to the split in three groups and just to observe with the new insights. *Table 39* provides an overview of the project plan.

#### *4.6.3.1. Project Description*

The project was conducted outside the Hogeschool in an experimental building serving as greenhouse, bar and connection space for sustainable technologies. The open, light and unusual place supported the students' independence and willingness to improvise. Even the fact that the other place was very cold in December and the students had to switch buildings for the impulse lectures has bothered the only few.

The class started with a short lecture about Design Thinking switching quickly to practical tasks for the students. The lecturer coached the students during their tasks walking from table to table. Whenever a task was concluded, the next impulse lecture was held, and new instructions given for the next task. The second day was similar.

The project was too short for Prototype and Test phase. But the lecturer provided instructions how to conduct those two phases independently, if the students wanted to proceed. On the first day, a part of the building was used by another group but there was ample space for the team work. Only for the lectures, the team needed another place. To keep these walks to the other building minimal, the lecturer reduced the number of impulse lectures and gave the task instructions in the open team work space.

#### *4.6.3.2. Observations*

The students were very dedicated and lively in the class. They all prepared the observation elements and worked with them. It was clear to see, that the way they worked changed with the tasks. During the define tasks, they were very concerted and serious. The Job-to-be-done task led to lively discussions. In ideation the single-work phases were again quite serious, with students sitting there with closed eyes and withdrawn mine, while the idea-sharing phases were full of laughter and lively discussions (see *Figure 92*).

The walks to the separate building for the lectures broke the flow. The students always needed time to settle down afterwards. Changing to only called instructions in the open building helped to keep the students on topic.

*Figure 92.* Project Ten – Team Observation. Left: Define Phase, Right: Ideation
Photography by author

Only 18 students answered the survey. So, the quantitative Data gave no valid insights. The open text feedback showed, that they appreciated to learn new ways of thinking and being challenged in a new way. Talking with them confirmed the positive impression. Some expressed the wish for a longer Design Thinking course, as they found it interesting but much too short.

# 5. Conclusion

## 5.1. Overview of Results

This research endeavour strictly followed the DREPT methodology throughout the whole process. The basic methodology was augmented with extensive empirical work, whose focus rested on the observation and evaluation of Design Thinking projects and which was regularly complemented with surveys. In all, twelve projects were conducted, observed and evaluated, eleven of which were in an academic setting. Nine projects lasted from several days up to ten weeks, and three projects were three to eight hours long. One of the projects was conducted in cycle one, two were in cycle two. Nine projects were conducted in the later cycles of the research project. All the surveys were evaluated qualitatively. One small survey was evaluated quantitatively as a pre-test. The largest survey was conducted in the final research cycle and fully evaluated quantitatively.

The overarching goal of the research was to develop a better understanding of the thought processes in Design Thinking, essentially looking for the driving force behind those thought processes. Beginning with the literature review, the research went through two evolutionary stages before arriving at the conceptualization which best fit the empirical findings and the current state of discussion in the literature. As part of this process, a number of key concepts could be clarified and differentiated from each other, most importantly the concepts of affective state, emotion, mood, feeling, mindset and cognitive mode.

The first evolutionary stage was based on a conjecture derived from H.G. Häusel, who states that every decision people make is led by emotions, and that human motivations, goals, and actions are all controlled by emotions. Accordingly, the initial hypothesis to be tested was that it is the emotions which play a pivotal role in Design Thinking thought processes. While this hypothesis had to be rejected due to the findings, its analysis led to a deeper understanding of the underlying issues, thereby facilitating the next evolutionary step.

In the second evolutionary step, the candidates for the process drivers were the concepts of mindset which have been a subject of intense research for the last thirty years in psychology and other disciplines. While the mindset hypothesis also turned out to be problematic, it led to the final hypothesis that cognitive modes drive the thought processes in Design Thinking. This final hypothesis could be substantiated through empirical field studies combined with a thorough analysis of the academic literature in psychology, neuroscience and design.

The starting point and the first two evolutionary stages of this research are discussed in chapter 5.1.1 and 5.1.2, and the ultimate hypothesis in chapters 5.1.3 ff.

### 5.1.1. The Starting Point

The author started the research with a literature review into the three subject areas:

- Design Thinking, because it is the key to developing a deep understanding of the research field itself; its scientific foundation, its contextualisation within design and its fundamental procedures in particular
- Creativity, because it is the core element of Design Thinking
- Emotion, because it is the central concept in the initial hypothesis of this research endeavour

#### *5.1.1.1. Design Thinking*

*Design Thinking* is basically a process for finding solutions to complex problems. It has a solid founding in psychology, philosophy, design and educational theory. Today, Design Thinking is implemented in many companies, organisations, and academic institutions. Its success and effectiveness are indisputable.

The methodology itself can be traced back to John E. Arnold and his curriculum for creative engineering at Stanford University. Creative engineering has deep roots in psychology – particularly research into creativity and intelligence – and its development has been strongly influenced by J. P. Guilford, A. H. Maslow, and A. F. Osborne. Many other designers and psychologists contributed to the further development of Design Thinking into its current form. David Kelley and Tim Brown introduced Design Thinking into the design business and, from there, to the world as the problem-tackling mindset/methodology/tool as it is known today.

The takeaway of the starting literature research into Design Thinking: The field can be considered mature, with a clearly established constituent phase structure of the Design Thinking process itself and a broad consensus on the relevance of affective states to the creative process (see below). There are a number of variations in the literature on how the phase structure should be built in detail. The author settled on the IDEO variation (*Understand*, *Observe*, *Define*, *Ideate*, *Prototype*, *Test*) because of its broad recognition.

#### *5.1.1.2. Creativity*

*Creativity* can be defined as the creation of novel and useful ideas. The literature review focused on inspiration and insight as the source for new ideas. An insight develops when a person changes her/his perspective on a problem. This change can happen unconsciously, in a mind-wandering period; or consciously, preferably guided through targeted techniques.

Professional idea generation starts with an intense exploration of the problem space, the diligent collection of data and its systematic analysis, which reveals patterns and hidden connections. The professional creative works with both detachment and dedication, trying to build empathy with the target group and to gain an in-depth understanding of the problem space without getting lost in its depths. This approach replaces serendipity with first delimiting and then thoroughly exploring a comprehensive solution space.

The takeaway of the first research cycles into creativity: It is impossible to delve into Design Thinking without having a close look at the inner workings of creativity. The key challenge rests in the question of to what extent, and how exactly, creation can be moved away from the haphazard towards a deliberate process. The constituent phase structure of the design thinking process clearly addresses this challenge by providing a step-by-step guide mirroring several process findings in creativity research.

#### *5.1.1.3. Emotion*

*Emotion* is relevant to the creative process. In the literature it is typically conceptualised as affective states such as curiosity, desire, ambition or discomfort. During the *Understand* phase of the Design Thinking process, curiosity and a desire to belong can help in building the team and comprehending the challenge at hand. A discomfort with the unresolved challenge the team must tackle should be awakened. The participants should perceive the sincere desire to resolve the challenge while feeling confident that the ongoing project can make a difference.

In *Observe*, curiosity is again naturally helpful. A sense of wellbeing enhances this openness, stifles straying thoughts about issues out of scope, and helps the participants to relax into an open and focused state of mind. In *Define*, diligence and ambition can help to deal with the frequently intimidating amount of data gathered and to track down insights in the problem space. *Ideate* flourishes when the team feels safe to be wild and daring, because crazy ideas are welcome and failure does not lead to condescendence.

This safety also helps in *Prototype*, where daring experiments and bold constructs call for adventure-some and self-confident people. In *Test*, curiosity should again be in the forefront. Good testers are distinguished by a certain detachment from the prototype while still feeling dedicated to finding the right solution. The process loops require that participants feel resilient and ambitious in order to find a solution that has optimisation potential.

This outline demonstrates that phenomenologically, emotions are strongly present throughout the Design Thinking process. It was this observation which gave rise to the initial H.G. Häusel based hypothesis that it is the emotions which drive the entire process.

The takeaway from the first research cycle is that emotions are perfect candidate drivers and that the initial hypothesis built on them had to be tested first.

### 5.1.2. Candidate Drivers: Emotions and Mindsets

The method of testing the initial hypothesis used an operationalisation grounded on the Limbic® Map and a pattern search utilising deep learning based artificial intelligence algorithms. The test itself used empirical data from the first design thinking project conducted.

The Limbic® Map is a functional holistic structure that maps emotions, values and motives into a two-dimensional area that is spanned between the three motives *Balance*, *Stimulant* and *Dominance*, which are assumed by the methodology to be fundamental human motives. The test of the initial hypothesis proceeded in two steps. First, the author determined the optimal predominant emotions for each Design Thinking phase and located these emotions within the Limbic® Map. Then, the evidence from the first Design Thinking project was used to find indications if any patterns could be clearly established. The core methodology was centred around Microsoft's deep learning based artificial intelligence system *Azure Cognitive Service*. Additionally, project observation and participant surveys were evaluated to complement these findings.

The *Cognitive Service* system had already been trained by Microsoft for recognition and classification of facial expressions of emotion. For this project, it was used to automatically identify participants' faces and emotions as shown in photographs shot during the Design Thinking project. With a stock of around 2.000 photos yielding some 500 facial expressions per Design Thinking phase and 250 facial expressions per participant. The results of the automated classification process were then grouped and evaluated by the author according to the Design Thinking phase structure and the emotions predicted for each phase by the hypothesis.

As a result, the initial hypothesis could be conclusively disproven. Emotions are connected to a specific object or event and they are short-lived, typically lasting only for a few minutes. It is nearly impossible to detect emotions reliably, even though people instinctively trust in what they believe to sense. Moreover, emotions with a high valence interfere with higher cognitive processes and should be avoided.

In going over the results of the AI based emotion recognition, it became clear that the system had not successfully identified any emotions but instead had given some indication if the students felt surprised or angry and if their mood was trending towards the positive or negative. The data indicated that there were phases when the students were too agitated to work with prime efficiency, but also that the overall mood was rather positive during the tasks.

What might therefore be beneficial for or detrimental to the creative process are feelings, moods and attitudes. This makes them good candidate drivers as well. The issue was well within the scope of this research project and supported by active ongoing research. Unfortunately, there is a lack of conceptual clarity in the space. Quite a few scientists investigating affective states in creativity do not clearly distinguish emotion, mood, feeling and attitudes, thus often presenting relevant results under the wrong label.

In accordance with the supervisors, the second cycle of the research investigated these issues more closely. Because mindsets can be defined as mental attitudes, or rather, mental attitudes can be defined as mindsets, they were identified as the drivers for the second hypothesis. Unlike existing theories, the author was interested in changing mindsets during the process and identified three mindset pairs and a first assumption about their dominances for the second hypothesis.

In the second research cycle, this hypothesis could be shown to be unsuitable for scientific investigation because the term *mindset* is not sufficiently well defined. The definition of mindset as mental attitude proved to be only one among many others. Currently, there are several research groups with fundamentally different definitions of 'mindset'. The differences are so irreconcilable that any attempt at amalgamation results in ambiguities which render reliable research impossible. The second alternative, to identify one of the definitions as a 'best in class' basis for the project also turned out to be unworkable, as the definitions themselves turned out to be too imprecise.

Given that any definition of 'mindset' has to be intentional, and an operational definition seems quite out of reach, such attempts are in danger of "... a hopelessly muddle-headed notion ..." (Russell, 2015, p. 210) anyway. The third alternative is therefore to use the term in an axiomatic fashion as one of the fundamental concepts of the Design Thinking language game which has no further recourse. Even though this approach is used often and readily, the author decided not to take this route.

Instead, a synopsis of the relevant research showed that there is one fundamental element present in all mindset theories. This element is the way to think, or more precisely the *cognitive function* or *cognitive procedures* activated during Design Thinking phases. Therefore, the concept of cognitive functions offered a third candidate set for the drivers behind the creative processes in Design Thinking.

### 5.1.3. Cognitive Functions as the Drivers of Creative Processes

From the beginning of the third research cycle to the conclusion of the research project the search for the drivers of the creative processes in Design Thinking narrowed to the cognitive functions involved. After determining how to approach the cognitive functions in general, a reasonable operationalisation and a meaningful test had to be developed and executed upon.

Cognitive procedures consist of one or several cognitive functions. The author first determined from the literature (K. C. Fox & Beaty, 2019; and Worwood & Plucker, 2017 in particular) that the conceptualization of the cognitive function approach is often discussed in terms of opposite pairs, coined cognitive modes. The author then proceeded to exhaustively collect all the candidates for opposite pairs discussed in literature. Of these candidates, she chose a set of five complementary cognitive modes for best fit to the Design Thinking process.

Finally, she used the empirical work to test which, if any, of the cognitive pairs can be reliably found in Design Thinking projects. The basis for the test was the informal hypothesis that " A set of five complementary opposite pairs of cognitive modes can be demonstrated to correspond strongly with the fundamental phase structure of Design Thinking." The test focused on the evaluation of the nine Design Thinking projects conducted during this stage of the research, augmented through an analysis of participants' self-assessments in the concomitant empirical surveys. Within the limits of this research project the test can be considered successful. Its details are discussed below.

The set of five complementary opposite pairs of cognitive modes with the best fit is listed below. Each line contains the denomination of the pair and its two opposite poles. In every Design Thinking phase in which a cognitive mode is relevant, one of the two poles should dominate:

- Acquisition of Data: COLLECTING – PROCESSING
- Alignment of Perception: OBSERVING – ENVISIONING
- Assessment of Information and Ideas: DEVELOPING – JUDGING
- Attention to a Specific Task: UNFOCUSED – FOCUSED
- Awareness of the Cognitive Process: AUTOMATIC – DELIBERATE

It is important to note that cognitive functions are latent, i.e. not directly observable. They can only be detected either through observation and interpretation of Design Thinking participants' behaviour or through interviews and/or self-assessments. In the latter case, the observable is a perception which can be modelled through a semantic differential with a neutral midpoint and two lobes, one each for the two opposite poles.

With each cycle, the cognitive pairs could be refined to better reflect the observed actions and the literature review that was pursued through all cycles. Observation, as well as the analysis of the surveys and interviews strengthened the findings with every project. However, there were also points that could not be convincingly evaluated. All surveys for the test of the informal hypothesis used the phase structure of the IDEO model. The fact that the phases of the Design Thinking project include very different tasks led to ambiguous results for the dominant element in some pairs. The cognitive functions themselves can be considered confirmed as all survey questions were optional and almost no answer was denied.

In addition to the nine projects, the author conducted a social media survey in diverse channels that promised to reach the Design Thinking community worldwide. With 56 participants completing the survey, a statistical analysis was possible. A Chi square ($\chi^2$) test demanding a 5% significance level could demonstrate that the cognitive pairs have at least some explanatory power. The binomial test demonstrated a significant skew for two thirds of the combinations of cognitive pairs and Design Thinking phases – that is a clear dominance towards one of the cognitive functions of the pair. The distribution of skewness showed a distinct pattern, which in the author's view provides strong explanatory power.

The supplementary open questions provided additional qualitative insights in excess of the author's expectations, for instance: "Some of the steps can require both mindsets (e.g. in the test phase you first have to collect information and then make sense out of it)" or "Often the phases have non mutually exclusive activities such as define through imagining future scenarios and observations from acting out those scenarios."

In summary, a first rather exploratory study of cognitive modes as candidates for the drivers of creative processes in Design Thinking indicates that this conceptualization has explanatory power. At the very least, its salience could not be refuted within the limitations of this research project.

### 5.1.4. Discussion of the Five Complementary Pairs of Cognitive Modes

In the following sections, the five complementary opposite pairs of cognitive modes identified through this research project will be discussed in more detail. First, some important sources for the selected pairs of cognitive modes are given and the triangulation process for finding the best fit is briefly discussed. For the sake of clarity, the sources are only examples for visualising the triangulation. Then, the complementary structure is discussed in general. To conclude, each of the pairs is discussed in detail.

