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Bachelor's thesis

Reference model for Design Thinking

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1 Introduction

1.1 Motivation and goal of this thesis

Innovativeness and creativity – two terms that incredibly increased in importance within the last decades. Offering innovative and creative solutions, specifically designed for the customer’s problems and needs, has become a key element to the competitive advantage of companies. (Schallmo, 2018, p. 1)

Concepts, that promise to fulfil and boost these two, are considered the hottest trends in business and management. “Design Thinking” is one of these concepts that received a lot of attention – and hence, an incredible growth in importance, within the last years. (Liedtka and Ogilvie, 2011) It emerged as a multidisciplinary, human-centred approach to innovation – by now, various publications throughout the business-press praise and promote Design Thinking as a universal remedy for any kind of problem. IBM, Microsoft, Daimler, SAP, and many more global players already successfully introduced Design Thinking into their daily business (Clark and Smith, 2008; Förderer and Schill, 2018; Shum, 2018) – various success stories in business and management press enhance the hype around the concept.

Although Design Thinking is an intensively discussed topic, there is no consensus among the promoters, practitioners, and scholars on how to exactly understand and define it. Throughout the literature and publications, Design Thinking is described and interpreted in a variety of ways. (Johansson-Sköldberg *et al.*, 2013) *“What is Design Thinking? If you ask a hundred persons, you most likely will receive a hundred different answers.”* (Kerguenne *et al.*, 2017, p. 4) To briefly bring context to this citation: “A process for innovation and problem-solving” (Brown, 2008), “Philosophy and culture” (Grots and Creuznacher, 2012), “Toolbox of methods” (Liedtka, 2018) and the list continues.

With all this inconsistency, it seems almost impossible to understand the concept without having to spend a tremendous amount of time reading and researching on your own. Therefore, the first research question to be answered in this thesis is:

“What is Design Thinking and how can the concept be understood?”

To adequately answer this question, different descriptions and interpretations will be evaluated – with the goal to build a regulatory framework, containing, explaining and structuring everything that constitutes the concept of Design Thinking.

The increasing need for innovation, together with the broad applicability, are making DT very attractive to many companies. Even more, because of the various published success stories involving global players. Due to the beforehand mentioned missing of a common understanding, there also is no standardized process that explains how to apply or utilize DT. The existing models are mostly ambiguous, informal and by far not detailed enough. Therefore, implementing and applying DT, only equipped with divergent descriptions, no clear procedure model and most likely no expertise, represents a particularly hard task; with a high probability of unsatisfying results or even failure. An endeavour like this could be simplified and supported through a clear structured and detailed process model. This issue embodies the basis for the second research question:

“What should a process/reference model for Design Thinking look like?”

For the construction of a reference model for Design Thinking, the most important and notorious DT-process models are analysed, to find a governable pattern as a foundation for the reference model. Through further investigation, the ground process is extended and complemented to a detailed level – with the underlying subprocesses, input, and output, as well as methods and techniques. In its final form, the reference model is supposed to give a clear step by step guide through the process of Design Thinking.

The objectives of the framework and the reference model are to enable an interested party to easily understand the whole concept of Design Thinking – and in the next step, to enable them to implement and apply it.

After the profound theoretical investigation of Design Thinking, the question occurs whether the processes are likewise used in the real industrial world – therefore the last research question is:

“How is Design Thinking practised in international companies?”

To answer this question, an expert interview, within a large German company is conducted. The derived final model will be presented to an expert who already applied DT in projects, to

evaluate the model and receive further practical insights. This will either approve, oppose or complement the model – the new findings will then be included.

1.2 Methodology

This thesis is going to be mainly a literary work. The qualitative research for the first two problems is based on existing literature - Through structured analyzing, summarising, comparing, logical reasoning and critical examination of the information provided in the literature and the DT promoting institutions, the theoretical part of this thesis will be evolved.