#### *5.1.4.1. Sources and Triangulation Process*

*Table 40.* Overview of the Most Important Research Sources on Cognitive Dichotomies

| Design Thinking / Design | Transdisciplinary Literature | Empirical Research findings |
|---|---|---|
| **Acquisition: COLLECTING – PROCESSING** | | |
| Synthesis (T. Brown, 2019, p. 76)<br>Separate analysis and observation (Liedtka et al., 2019, p. 49) | Data to information (North & Kumta, 2018, pp. 35–36)<br>Task-switching (Hirsch et al., 2018)<br>Storytelling (Lupton, 2017, pp. 72–89) | All phases save *Test* show a skewness in the social media survey (4.5.3.1.3). Mind map coding showed the transfer from data to information (9.3.2.1). |
| **Alignment: OBSERVING – ENVISIONING/IMAGINING** | | |
| Engage – Envision (Seelig, 2017, pp. 23–67)<br>Seeing – Imagining – Drawing (Kim & Park, 2020) | Attention Switching (Verschooren et al., 2019)<br>Neuroscience (Beaty et al., 2019; Benedek, 2018)<br>Mindful Alignment (Shamas & Maker, 2018) | All phases show a clear skewness in the social media survey (4.5.3.1.3)<br>Several open text feedbacks mentioned the change of perspective (e.g. 4.4.2.2) |
| **Assessment: DEVELOPING – JUDGING** | | |
| Sense making / Avoid judgement (Liedtka, 2018; Liedtka et al., 2019, pp. 21, 49)<br>Structure and select (Lewrick et al., 2018b, pp. 106–107)<br>Flip-Flopping (Dobson & Christoff, 2020, pp. 272–273) | Integrative thinking (Riel & Martin, 2017)<br>Emergence (Kun et al., 2019; Ward & Kolomyts, 2019, pp. 186–188) | The Henry Ford role model led more intense discussion in the *Define* phase. "Sense Making" was clearly observable (4.3.2.2.1).<br>Coining the Ideate results idea roughs led to emerging ideas (4.4.3.2.1) |
| **Attention: UNFOCUSSED – FOCUSSED** | | |
| World and detail (T. Brown, 2009, p. 89)<br>Save Spaces (Stickdorn, Hormess, et al., 2018, p. 399)<br>Private 'caves' (Elsbach & Stigliani, 2019) | Attention and Creativity (Zabelina, 2018)<br>Limitations of the mind (Lissack, 2019a, 2019b) | Students seeking solitude during demanding tasks (4.4.3.1).<br>Astonishingly well matching data in the social media survey (4.5.3.1.3). |

*Table 40.* continued

| Design Thinking / Design | Transdisciplinary Literature | Empirical Research findings |
|---|---|---|
| **Awareness: AUTOMATIC – DELIBERATE** | | |
| Reflection in Design Thinking (Sonalkar et al., 2020)<br>Design Thinking fast and slow (Kannengiesser & Gero, 2019) | Spontaneous–deliberate mode (Dietrich, 2019)<br>Intuition, reason and creativity (Barr, 2018) | The success of the Treasure box showed how disturbing spontaneous thought can be (4.5.2.2.1)<br>Reviewing the POV after Henry Ford remark (4.3.5) |

Devised by author

Triangulation is the standard method in social science to corroborate research findings (for details see chapter 2.3.3.1). *Table 40* serves as an illustration only for the triangulation methods used in this survey. As mentioned above, the cognitive functions can only be observed indirectly, the findings in observation are indications. Because of this, the author used various sources in literature to substantiate the hypotheses. The first sources were from Design Thinking literature to illustrate the demand. The second sources were from cognitive psychology, creativity research, behavioural science and neuroscience to create theory triangulation. Thirdly, observations and participant feedback received orally or in the diverse questionnaires showed the effect in real projects.

#### *5.1.4.2. The Complementary Structure*

The pairs of cognitive functions are complementary and non-exclusive. In extremis, all five pairs of cognitive functions can be active at the same time. To a significant extent, an individual can decide through an act of will and a matter of focus which of the modes dominates at a given moment.

The literature yields recommendations about the Design Thinking phases in which the various cognitive modes should be relevant, why that is the case, and which of the two poles of the corresponding opposite pair should prevail. The recommendations encourage the understanding of how the values of cognitive mode (which themselves are latent) should translate into observables, and in particular, which lobe of the matching semantic differential should dominate in interviews and/or self-assessments.

This chain of reasoning also provides the basis for an empirical test of the concept. Note, though, that the settings and constraints of Design Thinking projects are extremely varied, translating into an enormous number of degrees of freedom. Therefore, theoretical predictions are rather broad in nature and can only be formulated for 'representative' types of Design Thinking projects which also limits testability. The fact that Design Thinking phases have an internal structure with very diverse sub tasks add to the complexity. In theory, it should be possible to determine an optimal "cognitive mode activity profile" for a Design Thinking project. As the research showed, this is not fully feasible and that it is probably best to conceptualize cognitive modes as a set of options of action with a context-dependent profile.

It is therefore up to the facilitator of a Design Thinking project to recognise which kinds of cognitive functions would be most fruitful for the challenge, team, and task. It is also the facilitator's responsibility to provide the tools and motivation to promote the most crucial cognitive functions for the given setting. The concept developed in this research provides the five cognitive pairs and a possible activity profile but not a mandatory structure.

##### *5.1.4.3. Cognitive Mode ACQUISITION OF DATA*

A Design Thinking project requires that a considerable amount of information be gathered. The exploration of the problem space, the characteristics and needs of the people affected, the exploration of the solution space and the evaluation of the prototypes – all this can provide the vigilant observer with a plethora of data which constrains and informs the shape of the optimal solution. The full power of such data is only available, though, if it is both collected and preserved diligently and effectively transformed into information, i.e. integrated and connected with pre-existing knowledge.

Not only are the two steps of data collection and transformation demanding in and of themselves, the needed cognitive functions also serve conflicting goals. On the one hand, the collection of data needs an open mind that appreciates every input it can gather, that does not filter, that takes the data as it is, and that does not develop biases but stays aware and open to all senses. Even though the collection mode needs some cognitive spikes for the collector to pose the right questions and follow appropriate lines of action, the more the observer can avoid premature reflection on the data and the situation, the better the chance of unadulterated perception of the setting as a whole.

The processing of the collected data, on the other hand, demands the entire gamut of cognitive processes undesirable at the collection stage. They are imperative as processing proceeds through the steps of first sifting and sorting and then structuring and converting the data into information. Obviously, such processing requires any number of higher-order cognitive functions.

The conflicting requirements establish *Acquisition of Data* as an opposing pair of cognitive modes with the two poles COLLECTING and PROCESSING. Its inclusion in the five pairs with best fit follows from the theoretical predictions and the empirical evidence.

Literature review predicts that *Acquisition of Data* should be relevant in all Design Thinking phases, assigning great importance to this cognitive mode and it also indicates quite precisely what to expect for each phase. The empirical evidence confirms the theoretical predictions.

In detail, the following patterns for *Acquisition of Data* emerge: *Understand* starts at the COLLECTING pole but needs to switch to PROCESSING to be able to map the problem space and plan the *Observe* phase. *Observe* should be collective, as processing the data would be a distraction and might activate cognitive biases. In *Define*, designers process the data to create information and detect patterns that lead to insights. *Ideate* means in a first step PROCESSING the POV and all the collected information for the creation of ideas, shedding each idea after creation. In a second step, the ideas are collected and embraced in preparation for the next phase. In *Prototype* the ideas are analysed, filtered, and combined until solutions form that then are realised as prototypes. This needs PROCESSING. *Test* starts at the COLLECTING pole, gathering the evaluations and insights from the testing process itself. The information is then analysed in the next step to decide how to proceed, requiring PROCESSING. In a variation, *Test* might proceed through multiple trials separately, first gathering the test results proper, then immediately switching to thinking about variations of the test or instant optimisations of the prototype. Obviously, the mode would have to iterate with each trial.

In conclusion, note that a number of authors talk about divergent thinking in situations that concern the *Acquisition of Data*. There is a temptation to equate the cognitive function COLLECTING with the concept of divergent thinking because they do show some similarities. However, the findings of this research project show that the two concepts are not identical. In brainstorming phases, for instance, Design Thinkers should create ideas while PROCESSING the available information. This is a case of divergent thinking. However, COLLECTING is undesirable here, because ideas should be shed quickly – this is the very raison d'être of Post-Its. It is only in the next sub phase that the design team should absorb, i.e. mentally collect, all the ideas to be able to transform them into solutions.

#### *5.1.4.4. Cognitive Mode ALIGNMENT OF PERCEPTION*

Perception can be geared toward the external senses – seeing, hearing, smelling, tasting, feeling – or toward cognition and imagination, each to the exclusion of the other. To be aware of these two directions and to change them consciously allows for more precise capturing of the data or information a specific source provides. Creative processes need both: passively perceiving what there is on the one hand, and actively imagining what there could be on the other.

Imagination builds upon sensory perceptions. Empathy and openness are therefore essential for creativity. Basic mental imagery based on the recall of sensory experiences is strongly connected to external perception. It is considered an established fact in neuroscience that the visual cortex, needed to see and recognise the environment, is also activated when reconstructing the remembered image. There are strong indications that the same is true for other senses as well.

At the same time, imagination is more than just creating a representation of a sensual impression; it also includes correlations, abstract structures and varied perceptions. The human mind is able to use different personas to imagine a situation. Assuming that an observing mind was open and did not filter prematurely, the mind can consequently switch perspectives and recall a situation with different 'eyes'. Mindfulness plays an important role in both external perception – what is commonly called being open minded – and internal perception – thoughts and envisioning. Focussing on the cognitive processes of the inner mind enhances the potential for creative developments and interesting insights.

The mutual exclusion described above establishes *Alignment of Perception* as an opposing pair of cognitive modes with the two poles OBSERVING and ENVISIONING. Its inclusion in the five pairs with best fit again follows from the theoretical predictions and the empirical evidence.

The literature review predicts that *Alignment of Perception* should be relevant in all Design Thinking phases, assigning great importance to this cognitive mode as well. It also indicates quite precisely what to expect for each phase. Within the limitations of this research project, the empirical evidence confirms the theoretical predictions.

In detail, the following patterns for *Alignment of Perception* emerge: In *Understand*, *Observe* and *Test* OBSERVING dominates, while ENVISIONING prevails in *Define*, *Ideate*, and *Prototype*. The reason for this is the great relevance of imaginative cognition for these latter three phases. Nevertheless, there are indications that the second part of *Understand* needs some imagination to map the problem space. Likewise, the team interaction in the envisioning phases at least needs some observing functions for participants to appreciate the work of their team members and to prosper through synergetic work.

#### ***5.1.4.5. Cognitive Mode ASSESSMENT OF INFORMATION AND IDEAS***

The large amount of information and the many ideas necessary in Design Thinking are part and parcel of the intense *Understand* and *Observe* phases as well as the call for an abundance of ideas in *Ideate*. This links the ideation process with the *Assessment of Information and Ideas*, because the raw volume of data cannot be used directly, but has to be developed, i.e. fully 'unpacked', and judged as to its significance instead. This must be done very carefully because of its crucial importance. From a naive standpoint, to judge a point of information or an idea might be equated with the deletion of the material that is considered marginal. However, several authors go as far as advising to never delete information at all, but to only structure and rank it instead. This is because seemingly extraneous data might trigger interesting associations and because a change of perspective, for instance a changed POV can alter the status of an outlier, but of course only if it is still available.

Getting to the essence of a thing requires intelligent reduction. It is therefore not a process of deleting, but instead one of cross-linking, ranking, sorting and clustering. At the same time, convergence towards a point of view or a solution is an absolute requirement for a Design Thinking project to be successful. Insights as well as solutions are not so much the product of instant selection, but rather *emerge* over time from the basic ingredients - information and ideas.

Ideation itself is often found to be a repeated cycle between the generation and the evaluation of ideas. Those two cognitive processes are presumed to be activated in different neural networks in the cortex – namely the Default Mode Network for generation and the Executive Control Network for evaluation. Creative professionals were found to be able to switch between these networks faster and with less effort than laypeople. This means that they perform idea generation and evaluation more effectively and more efficiently, creating more and better output. Because generation and the evaluation of ideas can be equated with DEVELOPING and JUDGING, there is a common cognitive mode for the assessment of information and ideas.

The literature review predicts that designers must switch frequently between the two neural networks in play, and that this is actually a key fact for explaining why good design is so hard. As described above, mere JUDGING of information during a whole phase would be prohibitive in a truly creative scenario. Sticking to DEVELOPING can be fruitful. With the social media survey, the author could broadly confirm the findings outlined above. None of the phases shows dominance of the JUDGING mode. At the same time, *Ideate* and interestingly *Prototype* were considered dominantly DEVELOPING.

In the final analysis, the author concurs in the case of *Ideate* but disagrees in the case of *Prototype*, as one solution must emerge from the mass of ideas provided. She would also add *Understand* to the list of phases with a dominance of the DEVELOPING mode. All other phases appear to require both assessment modes because of the creative approach discussed above, with the role of the JUDGING mode toned down to more of a structuring and ranking function.

#### ***5.1.4.6. Cognitive Mode ATTENTION TO A SPECIFIC TASK***

Even considering that openness is a fundamental element of Design Thinking in particular and creativity in general, some tasks demand a designer’s full attention with no disturbance. The person responsible must withdraw from all distractions and focus on the task at hand. Conscious information processing typically builds on a number of input streams, both sensory and from the brain itself. Within an input stream, a bandwidth of information is available that is too broad for the human mind to process it in its fullness. So, the mind selects what it pays the most attention to. This selection process can be both deliberate and unconscious. As a consequence of this selection process, the mind also withdraws from some of the streams completely.

Note that the above discussed cognitive pair OBSERVING and ENVISIONING deals with internal and external channels but with a focus on a more passive (observing) or active (envisioning) role. The cognitive mode here deals with the selection of information one pays attention to. The selection can be broad, even unspecific or very narrow, concentrating on one specific topic. This subchapter, therefore, addresses the issue of focused versus unfocused attention.

All combinations of the choices outlined above can be useful in Design Thinking. It depends on the circumstances which choice is most appropriate. That said, focused attention is of particular interest, because it is a key success factor in some Design Thinking phases, *Ideate* in particular. The very idea of the creation of a POV is to focus the attention on one topic. Nevertheless, the ability to switch flexibly between focused and unfocused attention, and to tune the amount of focus, is a valuable creative trait.

Focused attention with cognition orientation also includes the selection of the line of thought. In ideation, creative professionals are found to be able to ignore obvious ideas served up by the salient network, which are often too inconsequential and trivial, and to focus instead on finding higher quality ideas. Creatives are also found to be able to consciously guide their mind-wandering. They can day-dream not only about personal affairs, as is common, but also about the professional challenges of current projects.

This last piece of evidence shows that deliberateness also is a central issue, because attention focused on the inner mind as a conscious choice means deep reflection and imagination, while the unconscious switch to the inner mind brings unfocused attention, leading to an unguided kind of daydreaming and mind-wandering. While in both cases the brain all but shuts down streams from sensory channels, keeping the mind on the train of thought, the two states of mind are clearly very different. This is the reason for the fifth cognitive mode *Awareness of the Cognitive Process* below.

Not everybody can easily select the streams they want to focus on. To reflect intensely, for instance, they have to close their eyes, plug their ears and expend a lot of mental energy on staying focused. Providing secluded areas for their mental work and offering exercises for enhancing mindfulness can help their performance.

It is important to note that focused attention can extend way beyond thought processes in the narrow sense. Flow in particular can be induced by all kinds of activities and typically leads to total immersion. In a state of Flow, people therefore also experience decoupling from all streams not needed for the flow inducing task, even to the point where the sense of passing time is shut off.

An example for focused attention and shift of focus, which is perception oriented, can be found in *Observe*. Here, participants should be focused on noticing what happens in the area under study, i.e. the sensory streams from that area of interest. The focus should switch from the environment as a whole to a specific line of action or a particular person when needed. Because this requires most of the conscious processing capacity, the less internal cognition that happens during this time, the better.

An example where focused attention is not always desirable can be found in teamwork. Here, too much withdrawn cognition can be detrimental as it blocks interaction and synergetic cooperation. Likewise, focus during an observation is typically a good thing. At the same time, observations both in *Observe* and in *Test* demand openness, i.e. a broad focus on the entire area under discussion – at least for part of the time – in order not to miss anything of potential interest. Such openness can also include thinking about the setting as a whole to analyse what is there, to compare it with other experiences, or to react according to the needs of the project.

The preceding discussion establishes *Attention to a specific task* with the poles UNFOCUSED and FOCUSED as an opposing pair of cognitive modes, and its inclusion in the five pairs with best fit.

The predictions of the theory and the empirical evidence align well for *Attention to a specific task*. The findings of the literature review are that the three phases *Understand*, *Observe* and *Test* mainly require UNFOCUSED attention with flexible shifts when needed. *Define*, *Ideate* and *Prototype*, on the other hand, require flexibility throughout, with deeply FOCUSED sessions alternating with openness in UNFOCUSED sessions for interaction and evaluation. This picture is confirmed through the results of the empirical studies.

The research allows to draw conclusions of immediate practical interest. It is clear from the last paragraph, for example, that during *Define*, *Ideate* and *Prototype*, Design Thinking teams should mainly work in a space that provides protection from disturbance and offers additional possibilities for team interaction and for individuals to withdraw.

##### 5.1.4.7. *Cognitive Mode AWARENESS OF THE THOUGHT PROCESS*

The previous subchapter has already established the relevance of the issue of deliberateness. Modern psychological research has shown that it goes far beyond a simple choice between the conscious and the unconscious mind. According to the dual process theory, thinking can be classified into Type 1 and Type 2 thinking. Type 1 is fast, spontaneous, typically subconscious and the default, while Type 2 is slow, thorough, deep, effortful, and deliberate. Clearly, deep reflection and thoroughness requires Type 2 thinking.

Conscious control of thought is never absolute. Type 1 thinking is always active and produces an enormous amount of background cognition. When a thought arises that the salient network considers relevant, it interrupts even deep reflection and brings this information to awareness. Because Type 1 thinking is the default and the deliberate switch to Type 2 thinking is rarely taught in a systematic fashion, many people have great difficulty deliberately switching to reflection.

The concept of Type 1 and Type 2 thinking has great bearing on creative production in general and Design Thinking in particular. Both types of thinking are needed, and their interplay leads to fruitful results. Idea generation in particular demands an interplay of spontaneous and deliberate thoughts, while evaluation requires conscious reflection. This shows that which type of thinking process and/or which mix is called for depends on the Design Thinking phase. Very often, swift mental cycling is needed, so that the ability to switch deliberately and quickly between types of thinking processes is a precious capability for Design Thinkers that should be treasured and trained.

Against common belief, Type 1 thinking can override deliberate cognition even without the awareness of the thinker. As Type 1 thought is quite emotion-driven, emotions affect our ideas and decisions significantly. Because the autonomous Type 1 relies on previous knowledge, experience and reflection, it improves with a growing store of such previous expertise. Intuition that is sourced in associative Type 1 thinking can therefore only arise in decent quality on the basis of previous work on challenges of the same kind. Additionally, the original intuition must always be refined and evaluated again in the executive Type 2 mode.

The concept of Type 1 and Type 2 thinking greatly informs a number of well-known design challenges: As Type 1 thinking is related to existing knowledge and beliefs, the first intuition typically feels so good and fitting that it takes considerable persuasive power to get laypersons to think again. A particularly difficult challenge is the re-definition of the Point of View, as the first, obvious definition also promises fast, obvious solutions that seem attractive at first glance.

Type 2 thinking is often hard to access, leading to erratic thought processes and therefore difficulty with goal-directed, deep reflection. As Type 2 thinking is behind crafting strategy, this explains why good strategy is so hard to achieve.

*Awareness of the Cognitive Process* embodies the concept of Type 1 and Type 2 thinking and the switching issue, with the poles AUTOMATIC for Type 1 thinking and DELIBERATE for Type 2 thinking. Clearly the two are an opposing pair of cognitive modes. The preceding discussion establishes the relevance of this cognitive mode and its inclusion in the five pairs with best fit.

The predictions of the literature review for *Awareness of the Cognitive Process* are that exemplary Design Thinking projects emphasize DELIBERATE Type 2 thinking through most of the phases. The sole exception is *Observe* because pondering is adverse here as it diverts from focused perception. *Ideate* is also a special case. Because it flourishes in a lively interplay of reflection and association, rapid cycling through AUTOMATIC and DELIBERATE thinking is called for. While the empirical evidence aligns well with the theory in principle, the volume of evidence from the empirical studies is quite limited because people are not used to thinking about AUTOMATIC and DELIBERATE thought processes. This is clearly an area for further research.

This research allows to draw conclusions of immediate practical interest as well. Firstly, it is clearly the facilitators' task to encourage DELIBERATE thinking as much as possible. They must therefore constantly monitor the team's level of *Awareness of the Cognitive Process* and provide 'food for thought' in the form of tasks, methods and tools to keep DELIBERATE thinking active.

Secondly, the concept of Type 1 and Type 2 thinking has recently entered the broader public's awareness through Kahneman's book 'Thinking, fast and slow' (2012). The title is very popular in management circles and talks about Type 2 thinking abound. The concept might therefore be quite useful for the targeted creation of some lingua franca between management and creatives.

### 5.1.5. Additional findings

While the core of the research project was the development of the five opposing cognitive pairs, a number of ancillary results are also worth mentioning and are presented in the following subsections.

#### *5.1.5.1. Designers or Non-Designers*

A frequent subject of discussion, and something that arises in several blog posts and articles on Design Thinking, is the question if Design Thinking is something for designers (i.e. creative professionals) and non-designers alike, or more precisely: Does a Design Thinking project need designers? And: Does a Design Thinking project need non-designers?

Neuroscience suggests that creative professionals have abilities laypeople typically don't have. Creative people can rapidly switch between the default mode network (DMN) and the executive control network (ECN), or even use them simultaneously. This allows for fast and efficient production and evaluation of ideas. Additionally, creatives can subdue ideas that the salient network provides early in the ideation process to concentrate on more unique ideas instead. Beaty and Kenett (2020) even claimed that they are able to identify a creative mind on the basis of the network connections of the brain.

Designers take to the Design Thinking process quite easily because their daily work (ideally) follows similar patterns. This routine gives the team stability that makes it easier to be daring. Furthermore, designers embrace wicked problems. They are willing to reframe a problem statement, even to the point of turning a non-wicked problem into a wicked one. Empirical studies showed that non-designers are unwilling to rework an established problem statement, even if they have to admit that there seems to be more to the problem than the statement represents.

On the side of potential negatives, designers are prone to 'design fixation', sticking to tried and tested processes and solutions. This can thwart the creation of new and unusual ideas. A mixed, non-hierarchical team can prevent this effect by questioning decisions and experimenting with new methods. Interdisciplinarity also provides expertise in various areas which allows a broad swathe of challenges to be solved professionally.

#### *5.1.5.2. The Groan Zone*

To recall, Groan Zone is a nickname for the switch from divergent to convergent sections of the Design Thinking process. One of the reasons the author chose the subject of this thesis was because of negative experience with the Groan Zone. The majority of Design Thinkers are at odds with Groan Zones, a view that is mirrored in the literature where Groan Zones are described as extremely difficult. This goes back to the typically vast amount of data in those zones and the demanding requirement to completely flip the thinking mode at the right time. Even proficient facilitators seem to be insecure and overstrained when teams struggle in this zone.

As it turned out, the quantitative surveys in this research project did not always lead to clear results when Groan Zones were involved, at first producing a bit of a crisis. The only sensible explanation is that Groan Zones are squeezed into phases that are intrinsically different from the Groan Zones themselves, requiring different tools and thinking modes. This easily leads to irritation and corresponding uncertainty in survey responses.

On closer analysis, the author has come to the belief that Groan Zones are, in fact, zones of potential that can be the best part of a Design Thinking project. They should therefore be treated as core development-zones of Design Thinking.

A similar train of thought underlies John Gero's concept of Emergence. Emergence was not only developed at approximately the same time as the term Groan Zone made its debut, Emergence also can take place at the same time as the Groan Zone. However, the attitude to emergence is completely different from the attitude to the Groan Zone. The focus is not on the problem but on the potential. Insights might emerge here, and little information- or idea-seedlings can be nurtured into solutions. The seedlings need both well-designed tools and all the cognitive powers of the team, and they need a positive attitude. Strategies like Flexible Thinking (Mlodinow, 2019), Integrative Thinking (Riel & Martin, 2017), Parallel Thinking (de Bono, 2016a), or Hypothetical Thinking (Ball, 2020) - all thrive best in the fullness that the Groan Zones provide.

After seeing the unique possibilities of the Groan Zone, the author changed her opinion of the zone and she incorporated experiments with the Groan Zone into later research cycle projects. Instead of introducing Groan Zones as problems, she presented the zones to the teams with an attitude of chance and the promise of potential. This worked very well after she stopped using the nickname Groan Zone, because this name has intense priming power. With the evidence from these experiments, the author proposes changing the name Groan Zone into Growth Zone, and to use it as it deserves to be used with great emphasis on its potential.

#### *5.1.5.3. Cool-Down Games*

Creativity, especially in laypeople, can be enhanced by giving them the possibility for mind-wandering and relaxed reflection. Mindfulness works best with a certain amount of tranquillity and detached dedication. However, design teams are often agitated and full of vigour because they are impatient to find to good solutions. The author found it helpful to use small exercises like short meditation sessions to steady the energy of the team. Based on this evidence, she proposes introducing *cool-down games* or exercises into Design Thinking; games that interrupt an all too busy phase with low key tasks that lead to relaxation and rest.

### 5.1.6. Research Questions and Discussion of Results

In the following subchapter, the research questions are discussed together with the results of the research project. This discussion is rather condensed as it basically serves to provide a synopsis of earlier, section-wise results. The final version of the research question comprises one research question and five sub-questions. All six are briefly covered in separate subchapters below.

#### *5.1.6.1. Final Research Question*

In its final form, the research question is "*What are relevant cognitive functions in a Design Thinking project?*". The empirical research and literature research conducted in each research cycle were mainly dedicated to answering this question. In all, the question could be answered with the five pairs of opposite cognitive modes laid out in some detail in the previous chapter.

The five pairs span the width of a Design Thinking project, covering the essential intellectual challenges it poses from initial comprehension of the problem through the exploration and building of the solution space to creating and evaluating the solution concepts. It is interesting to see that three of the pairs address information processing (*Acquisition of Data, Alignment of Perception*, and *Assessment of Information and Ideas*) and two pairs address flow control of cognition (*Attention to a specific task* and *Awareness of the Cognitive Process*). This is a surprisingly compact, ontologically pleasing result, which appears to align quite nicely with current research in other fields such as neuroscience and behavioural psychology.

Within the limitations of this research project, the five pairs of opposite cognitive modes can be considered substantially evidenced. In fact, both the projects and the quantitative analysis of the empirical surveys rendered more definitive results than could initially have been expected. On the other hand, analysis of the latter showed that further quantitative advances will be hard to achieve.

While the dimensionality of the data space is not as high as in typical data science problems, it is large enough to require answer sets of a size which must be considered effectively out of reach.

That said, the results not only lead to a number of follow-up questions (see 13.3. Further Research below); they also allow to draw conclusions of immediate practical interest and their close examination produced some additional findings (see above). Of the latter, the shift of perception of Groan Zones is particularly intriguing to the author, because it addresses a long-standing Design Thinking problem.

#### *5.1.6.2. Sub-Question F.1*

Sub-question F.1 is "*What is Design Thinking, and is it based on scientific methods or is it just something IDEO invented?*". The question is relevant because it provides a solid footing for the main research question of this thesis if it can be resolved in the affirmative. Should it have to be answered in the negative, it would render the entire research project moot. Chapter 3.1 is therefore dedicated to this question.

It could be established that Design Thinking is a structured and teachable method with a foundation in the sciences of design, technology and psychology. Thought leaders in creativity, didactics and philosophy were part of the method's development. IDEO's contribution is very much relegated to the popularization of the method in the context of business consulting. Hasso Plattner gave it the funding for a fruitful development anchored in high quality academia.

Design Thinking appears to have evolved into an established field with a broad consensus for the fundamentals and measurable success in generating desirable, viable and feasible solutions for pressing problems in a more reliable and effective manner. It uses methods which have proven their efficacy in other project management disciplines, such as multifunctional teams, careful observation, tightly controlled iterations and modern, goal-oriented management methods with a focus on empowerment and self-direction but always with a Design Thinking specific touch and unique creative methods and tools. Nevertheless, Design Thinking moves rather nicely in the mainstream of management trends for knowledge-oriented projects.

Potentially troubling is only the lack of clarity on a number of central concepts, of which emotion and 'mindset' have been demonstrated in this research project to be particularly irksome. However, concepts in the social sciences rarely achieve the precision they have in the exact sciences. Therefore, with a bit of detachment, none of this is really out of the ordinary.

#### *5.1.6.3. Sub-Question F.2*

Sub-question F.2 is "*What is creativity and what are relevant aspects in Design Thinking?*". The question is relevant because the search for Design Thinking drivers requires clarity on these issues. Creativity appears to be simple on the surface, as a natural property of human beings that can be developed and trained but also stifled into nothingness. However, this is where the complications start: Why are some people clearly more creative than others? How can creativity be elicited and taught reliably? How can creative output be better channelled?

This research did not attempt to give a full answer as the field of creativity is vast, and instead focused on the aspects of the question which are relevant to predictability and the role of Design Thinking. In achieving clarity on two key issues, question F.2 could be answered for the purposes of this investigation.

Creativity can be defined as the potential to create novel and useful ideas. This definition immediately shows the first key issue: the social factor of creativity. Who defines novelty and usefulness? The assessment is only possible in a defined social environment. Furthermore, research into creativity shows that creativity is a systems product, not achieved by a single individual but only possible and appraisable in a systems-setting including interpersonal ties, the cultural domain and the societal context it is rooted in.

The second issue concerns the fact that creative ideas can be produced both through reasoning and through inspiration. Reasoning is an analytical, deductive process that derives new ideas through logic processing. Inspiration is created in a subconscious associative process that is based on prior knowledge and experience. The issue has been discussed at length above. Recall that the amount of mastery individuals have over their creative abilities depends on their ability to exercise some flow control over these cognitive processes.

Design Thinking addresses both topics by giving the Design Thinking team a structure with which to work efficiently together and, with its phases and tools, the scaffold to guide thought processes to fruitful creativity.

#### *5.1.6.4. Sub-Question F.3*

Sub-question F.3 is "*What is emotion, how can it be identified, and how does it affect creativity?*". The question is relevant for the first research cycle. Because the issue was extensively documented in chapters 0 and 5.1.1.3, only the key findings as they pertain to the work on cognitive processes are discussed.

Leading researchers in emotional psychology concede that as of today, there is no definition of 'emotion' that all renowned scientists in the field can agree to. There is consensus, however, on a number of defining characteristics: Emotions are signals created by the mind as a reaction to external and internal influences. Emotions do not only influence human perception; they are of the same cognitive type. Cognition, perception and emotion build a continuum of cognitive processes.

It follows that emotion is indispensable for cognition and creativity. It influences the individual person, the team, the creative process and the developed solution. An interesting effect is association via emotion. Memories with similar emotional signatures seem to resonate with each other and build associative links much more easily than emotionally diverse remembered events. Emotional sensitivity seems to facilitate access to the whole cognitive spectrum from emotion to perception to memory, and thus enhance inspirational events.

The research into the role of emotions as potential drivers of the Design Thinking process revealed that although there are methods to identify emotions and that modern technology (namely deep learning algorithms) supposedly allows to automatically detect emotion in photos, the approach is not feasible because:

– Emotions are not reliably recognisable in photography
– Emotion is shaped by the cultural background
– The eight emotional states currently detectable in photos or videos could not reflect the complexity of human emotion even if they could be considered reliable

In an additional step, all three affective states – emotion, feeling and mood – were analysed and the author showed that for the concept to be workable, a reliable mechanism for distinguishing the three affective states would be necessary. Given that even specialised research into emotion and creativity cannot reliably distinguish between these states, affective states as a whole could be eliminated from consideration on epistemic grounds. Question F.3 could therefore be resolved, and it could be demonstrated that affective states are not suitable for the research in this project.

#### *5.1.6.5. Sub-Questions F.4 and F.5*

Sub-question F.4 is "*Which cognitive functions support which stage of the creative process?*", and sub-question F.5 is "*Can facilitators guide Design Thinking team members to activate these cognitive functions?*". The two questions are operationalisations of the main research question. This establishes their relevance.