The applied methodology in this thesis, as well as the creation of the framework and the reference model, is based on the seven guidelines for design science, as established by Hevner *et al.* (2004). In the following, the seven rules are displayed.

Guideline 1: Design as an Artifact	Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.
Guideline 2: Problem Relevance	The objective of design-science research is to develop technology-based solutions to important and relevant business problems.
Guideline 3: Design Evaluation	The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.
Guideline 4: Research Contributions	Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies.
Guideline 5: Research Rigor	Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.
Guideline 6: Design as a Search Process	The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.
Guideline 7: Communication of Research	Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.

Figure 1: Design-Science Research guidelines (Hevner *et. al*, 2004, p.83)

As far as possible, and with best of knowledge and conscience, these guidelines are abided.

Alongside the seven guidelines by Hevner *et al.* (2004), the modelling of the reference model is based on (Fettke and Loos, 2004, pp. 18–19) – they describe four steps for the construction of a reference model:

1. Problem definition: To begin, the desired target state of the reference model needs to be defined. This includes the determination of the domain (for which the model is designed), as well as the selection of an appropriate modelling language.
2. Construction: The processes are modeled with the chosen language. As a foundation for the construction-procedure, inductive or deductive methods or reverse engineering might be utilized. Resulting from the construction are the processes (and variants) and the relations between them.
3. Evaluation: The evaluation should not be focussed solely on single reference models but rather the comparison between diverse models to each other. The evaluation is supposed to already start during the construction.
4. Maintenance: The model is supposed to receive constant maintenance, further development, and reworking.

Furthermore, the beforehand addressed regulatory framework is based on the proceed model for the construction of frameworks (Meise, 2001) – classifying the framework as a supportive structuring method for complex reference models.

Regarding the literature research; the scientific databases, accessible through the university's portal, search engines such as Google Scholar, primary and secondary literature, as well as academic and business-related journals are going to be used. The search process itself is based on a systematic approach - for the search, certain keywords, such as "Design Thinking", "Innovation", "Innovation Management", "Creativity", "Product development" etc. were utilized. To gather further possible sources, the snowballing method, as explained by (Wohlin, 2014) was conducted on seemingly meaningful material.

2 Design Thinking

2.1 Preface and disambiguation of the term “Design Thinking”

The term “Design Thinking” is ambiguous. To develop an understanding without confusion, an important differentiation is to be made beforehand. Currently, there are two main discourses regarding DT – the management discourse and the design discourse (Johansson-Sköldberg *et al.*, 2013, pp. 123–124) Before briefly explaining the difference between them, it is noted that this thesis will focus solely on the management discourse.

The two discourses are different in nature and merely connected at all. The design discourse has its roots in the 1960s with Herbert Simon’s “Sciences of the Artificial” (1969) as fundament. It is rather focussed on research and the science in the design discipline itself, which is referred to in the context of arts, craftsmanship and the physical appearance of objects. (Johansson-Sköldberg *et al.*, 2013) call it “designerly thinking”: The theoretical reflexion and interpretation of practical work in design – the way designers think, address problems and apply their knowledge.

The managerial discourse relates Design Thinking to the intentional development of solutions, in the form of products or services. (Brown, 2008; Plattner *et al.*, 2009) Being considerably younger, this discourse emerged around the year 2000 – as a user-centred approach to problem-solving and innovation, inspired by the way designers think and work. (Kelley and Littman, 2001) The concept was picked up and further developed by various institutions and authors. (Brown, 2009; IDEO, 2019; Martin, 2009; Plattner *et al.*, 2009; Stanford d.school, 2010) IDEO, an international design consultancy, the Stanford University together with the Hasso Plattner Institute in Potsdam and many more, vigorously promote DT. According to them, it is the solution to a variety of problems that a company might face. In the managerial meaning, DT does not directly refer to classic disciplines connected to design, such as engineering or industrial design – it is understood as a concept that can be applied by anybody without boundaries to specific disciplines.