Because the cognitive functions were discussed at length in chapter 5.1.4, only the most pertinent points shall be covered here. The assumption in the research on cognitive processes, that Design Thinking is fundamentally about information processing. The split into acquisition, perception and assessment of data on the one hand and two flow control functions on the other hand proved to be very fruitful, with promising results on the cognitive functions themselves, their phase structure and even some details on the use cycles. The activity profile shown in chapter 4.6.1 shows the prevalent cognitive functions where applicable.

There were also practical results for sub-question F.4, demonstrating that guidance on cognitive functions for example with role models (with storytelling), warm-up games, framing and priming is possible. Project Eight (chapter 4.5.2) was especially dedicated to experiment with a portfolio of tools that showed some ways to guide towards the desired cognitive functions.

Within the analysis of the main research question, the two sub-questions F.4 and F.5 were therefore answered as fully as possible within the limitations of this exploratory project. Additional results, for example a concrete toolbox with tailor made tools and activities will require further research.

## 5.2. Perspective

### 5.2.1. Contribution to Knowledge

One of the reasons why Design Thinking is often called diffuse is the fact that "a common set of ways of 'thinking' and ways of 'doing' is missing" (J. Schweitzer et al., 2016, p. 84) in Design Thinking research. This research project was intended to work on this gap and to provide a better and more precise understanding of Design Thinking without curtailing its flexibility and versatility.

This thesis first clarifies empirically which approaches are promising as drivers of the process, identifying the cognitive processes of Design Thinking participants as the only viable option. It then proposes a set of five pairs of opposing cognitive functions that are relevant for Design Thinking processes. Those sets (cognitive modes) help to better understand how Design Thinking works and serve as guidance for facilitators during a Design Thinking project. As Benedek and Jauk (2018a) state: "The better we understand the relevant cognitive operations and strategies involved in a task, the better we will be able to estimate the relative relevance of controlled and spontaneous processes" (p. 291).

The activity profile (see *Figure 91*) offers some details on the phase structure of the five modes, indicating which cognitive function should prevail within every Design Thinking phase, or if there should be rapid cycling, and why. The thesis also offers some examples of practical applications of the theory for improved guidance of Design Thinking teams. Both the sets of cognitive modes and the dominance diagrams can serve as a basis for the development of further Design Thinking tools or activities that help to activate the thinking processes that are beneficial for the task at hand.

The DREPT approach of the research offers new insights from cognitive psychology and neuroscience into the processes of Design Thinking that provide a deeper understanding of creative cognition and problem solving. It also helps to comprehend the roles of trained creative people within the process.

### 5.2.2. Limitations

The research was subject to a number of limitations which centred around the types of possible projects and the limited resources available. Better resources and a wider variety of projects would be invaluable in refining the results of this exploratory study.

Types of Projects:

Most of the projects used in the empirical part of this thesis were conducted in an academic setting. The teams typically consisted of students who were exposed to Design Thinking for the first time. The challenges were specified by the lecturer or freely chosen by the project participants. While this provides for a certain freshness of thought, the lack of diversity and the absence of experienced Design Thinking practitioners was a clear drawback.

The research results should be evaluated in additional projects with mixed teams consisting of experienced Design Thinkers and novices with several areas of expertise. The projects should be commissioned by a variety of genuine third-party clients to address real-life problems and the solutions should have the potential to be fully implemented.

Research Group:

The author is a design student with engineering and communication expertise. As a DREPT research involves drawing information from diverse disciplines, a deepening of the research with a research group including specialists from the consulted areas would help to evaluate the results further and to develop the insights provided. For example, including cognitive psychologists and neuroscientists, but also specialists in team leadership and communication could enrich the research considerably. Richer approaches may also be available through extending the research to Design Thinking as an organisational development issue, looking into questions of organisational culture, attitudes and capabilities in particular.

Social Media Survey:

As the number of participants in the social media survey was adequate but limited, additional surveys with larger populations would unquestionably lead to valuable additional insights. As one of the findings indicated that the phases of the IDEO process sometimes span tasks that are too diverse to be treated with one set of questions, additional surveys could also be used to optimize the survey design. Because the quantitative analysis showed that the dimensionality of the challenge is so large that the size of the data sets needed for answers on certain of the interesting questions is out of reach, there is a certain natural limit to the utility of further quantitative research. However, the same analysis demonstrated that in-depth expert interviews, laboratory experiments or even the use of a magnetic resonance machine would have great potential to corroborate or change the given findings.

### 5.2.3. Further research

This project revealed several research fields that would enrich Design Thinking and creativity. Deepening the author`s research into the cognitive modes and applying the findings to practice is the foremost suggestion. The uncovered additional findings also need deeper research.

The author sees special potential in the following topics:

– Deepening the rigor of the five cognitive modes model. Especially the activity profile, that is the dominance of one side of the cognitive mode and the importance of the cognitive mode in each Design Thinking phase could be deepened. Furthermore, it should be investigated if the modes alter when the project jumps back to a previous phase during refinement loops.

– The research already uncovered some tools that can help activate a specific cognitive function, but this research must be intensified. The huge portfolio of tools and activities already available for Design Thinking provides a promising basis for this research. The *cool-down games* presented in 5.1.5.3 should also be part of the investigation. This research should also include some form of assistance for facilitators to recognise both the prevailing cognitive activities in the team and the cognitive functions needed.

– Corroborating the Growth Zone (Groan Zone) issue and the emergence of solutions over time. It is evident that this zone will remain a challenge but the author is confident that an optimised approach will further Design Thinking projects considerably.

– To investigate the abilities of creative professionals also seems extremely fascinating. There is already considerable active research, especially in neuroscience, but it should be a matter of great concern for the design community to identify the special aptitudes of designers and to promote the status of designers in society.

– Looking more closely into the topic of mindfulness. Mindfulness has interesting connections to creativity. Current research implies that creativity is fostered by mindfulness, but the same is also true in reverse: Mindfulness seems to flourish under the influence of creativity. As of today, the focus of research lies in the ideation phase alone. Agnoli and Vannucci (2020, p. 172) suggest studying the influence of mindfulness throughout the whole of the creative process. To the author of this thesis, this also seems a fascinating possibility.

Design Thinking, creativity and the human mind provide a rich and fascinating world to explore and to understand. The above list of further research topics is far from complete and still too vast to manage for a single individual or even research institute. It is therefore to be hoped that the academic Design Thinking community will be attracted to this line of investigation and address these questions in the future.

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## Appendices

Remark: Photos, scans of the surveys, presentation files and declarations of consent etc. are found in the online repository of the research project (restricted access).

## A.1. Documentation Project 1: Dornbirn 2016

### A.1.1. Source Code to Access the Emotion Recognition System in Microsoft Cognitive Services

```
<!doctype html>
<html>
<head>
<meta charset="UTF-8">
<title>Untitled Document</title>
</head>

<body>
<?php
// Vorabversion, die auf der Basis eines festen textes ($fulltext) die Datenverarbeitung für Microsoft Cognitive Services - Emotion API zeigt
// Heidi Weber 5.Juni 2016

// Einrichten der Session für die Bildanalyse:
//dummy zum Üben
$fulltext='Kam2_160511_1049_0532.jpg:[{"faceRectangle":{"height":77,"left":1300,"top":349,"width":77},"scores":{"anger":0.494623035,"contempt":0.003738962,"disgust":0.0105080921,"fear":0.0107938172,"happiness":7.50795743E-06,"neutral":0.44200176,"sadness":0.0129284291,"surprise":0.0253984053}},{"faceRectangle":{"height":75,"left":1050,"top":430,"width":75},"scores":{"anger":0.000271838042,"contempt":0.004863225,"disgust":4.70162558E-05,"fear":3.45343E-05,"happiness":0.0148457335,"neutral":0.9770476,"sadness":0.00252301758,"surprise":0.0003670246}},{"faceRectangle":{"height":67,"left":746,"top":364,"width":67},"scores":{"anger":0.00268473825,"contempt":0.0008159607,"disgust":0.000723958,"fear":0.000266883551,"happiness":0.00132880476,"neutral":0.973925948,"sadness":0.0149023235,"surprise":0.0053513567}}]';
//
// DTSession 1 ist Session Dornbirn am 15. bis 17.5.16 - weitere Sessions müssen manuell in PHPmyAdmin eingetragen und hier über die ID referenziert werden
$SessionID = 1;
//
// Das System geht davon aus, dass alle Bilder wie folgt formatiert sind: <Descriptor>_YYMMDD_hhmm_####.ext (Bildbezeichnung_Aufnahmetag_Aufnahmezeit_Seriennummer.Extension)
$Filename=substr($fulltext,0,strpos($fulltext,":"));
```

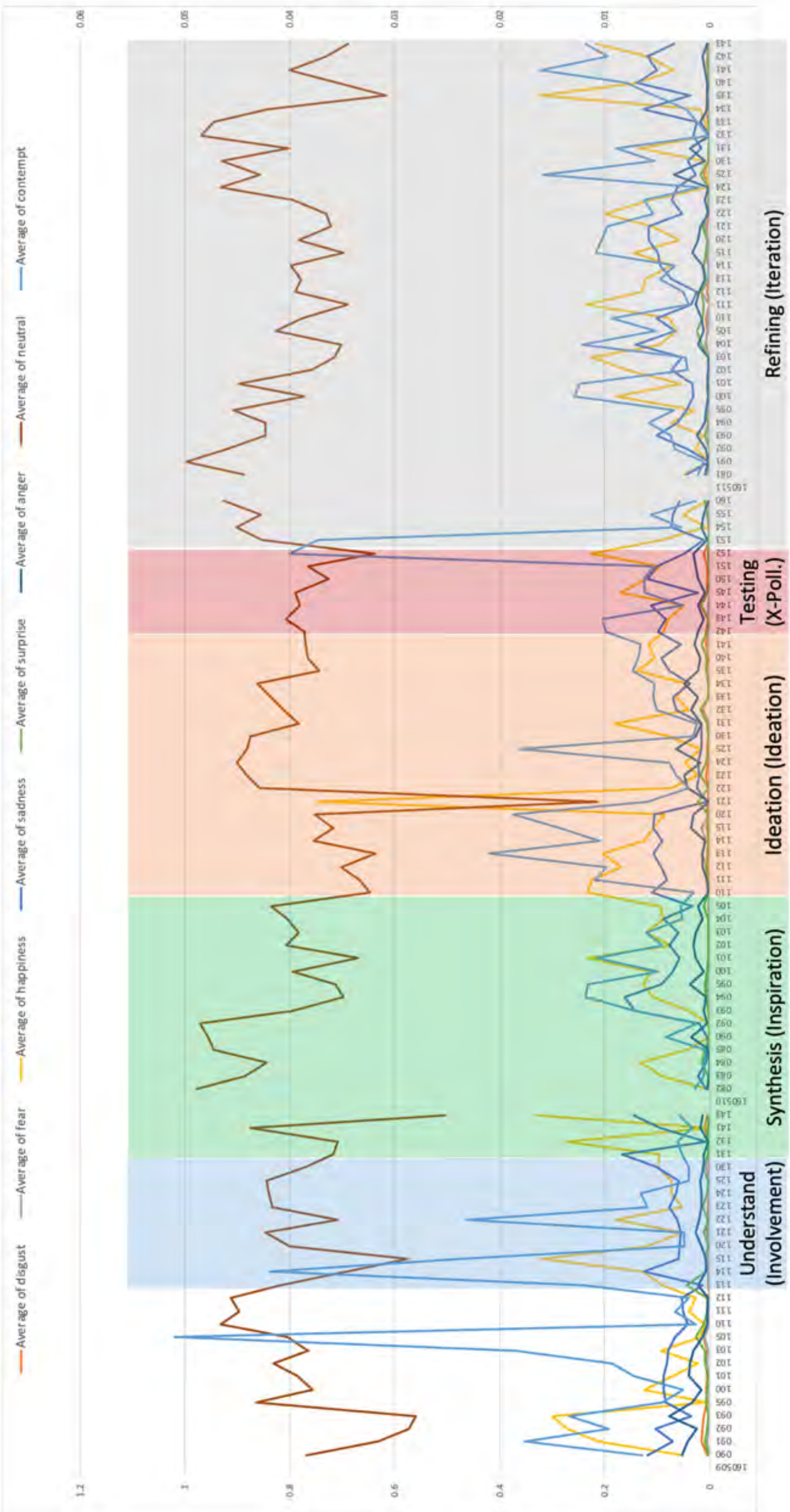
```
list($Descriptor,$ImageDate,$IT,,)=explode("_",$Filename);
$ImageTime=substr($IT,0,2).":".substr($IT,2,2).":00";
echo $Descriptor." ++ ".$ImageDate." ++ ".$ImageTime."<br>";
//Datenbank auswählen
$mysqli = new mysqli("","root","HttYepWV8HuZsje4","DTEmotion");
if ($mysqli->connect_error) {
die('Connect Error (' . $mysqli->connect_errno . ') '
. $mysqli->connect_error);
}
echo 'Success... ' . $mysqli->host_info . "<br>";


//Observer selektieren und ggf. anlegen
// vSession + Descriptor müssen eindeutig sein
$Observer = $mysqli->query("SELECT * FROM `Observer` WHERE vSession =
$SessionID AND `Descriptor` = '$Descriptor' ");
if ($Observer->num_rows == 0){
mysqli_query($mysqli,"INSERT INTO Observer ( vSession, Descriptor)
VALUES (1 , '$Descriptor')");
$Observer = $mysqli->query("SELECT * FROM `Observer` WHERE vSession =
$SessionID AND `Descriptor` = '$Descriptor' ");
echo "neuen Datensatz in Observer angelegt $Observer->num_rows <br>";
}

$ObserverRow=$Observer->fetch_assoc();
$ObserverID=$ObserverRow["Observer_ID"];
echo "ObserverID: $ObserverID <br>";

//Bild positionieren und ggf. anlegen
$Images = $mysqli->query("SELECT * FROM `Images` WHERE vObserver =
$ObserverID AND `Filename` = '$Filename' ");

if ($Images->num_rows == 0){
$mysqli->query("INSERT INTO Images
( vObserver,Filename,ImageDate,ImageTime) VALUES
('$ObserverID','$Filename','$ImageDate','ImageTime')");
$Images = $mysqli->query("SELECT * FROM `Images` WHERE vObserver =
$ObserverID AND `Filename` = '$Filename' ");
echo "neuen Datensatz in Images angelegt $Images->num_rows <br>";
}

$ImageRow=$Images->fetch_assoc();
$ImageID=$ImageRow["Image_ID"];
echo "ImageID: $ImageID <br>";
//Text so auflösen, dass jedes frame+emotionen in einem Array steht
```

```
$frames=explode('{"faceRectangle":{',$fulltext);
echo $frames[1] . "<br>";
foreach ($frames as $frame){
//ersten chunk auslassen
if (!strstr($frame,"scores"))
continue;
list($rectangle,$emolist)=explode('},"scores":{',$frame);
//
//rectangle aufteilen - Syntax "height":#*,"left":#*,"top":#*,"width":#*
$rect=explode('"',$rectangle);
for ($x=1; $x <count($rect); $x++){
//diverse delimiter entfernen
$rect[$x]=str_replace(":","",$rect[$x]);
$rect[$x]=str_replace(",","",$rect[$x]);
//liefert Liste mit abwechselnd Feldname und Wert für die Dimensionen
//echo $rect[$x]."<br>";
}
//Konvertierung in einzelne Variablen muss sein, da Insert keine Array-Elemente schluckt
list(,,$hv,,$lv,,$tv,,$wv)=$rect;
//
//echo "$hv __ $lv __ $tv __ $wv";
//frame speichern
$mysqli->query("INSERT INTO Frame
( vImage,Height,Left_pos,Top_pos,Width) VALUES
('$ImageID',$hv,'$lv','$tv','$wv')");
$RectID = $mysqli->insert_id;
//$Rects = $mysqli->query("SELECT * FROM `Frame` WHERE `vImage`= '$ImageID', `Height`='$hv', `Left_pos`='$lv', `Top_pos`='$tv', `Width`='$wv'");
//echo "Rectangle_ID: $RectID <br>";

//
// emotionen aufteilen
// echo $emolist;
//liefert Array mit abwechselnd Feldname und Wert für die Dimensionen
$emos=explode('"',$emolist);
for ($x=1; $x <count($emos); $x++){
//diverse delimiter entfernen
$emos[$x]=str_replace(":","",$emos[$x]);
$emos[$x]=str_replace(",","",$emos[$x]);
//echo $emos[$x]."<br>";
```

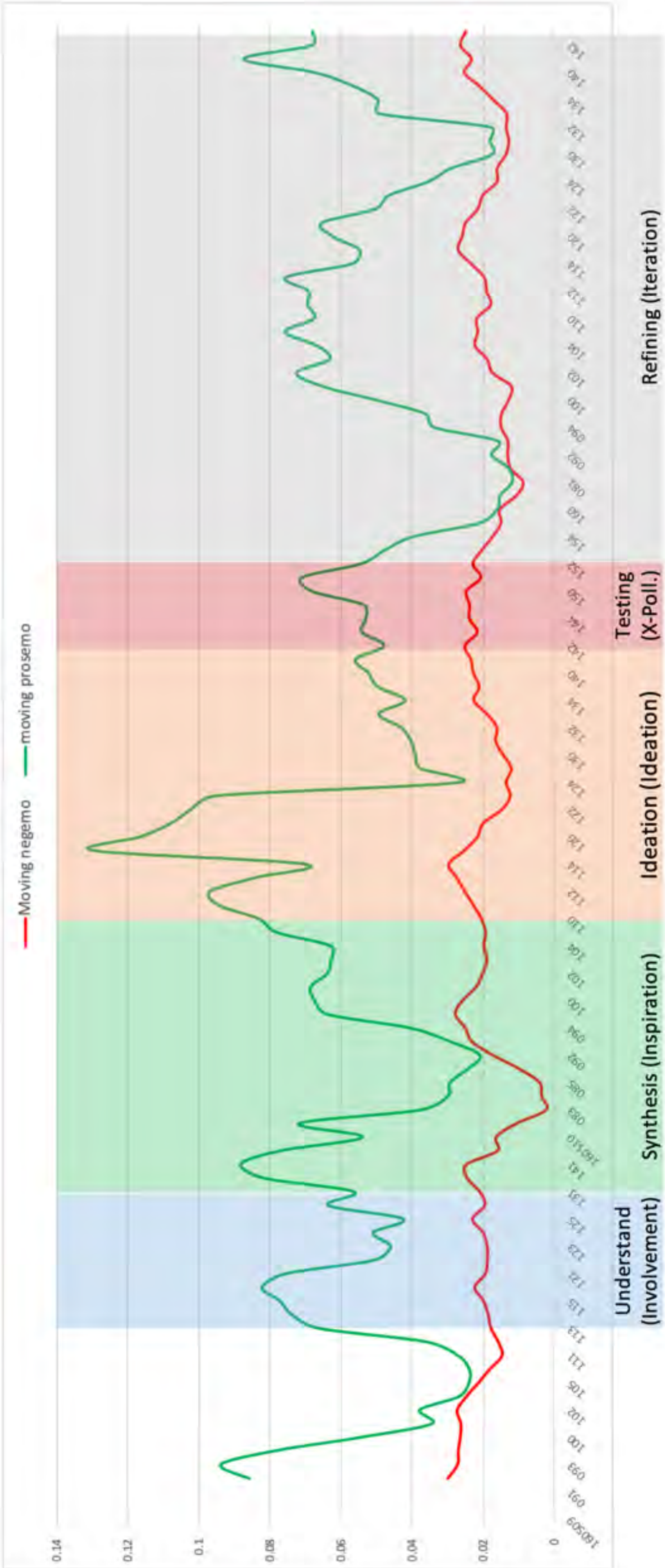
```
//anstatt der Bezeichnungen für die Emotionen gleich die Emo-id zuweisen
//in den ungeraden Feldern steht jeweils der Emotionstyp
if (fmod($x,2)==1){
$sel="SELECT `Emotype_ID`, `Emotype` FROM `Emotype` WHERE `Emotype` = '". $emos[$x] ."'";
$Emotypes=$mysqli->query("$sel");
$EmotypeRow=$Emotypes->fetch_assoc();
$EmotypeID=$EmotypeRow["Emotype_ID"];
//echo "Emotype: ".$EmotypeID;
}
else{
//bei den geraden Werten kann die Emotion-Tabelle gefüllt werden
//ich verzichte hier auf die Kontrolle, ob es pro Frame und emotion nur einen Eintrag gibt - sollte nocht gemacht werden
$sel="INSERT INTO `Emotion`( `vFrame`, `vEmotype`, `Emo_value`) VALUES ('$RectID','$EmotypeID','" . $emos[$x] . "')";
$mysqli->query("$sel");
$emoID = $mysqli->insert_id;
$Emos=$mysqli->query("SELECT * FROM 'Emotion' WHERE 'Emo_ID' = '$emoID'");
echo "<br>$emoID und die Suche: $Emos<br>";
$EmoRow=$Emos->fetch_assoc();
$EmoVal=$EmoRow["Emo_value"];
echo $EmoVal;

}
}


}
unset ($frame);

$mysqli->close();
?>
</body>
</html>
```

### A.1.2. Results of the emotion recognition analyses

Emotion intensity diagram with all emotions and project phases:



Emotion intensity diagram filtered to negemo and posemo emotions and smoothed with rolling average:



### A.2. Project Two: IPAM SS2017

#### A.2.1. Lecture Plan

8 hours lecture →

PLUS 1 15 Minutes breaks and 1 45 Minutes Break

→ I plan from 10:00 to 19:00

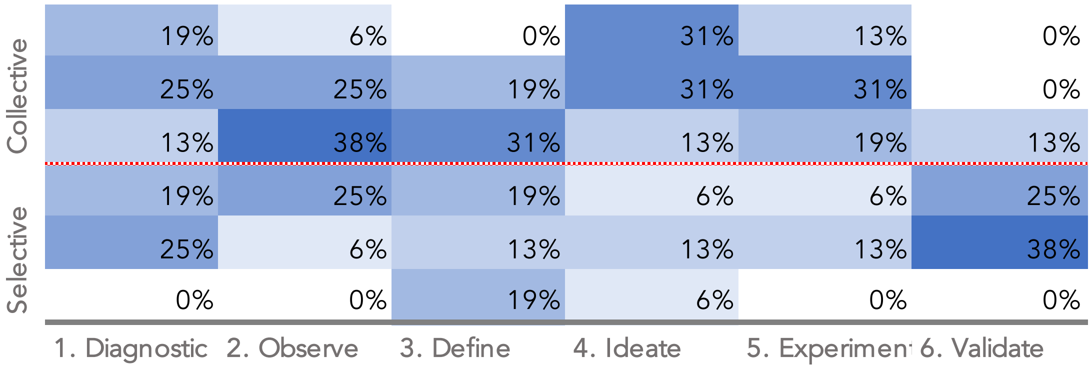
| HOUR | STEPS | CONTENT |
|---|---|---|
| **1** | 20 min – introduction<br><br>20 min – **Activation** co-creating stories<br><br>10 min – Showing the video<br>10 min – building the groups | Explaining the day and DT (might be a bit shorter)<br><br>1 – **Activation** using 3 groups – and three balls to throw the ball to |
| **2** | 5 min – **Observe** - explaining how to interview<br>45 min – Interviews<br><br>15 min – putting the most important information on post-its | 2 – **Understand – Interview:** Talk to people about the subject. Try to be emphatic. Don't ask yes/no questions. Listen, repeatedly ask "Why" – up to 4 times. Ask for alternatives<br>teams of two – one is asking, one is writing.<br>**Roots:** Research information to the subject, use the internet but more important your fellow students and maybe some external people |
| **3** | 5-10 – **Understand** – explaining clustering using roots<br>20 mins clustering<br><br>5 – **Define –** explaining the windmill (not sure) | 3 – **ROOTS** – is there a wallpaper for that?<br>cluster suggestions – people, planet, profits, culture |

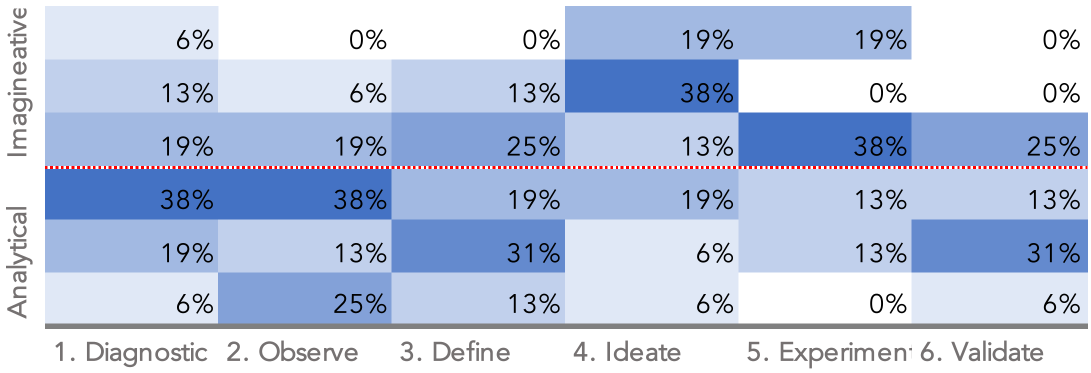
| | | |
|---|---|---|
| | | 4 – **CSF** – Critical Factors Everybody finds his 5 most important facts/thoughts/issues alone – they present it to each other and select the issues they want to solve.<br>If possible closing it with a question the want to solve |
| **45 MIN** | **Break** | |
| **4** | 10 min Bringing them back into the subject explaining next task<br>**30 min Ideation** → free **Brainstorming** with silent sessions (s10 min, t10, s10,)<br><br>30 min Ideation → using the windmill | maybe I need something funny here – 1234?<br><br>Tipps: Reverse thinking,<br><br>Windmill – selecting the best ideas |
| **5** | **50 min** Ideation – Experiment →Prototyping | Sketching – creating a prototype for your solution |
| **6** | 5 mins Experiment – the user – User stories - storytelling<br>20 min – creating personas<br><br>30 min – creating user stories | |
| **15 MIN** | **Break** | |
| **7** | | |

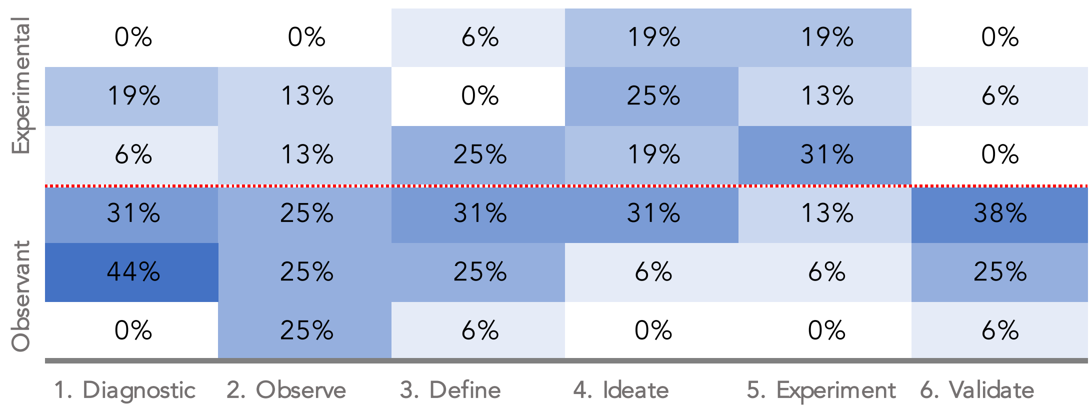
| | | |
|---|---|---|
| | 60 min Presenting the ideas (20 mins each) including feedback | Present your solutions with enacting user stories |
| **8** | Explaining the normally following further steps (no time for that)<br><br>Time to optimize their project | |

## A.3. Project Three: FHV Dornbirn SS2017

### A.3.1. Questionnaire results



### A.3.2. Evaluation results

#### *A.3.2.1. Overall feedback*

**1. How would you grade the whole lecture?**

| 3 | 8 | 5 | O | O |
|---|---|---|---|---|
|  |  |  |  |  |

#### *A.3.2.2. Open Text feedback*

**2. What was positive?**

Zoe (Control)

- The product in the end was nice work
- - The end product
  - See how a group works
  - different ideas that we all had the same challenge
- The impressive results each group was able to come up with during this short period of time
- Very good topic, interesting and on point
- The feedback and being challenged throughout the process.
- Learned a lot of new techniques

Package (Role models)

- I really enjoyed the lecture
  I really enjoyed Américo (he's awesome)
- I liked the positivity of the teachers and the Design Thinking. I think it is a really useful product.

- - to have own room and space
  - to see another process to get to a solution
  - to get good feedback
- I really liked the lecture, it was an interesting topic and I enjoyed very much having the opportunity to work as a team and learn all the Design Thinking process in a group.
- I thought everyone in the group really put in a great effort and it was really a learning process. Especially because we had a slow day on the second day and the third day was a really good day.
  Thanks for the class and I loved the positivity during the class!
- I can be really about this, the group dynamic was really good. We all had a equal contribution in the group. Day 2 was very hard and we got frustrated, we worked to much in a individual way. But I really feel like we were are very motivated to make the best out of the course.
- Different way of thinking, learned a lot about brainstorming and being creative in general

Happy Cow (Activity/games)

- Interesting methods. Good to have an insight.
- The groups were nice
- Process describing, presentations
- Good topic, good explained, interesting subject, nice teachers
- Time for teambuilding
  Work in groups- more ideas
- Working on project with other people
  very nice experience and project
- Interesting methods – good to have an insight

**3. What could be better? Do you have suggestions to improve?**

Zoe (Control)

- One week for the workshop…no others classes between!
  If you have one class in one week you can be more focused on the project.

- More time!
- - time management
  - Preparation (print things before the class)
  - the input is too fast and too much maybe too difficult explained
  –> more easy –>give more time to understand –>do a summary in the reflect and think about beginning about what is the class, what are the results, the goals and the steps and the explanations
- The time management, we had to rush the through the project (also because of the lecture on Thursday – which was not your fault) –>would be better if this course lasts longer – 1,5 weeks?
- In my opinion a one week lesson is too short and it would be nice if it was a longer course because this class is useful for working with a business or a creative industry. There is a lot of information so it will be nice to slow down and process it

Package (Role Model)

- Do not plan the course on the same week as the print midterm
- It would be better, if we would have more time
  Better handling with other courses
- Maybe have it in the beginning of the semester so you can use it in your semester
- The organisation
- It is a very intensive course and it was hard to do this presentation and the print presentation at the same time, so it would be nice to not do the course at the same time mid-terms are coming up.
- Sometimes it wasn't clear what the goal was all the time

Happy Cow (Activity)

- Too fast sometimes. Time management can improve. -H
- Too theoretical
- More flow
- The ways of finding ideas weren't really new. Maybe the time-management should be improved. For some parts less time to do, for others too much.

- Less time for thinking more time for doing
  (preparing presentation of final production statement
- The project was very interesting. I wish we had more days to really work on it.
- Too fast sometimes – Time management can improve

**4. If you want to tell us anything else – here is the place for it**

Zoe (Control)

- I personally think, it was too much information for four days
- Maybe more split the teaching part
  In the end from the different steps of microprocesses. I can't really remember the explanations were way too fast. But I like the course itself.
- I liked the class

Package (Role Model)

- Please don't plan it on the same week of print presentations
- Thank you – (Maybe talk a bit slower for understanding)
- It was a pretty nice course, thank you for your time, we had fun an even though it was intense we learned new things. Thank you!