Concluding, the managerial discourse is rather practice related, without scientific foundation (Kimbell, 2011) whereas, on the contrary, the design discourse is focussed on theory and scientific research. Johansson-Sköldberg *et al.* (2013) argue that the discourses are not connected - and as this thesis and its research questions are aimed at the current state of DT,

specifically the recent understanding of DT in business, “Design Thinking” will be referred to as in the management discourse – and thus particularly exclude the design discourse.

Within the management discourse, there is a diversity of descriptions and interpretations, as already outlined in the introduction. Therefore, the following chapter aims to thoroughly explain how to understand the term “Design Thinking”.

2.2 The modern understanding of Design Thinking

Within the last years, the attention around DT has massively increased – in practice, as well as theory. (Tschepe, 2018) Still, how to exactly understand the concept of DT is a severely debated topic. Neither in the academic nor the business-related press or publications, a clear and common definition can be found.

To demonstrate the discrepancies, some of the most prominent interpretations of DT within the management discourse are displayed in the table below.

Authors	Understanding of Design Thinking
(Kelley and Littman, 2001)	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 of business success.
(Dunne and Martin, 2006)	A mindset which management and employees should follow.
(Brown, 2008)	Using the designer’s sensibility and methods to match people’s needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity.
(Brown, 2009)	A powerful, effective and broadly accessible approach to innovation that can be integrated into all aspects of business and society.
(Martin, 2009)	The ability of professional designers to switch between abductive, inductive and deductive ways of thinking and a set of cognitive characteristics that managers can learn from designers.
(Plattner <i>et al.</i> , 2009)	A prescriptive process with multidisciplinary teams who use a user-oriented approach to come up with solutions for complex problems.
(Kimbell, 2011)	Cognitive styles of individual designers involved in problem-solving and the general theory of design as a discipline focused on solving complex problems.
(Meinel and Leifer, 2012)	A powerful methodology for innovation which integrates human, business and technological factors in problem forming, -solving and -design.
(Liedtka, 2018)	A toolbox of methods from design.
(Hasso Plattner Institute, 2019)	A systematic, team-based approach to complex problems from any background.
(IDEO, 2019)	Intentional process for creating new and relevant solutions with a positive impact.

These definitions, of course, do not fully cover each of the interpretations. Still, they display that the concept is interpreted in a variety of ways. Throughout the definitions there are some aspects that are at least gradually reflected in almost each of those:

-
- 1. Target: Development of new solutions for specific issues.**
 - 2. Orientation: DT is consequently oriented to the user**
 - 3. Process: DT is applied through a structured and iterative process.**
 - 4. Principles: DT is based on a set of principles.**
 - 5. Participants: DT is conducted by multidisciplinary teams.**
-

To date, there is no uniform definition – as Hassi and Laakso (2011, p. 55) state: “Regardless of all the current discussion, even the most established writers on design thinking within the management discourse (the same holding true for academic discourse) have not presented a comprehensive definition or conceptualization for the concept of design thinking”. Kimbell (2011) and Johansson-Sköldberg *et al.* (2013) concluded that there is no single common perspective or unique meaning to DT. Together they consented that a definition might oversimplify this broad multi-perspectival concept.

2.2.1 Analyses and research on Design Thinking

Many of the recent publications in research on DT, take into consideration that a singular definition is not suitable for describing DT. Therefore, they rather focus on common characteristics and features. In the following, the findings of several authors attempting to explain and fully grasp DT are listed. These different analyses and summaries will support the latter explanatory model to DT.