Happy Cow (Activity)

- We were in circles, no really progress
- Thank you for this opportunity

## A.4. Project Four: FHV Dornbirn SS2018

### A.4.1. Examples for the lecture slides

The soggy pizza example (translation by author):

| | **Past (Prevent)** | **Present** | **Future (Correct)** |
|---|---|---|---|
| **Super-System (Surroundings, Class)** | How can we prevent that the pizza gets soggy by changing the packaging or the way the pizza is delivered? | Production, Packaging, delivery system | Can we change the packag-ing or the delivery system in a way that makes the pizza crispy again? |
| **System** | How can wie prevent that the pizza gets soggy? | start here  **Soggy Pizza** | How can we make a soggy pizza crisp again? |
| **Sub-System (Components, Formation)** | Can we change a compo-nent to prevent that the piz-za gets soggy? | Crust (components of the dough?), sauce, salami, ham, cheese | Can we change/add a com-ponent that makes the pizza crisp again? |

### A.4.2. Examples of Working Material and Final presentations

Team Kommune 22

## A.5. Projects Five: Short Projects SS2018

### A.5.1. Project Five A: Computer Science SS2018

### A.5.2. Project Five B: IADE SS2018

### A.5.3. Project Five C: FHV Dornbirn Employees SS2018

## A.6. Project Six: Antwerp WS2018

### A.6.1. The Written Assignment at the Beginning of the Class (Example)

FH Vorarlberg
University of Applied Sciences

**Intensive class - Design Thinking**

Dear Students,

my name is Prof. Heidi Weber. I am your lecturer for a short time in December and I am looking really forward to it. I will give you a quick introduction into Design Thinking and I want to do it in a way that you can improve your big project with it.

As we only see each other on two days for 2 hours it is important, that you prepare yourself well.

**Your task:**

Work in small teams of 2 persons (only if your team has an uneven number, a team of 3 is allowed)

**First**: Define a challenge/question that your project gives you. It must include people and should be open enough to give you the chance for new insights.
Example:
Not: How do people convince themselves to go jogging at least twice a week?
But: What do people do to maintain (or regain) their fitness?

**Second:** Research! Go to the people that your challenge/question addresses and find out as much as possible about them and the challenge/question.

- Talk to them. Let them speak freely.
- Ask them questions. Use open questions (no yes or no answers possible). Show them that you listen. Use Why questions. Use Why questions in a row and add something from the former answer. (e.g. Why did you feel overwhelmed through the other people in the room?) Give them time.
- If your challenge/question includes something to do – ask them to do it and observe closely.
- Just stick to them and watch them. Try to get them to be relaxed and "normal" while you are there.

Take photos, take notes, be really open to discover things, don't think, don't try to work on the challenge, just watch.

For our first lecture prepare a Research-poster

- Title is your challenge/question
- Add photos (at least 6 really different and meaningful photos)
- Add important notes you took. Short sentences or keywords in a easily readable font, when you work on this task in a group.

**Imagine you are top notch detectives like in your favorite crime show.
Watch the scene and try to look beyond the things everybody sees.
Discover the relevant elements that hide behind the obvious.**

Have fun with this small project – you will discover it helps you dealing with your big project. If you have problems with the task you are welcome to mail me at heidi.weber@fhv.at

Kind regards

Heidi Weber

Heidi Weber 08.10.2018 1 von 1

## A.6.2. Survey

### *A.6.2.1. The Online Survey – the Form*

Introduction to Design Thinking https://docs.google.com/forms/d/e/1FAIpQLSds-7359LzoQkBZ...


## Introduction to Design Thinking

Thank you for participating in my little survey and helping me with my doctoral thesis. Please answer as much questions as you like - they are all optional. I just need your OK to use your data, so please check the last box of the survey.

Please do not answer before you finished the class on the second day.

*Required

I am in class/group

- ◯ 201
- ◯ 202
- ◯ 203

The phase I liked most was

- ◯ Research and Survey
- ◯ Define (Empathy map, better me, Creative question)
- ◯ Ideation (Brainstorming)

"Research and Survey" demanded to be more

1 of 5 20.07.20, 12:57

Introduction to Design Thinking https://docs.google.com/forms/d/e/1FAIpQLSds-7359LzoQkBZ...

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
|---|---|---|---|---|---|---|---|---|
| **Thinking mode** | | | | | | | | |
| Creative / Collecting | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | Analytical / Selecting |
| **The way to watch** | | | | | | | | |
| Observant | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | Envisioning |
| **The way to react** | | | | | | | | |
| Impulsive | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | Reflective |
| **How I perceive others** | | | | | | | | |
| Empathic | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | Introverted |

"Define (Empathy map, better me, Creative question)" demanded to be more

2 of 5 20.07.20, 12:57

Introduction to Design Thinking https://docs.google.com/forms/d/e/1FAIpQLSds-7359LzoQkBZ...

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
|---|---|---|---|---|---|---|---|---|
| **Thinking mode** | | | | | | | | |
| Creative / Collecting | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | Analytical / Selecting |
| **The way to watch** | | | | | | | | |
| Observant | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | Envisioning |
| **The way to react** | | | | | | | | |
| Impulsive | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | Reflective |
| **How I perceive others** | | | | | | | | |
| Empathic | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | Introverted |

"3 Ideation (Brainstorming)" demanded to be more

3 of 5 20.07.20, 12:57

Introduction to Design Thinking https://docs.google.com/forms/d/e/1FAIpQLSds-7359LzoQkBZ...

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
|---|---|---|---|---|---|---|---|---|
| **Thinking mode** | | | | | | | | |
| Creative / Collecting | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | Analytical / Selecting |
| **The way to watch** | | | | | | | | |
| Observant | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | Envisioning |
| **The way to react** | | | | | | | | |
| Impulsive | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | Reflective |
| **How I perceive others** | | | | | | | | |
| Empathic | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | Introverted |

Feedback

4 of 5 20.07.20, 12:57

Introduction to Design Thinking https://docs.google.com/forms/d/e/1FAIpQLSds-7359LzoQkBZ...

Positive - What Il like in this class?

Negative - What did you not like in this class?

Additional remarks

Conclusion

I am aware that my answers are used for research purposes in connection with a doctoral thesis and to evaluate the lecture. All data is kept strictly anonymous. *

☐ I herewith agree to this usage of my data.

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Google Forms

5 of 5 20.07.20, 12:57

### A.6.2.2. Quantitative Results

Cross tabulation – entry count for all participants:

All Groups

| | 1_Understand Observe | 2_Define | 3_Ideate |
|---|---|---|---|
| **Thinking mode** | | | |
| Creative / Collecting | 20 | 33 | 32 |
| Neutral | 13 | 9 | 12 |
| Analytical / Selecting | 21 | 12 | 10 |
| **The way to watch** | | | |
| Observant | 24 | 23 | 17 |
| Neutral | 10 | 8 | 14 |
| Envisioning | 20 | 23 | 23 |
| **The way to react** | | | |
| Impulsive | 9 | 19 | 23 |
| Neutral | 12 | 13 | 15 |
| Reflective | 33 | 22 | 16 |
| **How I perceive** | | | |
| Empathic | 33 | 26 | 31 |
| Neutral | 10 | 15 | 13 |
| Introverted | 11 | 13 | 10 |

Result for "The phase I liked most is…"

| | | |
|---|---|---|
| Most liked class | Research and Survey | 8 |
| | Define (Empathy map, better me, Creative question) | 22 |
| | Ideation (Brainstorming) | 24 |

Cross tabulation – split by control group

| | Group 201: no role model | | | Group 202: abstract role model | | | Group 203: concrete role model | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1_Understand Observe | 2_Define | 3_Ideate | 1_Understand Observe | 2_Define | 3_Ideate | 1_Understand Observe | 2_Define | 3_Ideate |
| Thinking mode | 17 | 17 | 17 | 13 | 13 | 13 | 24 | 24 | 24 |
| Creative / Collecting | 1 | 11 | 8 | 5 | 10 | 12 | 14 | 12 | 12 |
| Neutral | 6 | 4 | 4 | 4 | | 1 | 3 | 5 | 7 |
| Analytical / Selecting | 10 | 2 | 5 | 4 | 3 | | 7 | 7 | 5 |
| The way to watch | | | | | | | | | |
| Observant | 7 | 5 | 6 | 4 | 4 | 3 | 13 | 14 | 8 |
| Neutral | 4 | 6 | 6 | 2 | | 3 | 4 | 2 | 5 |
| Envisioning | 6 | 6 | 5 | 7 | 9 | 7 | 7 | 8 | 11 |
| The way to react | | | | | | | | | |
| Impulsive | 3 | 7 | 8 | 5 | 7 | 8 | 1 | 5 | 7 |
| Neutral | 4 | 5 | 4 | 2 | 2 | 3 | 6 | 6 | 8 |
| Reflective | 10 | 5 | 5 | 6 | 4 | 2 | 17 | 13 | 9 |
| How I perceive | | | | | | | | | |
| Empathic | 6 | 8 | 9 | 11 | 6 | 9 | 16 | 12 | 13 |
| Neutral | 5 | 6 | 6 | | | 2 | 5 | 9 | 5 |
| Introverted | 6 | 3 | 2 | 2 | 7 | 2 | 3 | 3 | 6 |

### *A.6.2.3. Open text feedback*

**Positive - What II like in this class?**

- interactive way of teaching, we are actually doing something
- The energie
- I liked it to come up with crazy ideas and to think from different points of view
- CREATIVITY
- Mrs. Weber is very creative
- Work togheter, being creative, working with big papers and colors
- Room for thought
- Using it in real life
- The elaborate information on the subject
- Other view on the project
- The brainstorm session
- Quality brainstorming
- Teamwork
- Creative and new view on the project and nice feedback from the prof.
- The task about the empathy map
- Being creative
- It have a boost to our creativity.
- Brainstorming
- Groupwork, creative thinking
- That we did something different.
- Helpfull in different ways
- The design thinking process
- The creative part
- Creativity
- Unique chance
- Creativity
- Getting more insights, open communication, good student-teacher proportions.

- the creative thinking
- I got to know myself more
- Creativity
- Creativity
- Be able to be creative as much as I wanted
- The brainstorming session
- It gave another perspective on how to think about creative situations

**Negative - What did you not like in this class?**

- not really a negative thing
- DIFFICULT TO FIND A LOT OF IDEAS
- Sometimes it was not really clear what we needed to do
- The powerpoints took a little too much time and sometimes cut off the creativity
- Some topics were a bit vague to utilize
- The use of English diminished the information she wanted to give.
- Location
- The lack of time
- Sometimes the long talk periodes.
- The environment (loud noises)
- There was to little time.
- Theory part was a bit boring and too theoretical. Would have liked to have more time to work with the group instead of listening to the powerpoint for too many minutes... a lot of people lost concentration because of that and we could have had a better outcome.
- The nois in the romm
- The task beforehand had no use in class.
- Lot of info in a short time (not so negative)
- The powerpoints
- Sitting still
- Noisy students in theory class, you should shut them down faster.
- a bit too long brainstorming
- Thinking of new ideas got me a bit intimidated
- It was short!
- Sometimes it was long-winded
- The location
- too much emphasis on brainstorming. I would have liked to use the new ideas more in practice
- I didn't really see the point

**Additional remarks**

- Thank you very much for your courses Heidi!
- Thank you
- Keep up the good work
- You were a nice lecturer.
- Not so comfortable in public, it was like a challenge to me
- Thank you for the interesting class

## A.7. Project Seven: FHV Dornbirn WS2018/19

### A.7.1. The Online Survey – the Form


3. Umfrage zu den Design Thinking Phasen - Definieren (POV) https://docs.google.com/forms/d/e/1FAIpQLSffVvV3FJuPxevu_...

3. Umfrage zu den Design Thinking Phasen - Definieren (POV)

Die Umfrage ist anonym. Die Angabe des Studiengangs wird nicht zu Rückschlüssen auf die Person genutzt, die Angabe ist aber freiwillig.

Ich bin oder war im Studienbereich

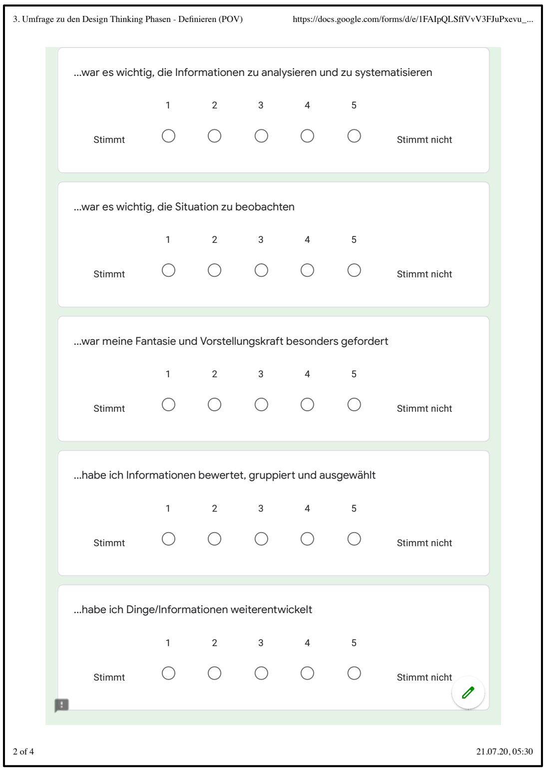
- Gestaltung oder Soziales
- Wirtschaft
- Technik

In der Phase Definieren ....

...habe ich Informationen gesammelt

Stimmt 1 2 3 4 5 Stimmt nicht

1 of 4 21.07.20, 05:30


3. Umfrage zu den Design Thinking Phasen - Definieren (POV) https://docs.google.com/forms/d/e/1FAIpQLSffVvV3FJuPxevu_...

...war es wichtig, die Informationen zu analysieren und zu systematisieren

Stimmt 1 2 3 4 5 Stimmt nicht

...war es wichtig, die Situation zu beobachten

Stimmt 1 2 3 4 5 Stimmt nicht

...war meine Fantasie und Vorstellungskraft besonders gefordert

Stimmt 1 2 3 4 5 Stimmt nicht

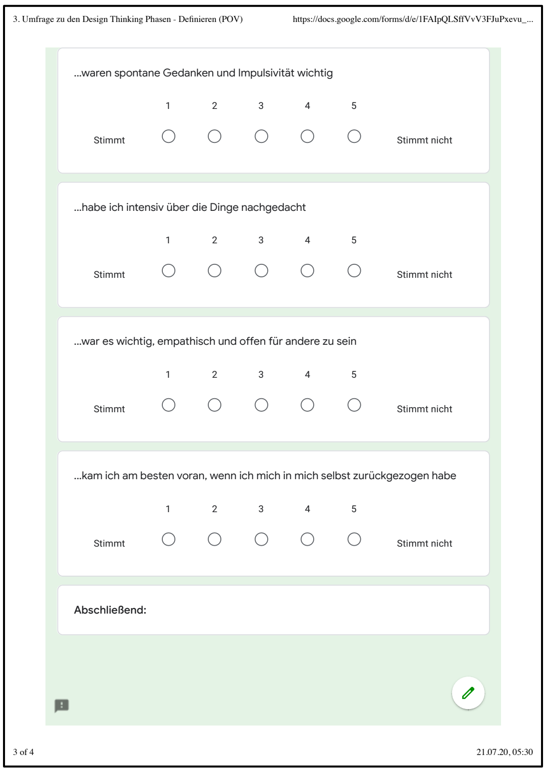
...habe ich Informationen bewertet, gruppiert und ausgewählt

Stimmt 1 2 3 4 5 Stimmt nicht

...habe ich Dinge/Informationen weiterentwickelt

Stimmt 1 2 3 4 5 Stimmt nicht

2 of 4 21.07.20, 05:30


3. Umfrage zu den Design Thinking Phasen - Definieren (POV) https://docs.google.com/forms/d/e/1FAIpQLSffVvV3FJuPxevu_...

...waren spontane Gedanken und Impulsivität wichtig

Stimmt 1 2 3 4 5 Stimmt nicht

...habe ich intensiv über die Dinge nachgedacht

Stimmt 1 2 3 4 5 Stimmt nicht

...war es wichtig, empathisch und offen für andere zu sein

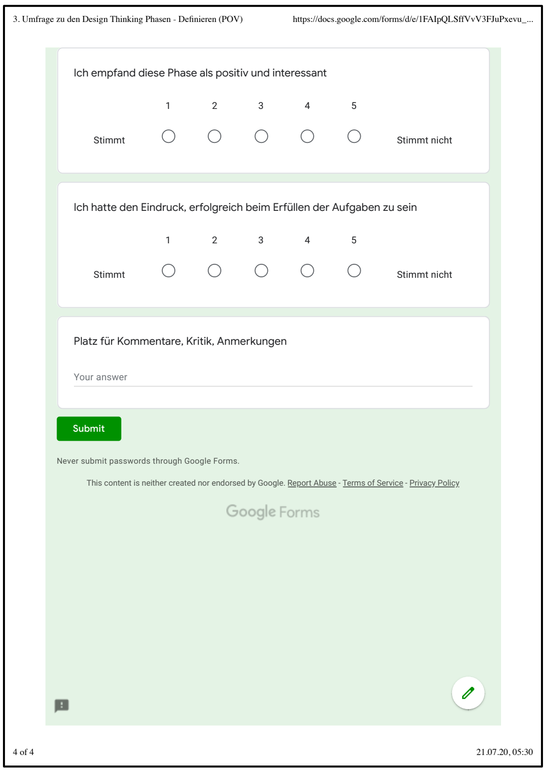
Stimmt 1 2 3 4 5 Stimmt nicht

...kam ich am besten voran, wenn ich mich in mich selbst zurückgezogen habe

Stimmt 1 2 3 4 5 Stimmt nicht

Abschließend:

3 of 4 21.07.20, 05:30


3. Umfrage zu den Design Thinking Phasen - Definieren (POV) https://docs.google.com/forms/d/e/1FAIpQLSffVvV3FJuPxevu_...

Ich empfand diese Phase als positiv und interessant

Stimmt 1 2 3 4 5 Stimmt nicht

Ich hatte den Eindruck, erfolgreich beim Erfüllen der Aufgaben zu sein

Stimmt 1 2 3 4 5 Stimmt nicht

Platz für Kommentare, Kritik, Anmerkungen

Your answer

Submit

Never submit passwords through Google Forms.