- Carlgren *et al.* (2016) conducted an empirical study in various multinational organizations, focussed on the application and interpretation of DT within them. As a result, they identified five key themes – each connected with certain mindsets, practices, and techniques.
 - 1. User focus
 - 2. Problem framing
 - 3. Visualization
 - 4. Experimentation
 - 5. Diversity

- Efeoglu *et al.* (2013) analyzed different processual approaches. They found that each of the approaches is comprised of a certain pattern of characteristics, which are:
 - Separation into the problem and the solution space: These two spaces split the DT-process in half – at the end of the problem space a very detailed end-user specific problem formulation is defined which then, in turn, will be addressed in the solution space. The two spaces are supposed to approximately require the same amount of time.
 - Alternating between divergence and convergence: Divergence refers to thinking broadly, considering multiple perspectives and generating many alternatives – in both, the exploration of the problem and the solution. Convergence, on the other hand, refers to focussed thinking, narrowing down the alternatives and becoming more and more detailed. In short, switching between the creation and selection of alternatives.
 - The symbiosis between a) the problem and solution space and b) divergent and convergent thinking. Each of the two spaces begins with divergent phases and ends with convergent ones.

Additionally, to these characteristics, they outlined a set of five principles, inherent in each of the approaches. These are:

- 1. Human-Centricity
 - 2. Collaboration and teamwork
 - 3. Interdisciplinary teams
 - 4. Ideation and Experimentation
 - 5. Timeboxing
- Hassi and Laakso (2011) conducted extensive literature research on the topic and condensed DT into a three-dimensional framework, consisting out of:
 - 1. Practices: Concrete activities, ways of working and specific tools
 - 2. Cognitive approaches: Mentality, thinking styles
 - 3. Mindset: Orientation towards work and the mentality on which problems are approached

- Seidel and Fixson (2013) found three common denominators throughout processual descriptions of DT.
 - 1. Need finding and encompassing the definition of a problem or opportunity through observation
 - 2. Brainstorming, a formal framework for ideation
 - 3. Prototyping, Building models as a source of ideation and the testing of ideas.

2.3 Application scenarios

The dissension within the understanding is also reflected by the diversity of possible application scenarios. These application fields reach from creating innovations in form of new products or services (Brown, 2008; Plattner *et al.*, 2009) to strategy changes and organizational renewal (Holloway, 2009) and issues of social nature. (Brown and Wyatt, 2010) Furthermore, on an organizational level, processes, as well as the management can be improved, and change facilitated. (Carlgren *et al.*, 2016; Martin, 2009) The Stanford Design school, an institute at the Stanford University, even states that DT can improve “any area of life”.

In an empirical study, Carlgren *et al.* (2016) researched the implementation and application of DT in six multinational companies (f.e. Procter & Gamble, Panasonic, Deutsche Bank). Their study revealed what these companies utilize DT for:

As a process in large scale innovation projects

As a product innovation process

As a set of principles, the management and employees should adhere to

As a facilitator in change processes

To improve existing work practices (by implementing DT principles)

To develop new ways of working (by implementing DT principles)

As this study reveals, even within application DT is approached and applied in various ways.

2.4 The concept of Design Thinking:

To conclude; In its most basic form, the form in which it emerged, DT is a generic user-centred approach to innovation and problem-solving that can be applied in a diversity of situations. It unites the users desires with technological possibilities and economic viability. (Brown, 2008;

Kelley and Littman, 2001; Plattner *et al.*, 2009) As displayed in the graphic below, Design Thinking represents the intersection of these three:

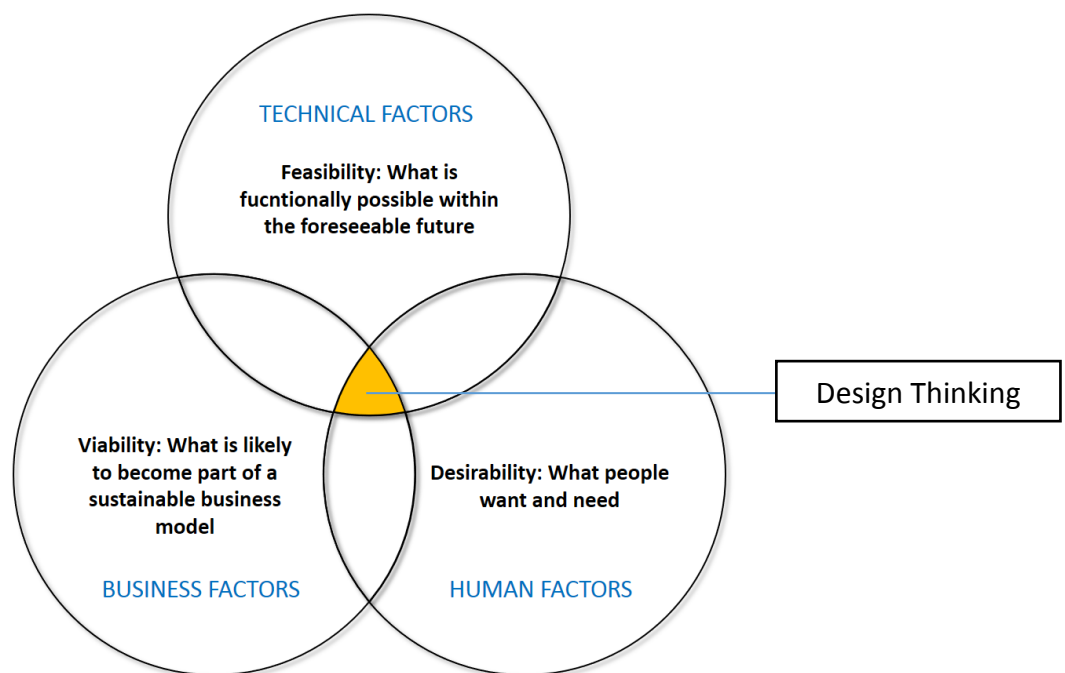


Figure 2: The basis of Design Thinking (based on Brown, 2008)

Considering the different approaches, especially the research that has been conducted to find a definition or conceptualization, showed that the DT is too versatile and case-dependent to capture it in a simple definition. (Carlgren *et al.*, 2016; Hassi and Laakso, 2011; Johansson-Sköldberg *et al.*, 2013; Kimbell, 2011)

“There is a need for a description of DT that is less normative and static and that is specific enough to be able to frame DT as a concept, yet flexible enough to allow for variety in its local use. There is also a need for a description that takes account of the various facets of use, so that DT can be seen as a process, or as methods, a toolbox, a mental approach, a culture or a mix thereof.” (Carlgren et al., 2016, p. 49)

Hence, to create a thorough explanation of the paradigm Design Thinking, this thesis proposes a regulatory framework as a solution – following and extending the attempts of Carlgren *et al.* (2016; Hassi and Laakso). To construct the regulatory framework, the structure of the HyProMM framework (Timinger, 2017, p. 374) was taken as inspiration – the three layers processes, methods and tools, and roles are also part of the DT-framework, the representation is altered. As described by Meise (2001, p. 62) a regulatory framework is ought to create an

overview by organizing all as relevant declared elements and their relations on a high level of abstraction. Following Timinger (2017) and Meise (2001), the regulatory framework will consist of four levels, each representing an important and distinctive part of DT.

The four levels A, B, C, and D: DT is characterized by different principles and methods which are adhered to and applied in relation to a process model. Furthermore, the human as a factor, as well as the environment are considered as parts of the concept that strongly influence it. Abstractedly regarded, the four levels represent the “What, How, Who and Where” to DT.

Respectively, Level A consist out of the key principles that characterize Design Thinking. Each of these principles has associated thinking styles (mindsets) and working styles (practices), as well as a set of techniques. These principles are ought to not only be lived by the team but also to be integrated into the whole organization – the management, the processes and the employees in general.

Furthermore, Design Thinking is described and applied through a structured process with the target to create innovative solutions – which is constituted by the Level B. The process itself has certain characteristics, such as being able to iterate within and between phases as required; These characteristics are embodied by the accompanying process properties.