This content is neither created nor endorsed by Google. Report Abuse - Terms of Service - Privacy Policy

Google Forms

4 of 4 21.07.20, 05:30

### A.7.2. Survey results – Synopsis

The values are Medians of the results. The rows are following the sequence in the survey. Please note that value 1 refers to 'strongly agree' and 5 to 'strongly don't agree'.

| | Understand | Observe | Define | Ideate | Prototype | Test |
|---|---|---|---|---|---|---|
| 1a_Col | 1,5 | | 2 | 3 | 3 | 2 |
| 1b_Ana | 2 | 2 | 1 | 1 | 3 | 2 |
| 2a_Obs | 1,5 | 1 | 2,5 | 3 | 3 | 1 |
| 2b_Env | 2,5 | 2 | 2 | 1 | 1 | 2 |
| 3a_Sel | 1 | 2 | 1,5 | 1 | 3 | 1 |
| 3b_Dev | 1 | | 1 | 1 | 1 | 1 |
| 4a_T1 | 1 | 2 | 2,5 | 1 | 1 | 2 |
| 4b_T2 | 1 | 1 | 1,5 | 1 | 1 | 1 |
| 5a_emp | 1 | 1 | 2 | 1 | 1 | 1 |
| 5b_with | 4,5 | 4 | 5 | 4,5 | 5 | 4,5 |
| Positive | 1 | 2 | 1 | 1 | 1 | 2 |
| Success | 1 | 2 | 1 | 1 | 1 | 1,5 |

### A.7.3. Survey results – Cross Tabulation (Pivot chart) heat mapped

The values are sums of the entries for each result. The rows are following the sequence in the survey.

| | 1_Understand | 2_Observe | 3_Define | 4_Ideate | 5_Prototype | 6_Test |
|---|---|---|---|---|---|---|
| 1a_Col | n=6 | | n=10 | n=8 | n=9 | n=6 |
| agree | 3 | | 3 | 2 | 2 | 1 |
| 2 | 2 | | 4 | 2 | 1 | 3 |
| 3 | 1 | | | | 2 | 1 |
| 4 | | | 3 | 3 | 3 | |
| don't ag. | | | | 1 | 1 | 1 |

| | 1_Understand | 2_Observe | 3_Define | 4_Ideate | 5_Prototype | 6_Test |
|---|---|---|---|---|---|---|
| 1b_Ana | n=6 | n=16 | n=10 | n=8 | n=9 | n=6 |
| agree | 2 | 5 | 7 | 5 | 2 | 2 |
| 2 | 3 | 8 | 2 | 2 | 2 | 2 |
| 3 | 1 | 2 | 1 | | 3 | 2 |
| 4 | | | | 1 | | |
| don't ag. | | 1 | | | 2 | |

| | 1_Understand | 2_Observe | 3_Define | 4_Ideate | 5_Prototype | 6_Test |
|---|---|---|---|---|---|---|
| 2a_Obs | n=6 | n=16 | n=10 | n=8 | n=9 | n=6 |
| agree | 3 | 12 | 2 | 2 | 1 | 5 |
| 2 | 3 | 2 | 3 | 1 | 3 | 1 |
| 3 | | 1 | 1 | 2 | 1 | |
| 4 | | 1 | 2 | 1 | 1 | |
| don't ag. | | | 2 | 2 | 3 | |

| | 1_Understand | 2_Observe | 3_Define | 4_Ideate | 5_Prototype | 6_Test |
|---|---|---|---|---|---|---|
| 2b_Env | n=6 | n=16 | n=10 | n=8 | n=9 | n=6 |
| agree | 1 | 3 | 2 | 6 | 8 | 3 |
| 2 | 2 | 6 | 5 | 1 | | |
| 3 | 2 | 1 | 2 | 1 | 1 | 1 |
| 4 | 1 | 5 | | | | 1 |
| don't ag. | | 1 | 1 | | | 1 |

| | 1_Understand | 2_Observe | 3_Define | 4_Ideate | 5_Prototype | 6_Test |
|---|---|---|---|---|---|---|
| 3a_Sel | n=6 | n=16 | n=10 | n=7 | n=9 | n=6 |
| agree | 4 | 3 | 5 | 5 | | 4 |
| 2 | 2 | 9 | 5 | 1 | 4 | 1 |
| 3 | | 2 | | 1 | 3 | |
| 4 | | 1 | | | 2 | 1 |
| don't ag. | | 1 | | | | |

| | 1_Understand | 2_Observe | 3_Define | 4_Ideate | 5_Prototype | 6_Test |
|---|---|---|---|---|---|---|
| 3b_Dev | n=6 | | n=10 | n=8 | n=9 | n=6 |
| agree | 4 | | 7 | 5 | 6 | 6 |
| 2 | 1 | | 3 | | 1 | |
| 3 | | | | 2 | | |
| 4 | 1 | | | 1 | 2 | |

| | 1_Understand | 2_Observe | 3_Define | 4_Ideate | 5_Prototype | 6_Test |
|---|---|---|---|---|---|---|
| **4a_T1** | n=6 | n=16 | n=10 | n=8 | n=9 | n=6 |
| agree | 5 | 4 | 3 | 7 | 7 | 2 |
| 2 | 1 | 6 | 2 | | 1 | 2 |
| 3 | | 4 | 4 | | | 1 |
| 4 | | 1 | 1 | 1 | 1 | |
| don't ag. | | 1 | | | | 1 |

| | 1_Understand | 2_Observe | 3_Define | 4_Ideate | 5_Prototype | 6_Test |
|---|---|---|---|---|---|---|
| **4b_T2** | n=6 | n=16 | n=10 | n=8 | n=9 | n=6 |
| agree | 5 | 12 | 5 | 5 | 7 | 4 |
| 2 | 1 | 3 | 3 | 2 | 1 | 2 |
| 3 | | 1 | 2 | | 1 | |
| don't ag. | | | | 1 | | |

| | 1_Understand | 2_Observe | 3_Define | 4_Ideate | 5_Prototype | 6_Test |
|---|---|---|---|---|---|---|
| **5a_emp** | n=6 | n=16 | n=10 | n=8 | n=8 | n=6 |
| agree | 6 | 9 | 4 | 7 | 5 | 6 |
| 2 | | 5 | 4 | 1 | 3 | |
| 3 | | 2 | 1 | | | |
| 4 | | | 1 | | | |

| | 1_Understand | 2_Observe | 3_Define | 4_Ideate | 5_Prototype | 6_Test |
|---|---|---|---|---|---|---|
| **5b_with** | n=6 | n=16 | n=9 | n=8 | n=9 | n=6 |
| agree | 1 | 2 | 1 | 1 | | 1 |
| 2 | | 3 | | 1 | 1 | |
| 3 | 1 | 2 | 2 | | 1 | 1 |
| 4 | 1 | 4 | 1 | 2 | 2 | 1 |
| don't ag. | 3 | 5 | 5 | 4 | 5 | 3 |

| | 1_Understand | 2_Observe | 3_Define | 4_Ideate | 5_Prototype | 6_Test |
|---|---|---|---|---|---|---|
| **Positive** | n=6 | n=16 | n=9 | n=8 | n=9 | n=6 |
| agree | 4 | 7 | 6 | 6 | 5 | 2 |
| 2 | 1 | 7 | 2 | 2 | 4 | 3 |
| 3 | | 2 | 1 | | | 1 |
| 4 | 1 | | | | | |

| | 1_Understand | 2_Observe | 3_Define | 4_Ideate | 5_Prototype | 6_Test |
|---|---|---|---|---|---|---|
| **Success** | n=6 | n=16 | n=10 | n=8 | n=9 | n=6 |
| agree | 4 | 7 | 8 | 6 | 7 | 3 |
| 2 | 1 | 8 | 2 | 2 | 1 | 2 |
| 3 | 1 | 1 | | | 1 | 1 |

### A.7.4. Final Evaluation (paper based) – Open Text Feedback

The scans of the feedback survey are provided in the download area for the jury.
Translation by the author.

**What was especially positive in this class?**
(Was haben Sie in dieser Lehrveranstaltung besonders positiv wahrgenommen?)

| **English translation** | **German** |
|---|---|
| Presentations were always positive<br>The warm up games were also positive | Präsentationen waren immer positiv<br>Die warm up Spiele waren auch positiv |
| The creative handicraft phases<br>Exchange between the different study programmes | Die kreativen Bastelphasen<br>Austausch zwischen den unterschiedlichen Studiengängen |
| teamwork, prototyping, external lecturer | Teamwork, Prototyping, Externer Vortragender |
| Teamwork, free presentation possibilities, open work | Teamwork, freie Präsentationsmöglichkeit, offenes Arbeiten |
| New ways of thinking<br>Create prototypes → better visualization | Neue Wege des Denkens<br>Prototypen erstellen → bessere Visualisierung |
| The relaxed and varied teaching style<br>The unit with Pieter Sprangers | Den lockeren und abwechslungsreichen Unterrichtsstil<br>Die Einheit mit Pieter Sprangers |
| The different methods were very interesting and helpful<br>The games loosened up the lecture, especially as it was already late in some cases. | Die verschiedenen Methoden waren sehr interessant und hilfreich<br>Die Spiele haben die Lehrveranstaltung aufgelockert, insbesondere da es teilweise schon spät war. |
| Interdisciplinary groups<br>super input, great variety of methods<br>Responding to students' interests<br>warm-ups | Interdisziplinäre Gruppen<br>super input, tolle Methodenvielfalt<br>Eingehen auf Interessen der Studierenden<br>Warm ups |
| - practical application, leads to motivation<br>- theoretical introduction in each case | - Praxisanwendung, führt zur Motivation<br>- Jeweils theoretische Einführung |

| | |
|---|---|
| - The application directly after the theoretical inputs<br>- Presentation of examples<br>- The processed task led to the subsequent presentation and grading<br>- Internationality through guest speakers | - Die Anwendung direkt nach den theoretischen Inputs<br>- Vorstellung von Beispielen<br>- Bearbeitete Aufgabenstellung führte zur anschließenden Präsentation und Benotung<br>- Internationalität durch Gastvortragenden |
| x Try Design Thinking for yourself, as well as the basics. Do this yourself with a group<br><br>x Creative work<br>x Group processes (interdisciplinary)<br>x Variety and broadening of horizons in relation to the subject-specific everyday study routine<br>x Your enthusiasm for the topic | x Design Thinking selbst ausprobieren, sowie die Grundlagen. Dies selbst mit einer Gruppe durchzuführen<br>x Kreatives Arbeiten<br>x Gruppenprozesse (Interdisziplinär)<br>x Abwechslung bzw. Horizonterweiterung zum fachspezifischen Studienalltag<br>x Deine Begeisterung für das Thema |
| o very good methodology (not only frontal lecture and Powerpoint)<br>o students learning-by-doing => much higher learning effect<br>o Lecturer has presented various tools of Design Thinking wide range of tools for own application | o sehr gute Methodik (nicht nur Frontalvortrag und Powerpoint)<br>o Studenten learning-by-doing => viel höherer Lerneffekt<br>o Dozentin hat unterschiedliche Werkzeuge von Design Thinking vorgestellt → breites Sprektrum für eigene Anwendung |
| Very nice lecturer | Sehr netter Dozent |

**What suggestions for improvement do you have for this course?**

(Welche Verbesserungsvorschläge haben Sie für diese Lehrveranstaltung?)

| English translation | German |
|---|---|
| A block week would be great<br>Intensive work | Als Blockwoche wäre super<br>Intensive Arbeit |
| Don't put too much into a teaching unit<br>Relatively small time windows for the tasks | In eine Lehreinheit nicht so viel reinpacken<br>Relativ kleine Zeitfenster für die Aufgaben |
| Topic not realistic, just play pretend | Thema nicht realistisch, nur Spielerei |

| | |
|---|---|
| Theme can be chosen more freely, e.g. 2 different themes instead of 1 → because in the end it was something different anyway | Thematik freier wählbar, z.B. 2 verschiedene statt 1 → weil es im Endeffekt eh was anderes war |
| Ideas: Quality before quantity<br>→ There are many ideas in the foreground but it is not about the quality, this should be changed | Ideen: Qualität vor Quantität<br>→ Es stehen viele Ideen im Vordergrund aber es geht nicht um die Qualität, das sollte man ändern |
| More time for improvement | Mehr Zeit für Inprovement |
| Obligation to attend or consideration of attendance when awarding marks | Anwesenheitspflicht oder Berücksichtigung der Anwesenheit bei der Notenvergabe |
| Block week (would be good, if possible)<br>1 week of research in the test phase is very little | Blockwoche (wäre gut, wenn möglich)<br>1 Woche Recherche in der Test Phase ist sehr wenig |
| Smaller groups (max 4-5 persons per team)<br>longer creative phases<br>too much time pressure/stress<br>sometimes a little more structure would be nice | Kleinere Gruppen (max 4-5 Personen pro Team)<br>längere Kreativphasen<br>zuviel Zeitdruck/Stress<br>manchmal etwas mehr Struktur wäre schön |
| Not only half a semester, then you could go deeper into the subject | Nicht nur ein halbes Semester, dann könnte tiefer in die Materie gegangen werden |
| - More time for business context would be interesting for me personally<br>- Further inputs towards implementation Combination with Lean Startup? | - Mehr Zeit für Business Kontext wäre für mich persönlich interessant<br>- Weitere Inputs in Richtung Umsetzung → Kombination mit Lean Startup? |
| x The two runs were good, but it was confusing that different instruments/methods were used<br><br>x Requirements for research work were not realistic - It turned out that nobody has that much time resources | x Die zwei Durchgänge waren gut, aber es war verwirrend, dass jeweils andere Instrumente/Methoden angewandt wurden<br>x Anforderungen zu Recherchearbeit waren nicht realistisch – Es zeigte sich, dass niemand so viele Zeitressourcen hat |
| Possibly block week instead of Thursday evening → specially to encourage attention and creativity | Eventuell Blockwoche statt Donnerstag Abend → speziell damit Aufmerksamkeit und Kreativität gefördert wird |
| I would have liked more information and examples from the practice | ich hätte mir mehr Infos und Beispiele aus der Praxis gewünscht |

| | |
|---|---|
| Unfortunately, the technical area has been neglected. If the topic comes from the technical area, I would have expected more. | Der technische Bereich ist leider sehr zu kurz gekommen. Wenn das Thema schon aus der Technik kommt, hätte ich mir mehr erwartet. |

**Additional remarks**

| **English translation** | **German** |
|---|---|
| Sometimes the creative process was interrupted by the time factor (stress), which was very annoying | Manchmal wurde der Kreativprozess durch den Zeitfaktor (-Stress) unterbrochen, das war sehr ärgerlich |
| Great seminar! | Tolles Seminar! |
| I enjoyed the context study very much | Mir hat das Kontextstudium sehr gut gefallen |
| More into the focal points of the study programs. It was all very social oriented | Mehr in die Schwerpunkte der Studiengänge eingehen. Es war alles sehr sozial-lastig |

### A.7.5. Image Stacked Ideas

## A.8. Project Eight: FHV Dornbirn SS2019

### A.8.1. Open Text Feedback

Feedback was mainly given in English. The few German inputs were translated by the author.