In Level C, the human side to Design Thinking is elaborated. There are three facets to consider; The profile of an individual Design Thinker, the group dynamics which are necessary to constitute an efficient DT-team, and the user, which constantly represents the centre of attention.

Lastly, Level D considers the physical environment in which Design Thinking functions at its best, as well as the materials that should be provided to maximize experimentation and creativity.

(The information contained in the following principles was derived from the four sources under 2.2.1 – they are not cited for each principle again.)

2.4.1 Level A – Key themes and Principals

Level A represents the key themes, their associated cognitive principles and working styles in the form of practices. They build the foundation for DT and should be embraced by both, the

DT-team and the company. In the following, each of the key themes will be explained. Each key theme is anchored in thinking and working styles – mindsets and practices.

a) User-focus:

The first key theme to DT, probably the most important one, refers to an inherent user focus – empathy building, deep user understanding and user involvement throughout the whole process. Gaining a thorough understanding of the user's actions, emotions, needs, and problems is essential to DT. But not only understanding, but also constant and active involvement of the users in idea generation, prototyping, and testing. After all, receiving feedback from them is the best way to validate and optimize ideas and solutions.

b) Problem(re-)framing:

The second key theme refers to how the team relates to the problem. Instead of the usual procedure, to go ahead and solve the problem, DT-teams are encouraged to widen, challenge and reframe the problem. Repeated questioning and reformulating of the initial problem is necessary to get a better understanding and feeling for it. Also, identifying a larger problem space helps to create a larger solution space; in short, when utilizing DT, it is desired to create many alternatives before narrowing down to a single solution. This requires the team to feel comfortable and confident with complexity and ambiguous problems.

c) Collaboration and Diversity

The third key theme refers to the team composition and the teamwork within the group. In DT, diversity is desired. Forming multidisciplinary teams ensures different skillsets and personalities, which lead to a greater variety of perspectives and inspiration. Ideally, the group is heterogeneous, so that the skillsets and perspectives of the team members complement each other. A well-composed team has the potential to discuss and question anything, which in turn fosters innovative thinking.

Within the team, a democratic spirit is required – this could be supported through the implementation of a moderator (with process and discussion superiority). Collaboration between the team members should be manifested through supporting others, sharing knowledge and joint development of a better understanding. To ensure a common

understanding within a diverse team, abstraction, and simplification of theories, e.g. through visualization, is necessary.

e) Experimentation

The fourth theme comes hand in hand with the fifth. It refers to the manner in which the team comes up with ideas and how they are supposed to interact with them. The bias within the team should be towards trying and testing in an iterative way.

“Failure and mistakes” are valued in Design Thinking – Trying alternatives and iteratively improving solutions are key elements to DT. To fail early and often enables learning and reduces the risk of a later and exponentially more expensive failure. Constant testing and connecting with the users ensures that the development of the solution is heading in the right direction – even if various repetitions are necessary. The experimental character should allow the team to focus on learning, instead of achievement.

Switching between convergent and divergent thinking styles, in combination with iterations whenever necessary, makes DT incredibly flexible. Still, cycling back various times requires the team to stay optimistic and energetic, and to hold on to their positive experimental attitude.

d) Visualization and Prototyping

As already mentioned, the fifth theme is strongly connected with the fourth. Participants are encouraged to making their ideas tangible and experienceable, as well as expressing themselves visually. A “thinking by doing” attitude is desired.

Visual representation is used to display facts and stories, to structure data and select ideas. Together with prototypes, they are meant to facilitate and support communication within the team and towards the users (and stakeholders). Within the team, visual representations and prototypes are utilized to share insights, discuss objectives, find consensus and to refine features of the prototype. Prototypes make ideas tangible and experienceable for the user so that testing and receiving feedback is enabled. The feedback, in turn, is integrated into the following version of the prototype. Through repeating these steps, again and again, the prototypes gradually evolve. This reflects the vehement focus on the users – feedback is the most valuable resource to ensure a successful solution.