**What was positive?**

- Interesting input
- Very good lecture clima
- Al lot of practical work
- A lot of time to work in groups
- Time to think about the problem/discussions
- Topic itself, great group [?] team work
- Mood exercises like meditation, candle on the wall etc.
- Very structured classes [?] lectures!
- Getting the "thinking" out of the box
- The short exercises were nice to get
- The brain running
- Attitude to think outside the box / within the box
- Positive atmosphere and teamwork
- Different people, studying different subjects → several ideas
- Mix of presentation and teamwork
- Overview of concept
- Aspects of concept
- New unknown technique which can help me in future
- New knowledge, thanks
- I liked the "mood exercises" for the team work – motivation to build the tower with marshmellow. I like the way how the lecturer guided us and gave davices during the work – I found it not pushy and helpful
- Praxis work
- Knowledge of teacher

**What could be better? Do you have suggestions to improve?**

- A little more information about the phases and structure → as "Newbies" at the beginning not clear what to do when
- Show more examples
- Not enough time for group work
- One loop as prepared example from the teacher → more time for the second run
- To communicate on the channel
- I missed some messages unfortunately, like postponing the new day of presentation, I couldn't neither react nor decide and have had some problems with postponing my own appointments [*hard to read, might be partially incorrect*]
- I have heard this topic first time, so for me was everything new. At the evening I was very tired.

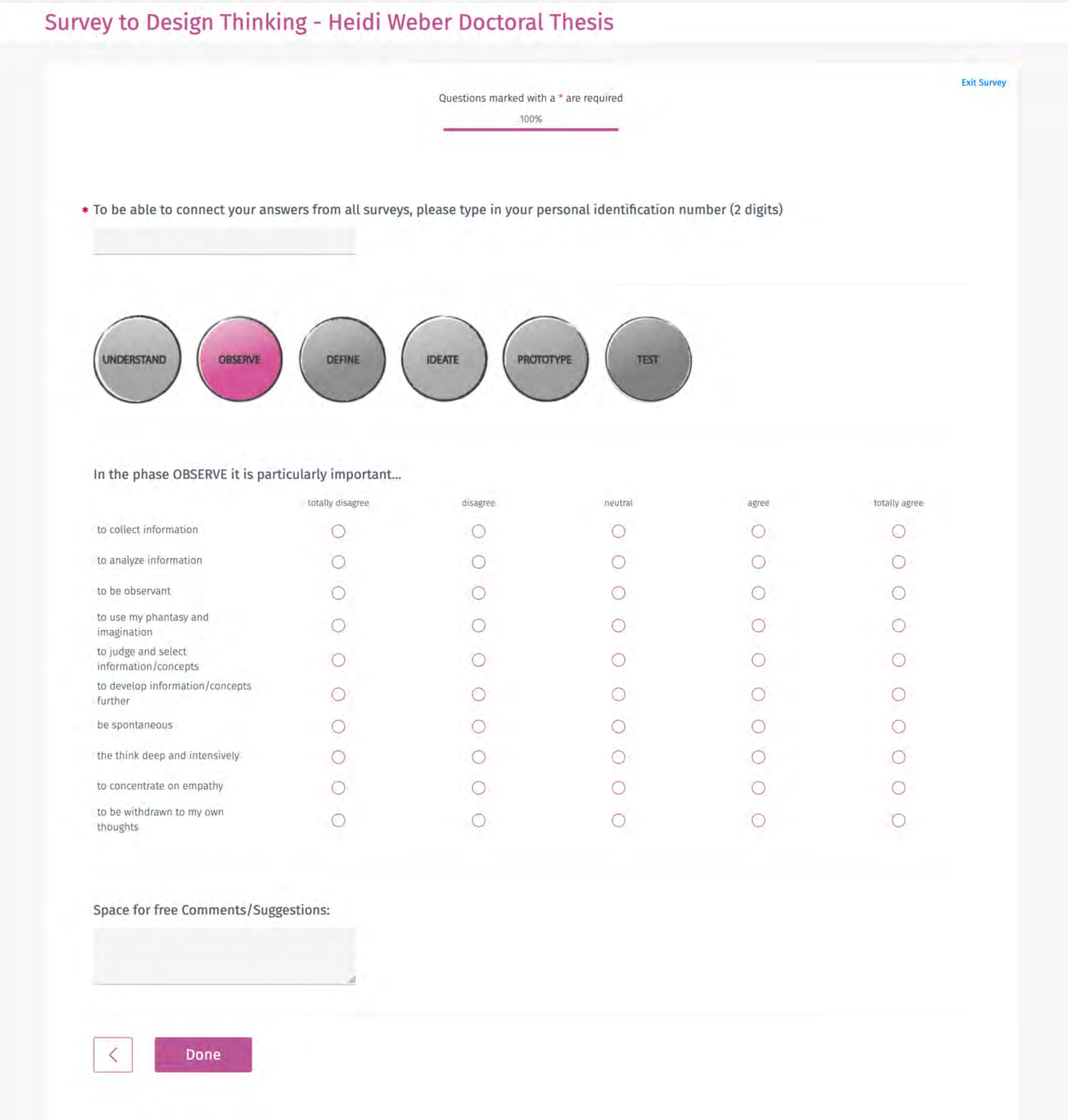
- Exercise, Timing, work theory the process more in depth [*hard to read*]
- Workload very high, we had only a small time slot
- I personally think it is a lot of work for 3 ECTS
- I think that sometimes we did not have enough time for group work and this time was denoted [?] to the lecture itself.
- More structure in Class
- More practical experience supervised in order to have a good role model in each group.

**Additional remarks:**

- Challenges like the marshmallow-tower very cool and funny!
- Please let's agree on one channel like outlook
- Thanks!
- Nice slides and examples
- Well organized professor, well done.
- All to getter it was good. It's just not my thing.
- Blending full-time and part-time made collaboration really difficult

### A.8.2. Survey Results (clustered)

Survey example:



Survey to Design Thinking - Heidi Weber Doctoral Thesis

Exit Survey

Questions marked with a * are required

100%

* To be able to connect your answers from all surveys, please type in your personal identification number (2 digits)

UNDERSTAND OBSERVE DEFINE IDEATE PROTOTYPE TEST

In the phase OBSERVE it is particularly important...

| | totally disagree | disagree | neutral | agree | totally agree |
|---|---|---|---|---|---|
| to collect information | ○ | ○ | ○ | ○ | ○ |
| to analyze information | ○ | ○ | ○ | ○ | ○ |
| to be observant | ○ | ○ | ○ | ○ | ○ |
| to use my phantasy and imagination | ○ | ○ | ○ | ○ | ○ |
| to judge and select information/concepts | ○ | ○ | ○ | ○ | ○ |
| to develop information/concepts further | ○ | ○ | ○ | ○ | ○ |
| be spontaneous | ○ | ○ | ○ | ○ | ○ |
| the think deep and intensively | ○ | ○ | ○ | ○ | ○ |
| to concentrate on empathy | ○ | ○ | ○ | ○ | ○ |
| to be withdrawn to my own thoughts | ○ | ○ | ○ | ○ | ○ |

Space for free Comments/Suggestions:

Done

Since different numbers of answers were given per segment, each answer pair was color-coded separately

| | Understand | Observe | Define | Ideate | Prototype | Test |
|---|---|---|---|---|---|---|
| 1a_to collect information | | | | | | |
| Disagree | 2 | 2 | 5 | 2 | 4 | 1 |
| Agree | 15 | 9 | 1 | 3 | 3 | 6 |
| 1b_to analyze information | | | | | | |
| Disagree | 7 | 4 | 2 | 2 | 3 | 2 |
| Agree | 10 | 7 | 4 | 3 | 4 | 5 |
| 2a_to be observant | | | | | | |
| Disagree | 8 | 0 | 4 | 3 | 3 | 0 |
| Agree | 8 | 11 | 2 | 2 | 4 | 7 |
| 2b_to use my fantasy and imagination | | | | | | |
| Disagree | 10 | 8 | 4 | 2 | 0 | 5 |
| Agree | 7 | 3 | 2 | 3 | 7 | 2 |
| 3a_to judge and select information/concepts | | | | | | |
| Disagree | 11 | 7 | 0 | 1 | 2 | 2 |
| Agree | 6 | 4 | 6 | 4 | 5 | 5 |
| 3b_to develop information/concepts further | | | | | | |
| Disagree | 11 | 6 | 1 | 2 | 1 | 0 |
| Agree | 6 | 5 | 5 | 3 | 6 | 7 |
| 4a_be spontaneous | | | | | | |
| Disagree | 8 | 5 | 2 | 2 | 1 | 4 |
| Agree | 9 | 6 | 4 | 3 | 6 | 3 |
| 4b_the think deep and intensively | | | | | | |
| Disagree | 4 | 2 | 2 | 1 | 1 | 2 |
| Agree | 13 | 9 | 4 | 4 | 6 | 5 |
| 5a_to concentrate on empathy | | | | | | |
| Disagree | 10 | 2 | 3 | 2 | 3 | 2 |
| Agree | 7 | 9 | 3 | 3 | 4 | 5 |
| 5b_to be withdrawn to my own thoughts | | | | | | |
| Disagree | 7 | 6 | 3 | 2 | 4 | 3 |
| Agree | 10 | 5 | 2 | 3 | 3 | 4 |
| | Understand | Observe | Define | Ideate | Prototype | Test |

## A.9. Project Nine: IFS Vorarlberg

## A.10. Project Ten: Antwerp SW2019

### A.10.1. Open Text Feedback – Antwerp 2019

**Positive - What II liked in this class?**

- Actively working in group and improving creativity
- Other Visions
- The new perspectives
- Interesting subject
- The individual efforts
- The new ways of thinking
- Everything
- It pushed us out of the comfort zone
- Learning about creativity
- lot's of freedom to work and try for your own
- Heidi Weber
- The system behind design thinking.
- You were very extroverted and kind
- short lessons (theory) and immediately working in group afterwards
- That we got a lot of freedom

**Negative - What did you not like in this class?**

- It was sometimes hard to understand the assignement
- Too much information - Try to stick to the point
- The short theoretical lessons
- The second day it was very early
- Cold room
- It was all in a short notice
- Nothing
- not as much supervision when needed (only 1 teacher for big group)
- To repetetive. I would like to have a more in depth feeling of design thinking.
- We already knew a lot of what you've told us
- the research and survey
- That it was too short to really do what was expected

**Additional remarks**

- Try to stick to facts and real examples.
- The lectures were very instructive.
- Kind teacher

## A.11. Social Media Survey

### A.11.1. Open Text Feedback – Social Media Survey

- You should offer to collect e-mail addresses so that you can share results with interested parties.
- I think you may have predetermined the characteristics of each phase in some of your questions.

  Often the phases have non mutually exclusive activities such as define through imagining future scenarios and observations from acting out those scenarios.

  A Design Thinker would never be constrained by being 'withdrawn to own thoughts'
- I elt challenging to define mindset in scale compared to different phases as the characteristics may somewhat vary because of the differences in task and its objectives, team or the level of participation in co-creation. Though there are certain differences in focus of divergent or convergent thinking (see double diamond model), there are several ways of working where you may advance the development when working with others, e.g. ideation can be done together, when you need to be open and empathic towards different ideas developed in a team, not just with your own thoughts you commonly do as a product designer.
- I never really understood the idea of design thinking, nevertheless, alone this Survey gave me a lot of insight into the inner mechanisms of it so it was my pleasure to participate to the best of my abilities.
- Keep the good work
- It really cool. And all design thinking is placed in one page
- Some of the steps can require both mindsets (eg in the test phase you first have to collect information and then make sense out of it)
- n.a.
- Liebe Frau Weber,

  Bei manchen Einschätzungen ist die Antwort nicht ganz einfach zu geben. Zum Beispiel ist es in der Phase Beobachten sehr wichtig nur zu beobachten. Wenn ich aber keine Phantasie einsetze, mache ich ggf. gar keine Beobachtung, weil ich nichts erkenne/wahrnehme. Deshalb habe ich meinen Punkt weiter rechts gesetzt.

Viel Erfolg und viele Grüße

XXX

*Translation:*

*Dear Frau Weber,*

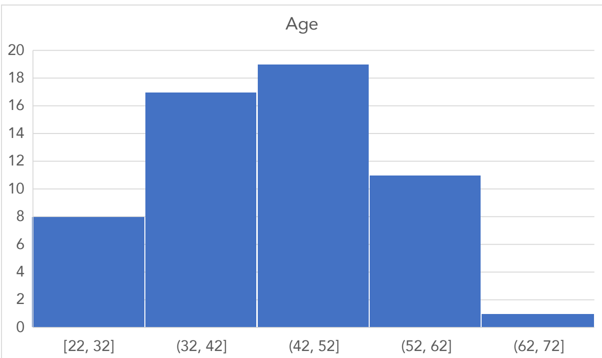
*For some assessments the answer is not easy to give. For example, in the Observe phase, it is very important only to observe. But if I do not use my imagination, I might not make any observation at all, because I do not recognize/perceive anything. Therefore I have set my point further to the right.*

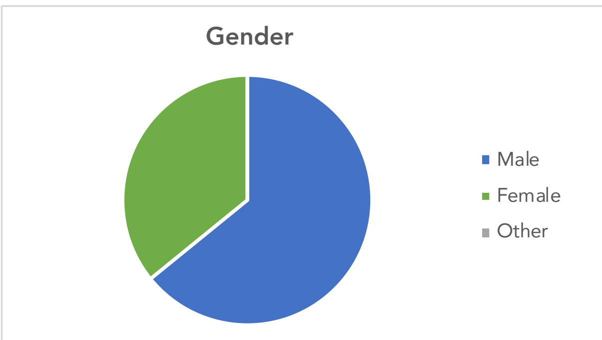
*Good luck and many greetings*

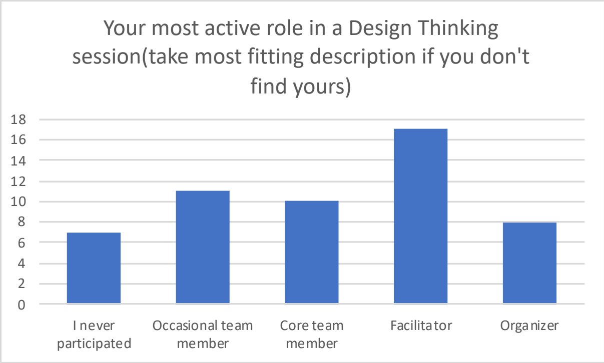
*XXX*

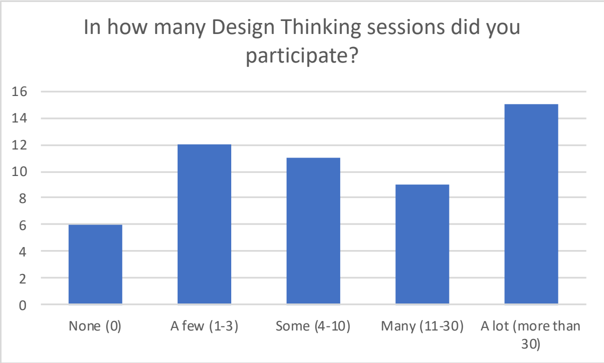
– Hope this helps. You are assuming people that are doing this not only have the experience and understanding, but that they also agree with what you define as Design Thinking process and sessions.

Additional data:




Your most active role in a Design Thinking session(take most fitting description if you don't find yours)
18
16
14
12
10
8
6
4
2
0
I never participated
Occasional team member
Core team member
Facilitator
Organizer


In how many Design Thinking sessions did you participate?
16
14
12
10
8
6
4
2
0
None (0)
A few (1-3)
Some (4-10)
Many (11-30)
A lot (more than 30)