Ideas are the basis for tangible solutions, the prototypes. In Design Thinking, prototypes can basically be anything – sketches, paper mock-ups, play-doh objects, Lego models, role-plays, etc. – anything that helps to make the solution more tangible. (Brown, 2008; Dunne and Martin, 2006; Plattner, 2009; Schallmo, 2017)

2.4.2 Level B – The process

The second level describes the process and its characteristics. The process represents the centre of the model – the principles are to be applied and minded in each step of the process, the environment is supposed to support the process, and the humans are the ones applying it. In this chapter, the process will only be briefly discussed, as it completely explained and rolled out in the reference model, which follows later. The target of Design Thinking is to creatively solve problems through innovative solutions. As outlined before, DT can be applied for a variety of issues.

The process is separated into six phases, similar to the processual descriptions of the Hasso Plattner Institute. Their process-model was chosen as the basis for the reference model because it is one of the more structured and detailed models. (Hasso Plattner Institute, 2019)

The processual characteristics of DT: One clearly distinguishable characteristic of the DT-process is its iterative character. Iterations can take place within process steps, between process steps and also within subprocesses – whatever is required. Even loopbacks from the final stage to the beginning are thinkable. A further characteristic which is formative for DT is the separation into problem and solution space. Efeoglu et al. (2013, p.249) state that a solution can only be as good and fitting as the problem was understood. Therefore, it is not unusual, that the “exploration of the problem space” takes up just as much time as finding a solution to the problem. Additionally, switching between convergent and divergent thinking along both, the problem and solution space is indicative for DT. Alongside the whole DT-process, the team continuously learns. Lastly, it must be mentioned, that especially divergent phases (collecting of data, creating many alternative ideas) are predestined for disproportionate spending of time – therefore time framing these tasks or “Timeboxing” is strictly advised. (Efeoglu et al., 2013, p.252)

2.4.3 Level C – The human

A further critical and reoccurring topic within Design Thinking is the human being. The human perspective can be divided into the individual's profile, the team and its dynamics, and the users.

To be a Design Thinker, an individual is required to have a certain set of characteristics and traits. Brown (2008, p.87) and Plattner (2009, p.72) describe the following:

Empathy	Being able to imagine the world from multiple perspectives.
Integrative Thinking	"The ability to face constructively the tension of opposing ideas and, instead of choosing one at the expense of the other, generate a creative resolution of the tension in the form of a new idea that contains elements of the opposing ideas but is superior to each." (The Opposable Mind, Roger Martin) (s.Schallmo)
Optimism	Having the idea that every problem is solvable.
Experimentalism	Exploring constraints in creative ways that proceed in entirely new directions.
Collaboration	A Design Thinker should be an enthusiastic interdisciplinary collaborator, who not only works alongside other disciplines but often has experience in more than one. (For instance: engineers with marketing experience, architects with a psychological background, etc.)

Additionally, a Design Thinker needs to be rational and analytical as well as emotional and intuitive. (Brown, 2009, p.78)

A further characteristic, constituting an ideal Design Thinker, is the "T-shaped" person. The T-profile was made famous by McKinsey & Company. (Brown, 2009, pp.22-23, p.27; Johnston, 1978)

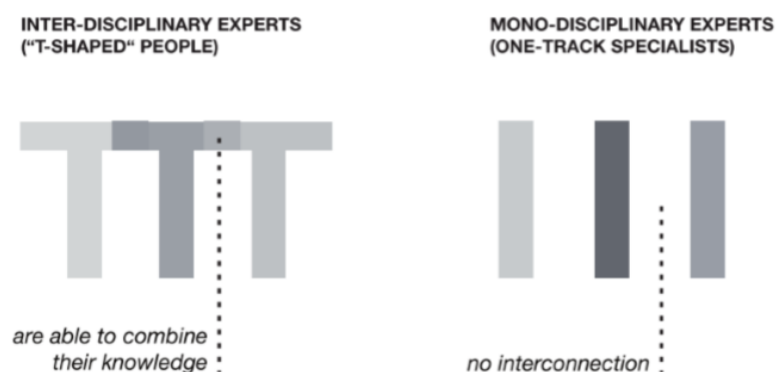


Figure 3: T-Shaped People vs. One-Track Experts (Efeoglu et al., 2013, p. 253)

The vertical axis of the T stands for the depth of skill in the team members own field, which is required to make tangible contributions to the outcome. The horizontal axis stands for disposition and the capacity to collaborate across disciplines; Being able to communicate with other disciplines and showing enthusiasm and interest.

Highlighted in every approach to DT are the multidisciplinary teams – people with diverse backgrounds and experiences. (Brown, 2009) The Hasso Plattner Institute (2019) and Schallmo (2017, pp. 15–16) state, that a DT-team with five to six members is most effective. Teams should be composed of several disciplines, equally distributed. It should be noted here, that the technical realization, especially from complex technical products, is not directly conducted by the DT-team – they evolve and test ideas as far as possible with prototypes.

As already outlined in the first principle, the user is essential to DT – they are the ones who the solution is ultimately designed for. Therefore, the target group needs to be defined as early as possible, so that observation and feedback can be integrated from the beginning. Within these groups are “mainstreams” (average users) and “extremes” (fringe users). (IDEO, 2019) The extremes are for instance elderly people or children; They might have to cope with problems an average user would not be affected by. Thus, they have the potential to reveal unknown issues and by doing so, to help to create a solution that is suitable for everybody.

Considering the roles; Within the DT team, each of the members is equal – except the moderator, who has process and communication superiority. This role is implemented to solve conflicts, take decisions when no consensus is found (f.e. if an iteration is necessary) and keeping the project on track. (f.e. limiting the time during divergent phases) (Hilbrecht and Kempkens, pp. 361–362)

2.4.4 Level D – Environment and material

Gürtler and Meyer (2013, p. 20) describe the environment in which the team is working as “catalyst” for creativity – it cannot produce ideas but inspire and support the creation of those. Therefore, each DT project requires a dedicated room, in which the project can “live and evolve” throughout its whole duration. (Gürtler and Meyer, 2013; Brown, 2009, pp.26-27)

A room for Design Thinking should fulfil certain requirements. As already mentioned before, teamwork and collaborative working are essential in DT – therefore spaces, furniture, and equipment that support working together, to discuss and to hold presentations should be

given. Furthermore, a space for concentrated working, as well as a “break and relax” space, are advisable. The combination of working and discussion spaces requires the room to be flexible, for instance through movable furniture that can be adjusted to the team's needs. Standing tables, normal tables (optional with wheels), chairs with different heights, sofas, movable whiteboards, room dividers (as used in open-plan offices) are possible solutions for a flexible room arrangement. These different types of furniture also incite movement and active participation through a change of the posture. (Gürtler and Meyer, 2013, pp. 20–22; Grots and Pratschke, 2009, pp. 18–19)

In 2013, SAP opened its “Apphaus” in Heidelberg – a place specifically designed for Design Thinking workshops. As visible in the pictures below, the rooms are very spacious with various flexible furniture elements and equipment.



Figure 4: SAP Apphaus 1 [<http://experience.sap.com/news/internship-apphaus-nothing-better-happened/>, accessed: 14.03.2019]



Figure 5: SAP Apphaus 2 [<http://experience.sap.com/news/an-academic-perspective-on-innovationpractices/>, accessed: 14.03.2019]

DT creates a vast amount of physical output – therefore, and to fulfil the principle of visualization and prototyping, a lot of free spaces are necessary. Horizontal spaces (tables etc.) are required for working, writing, drawing or creating prototypes. The vertical spaces are used for displaying output and data in the form of pictures, post-it accumulations, user journeys, storyboards, empathy maps, sketches, photographs and many more. In DT, every free vertical space might be used for visualization: windows, walls, whiteboards, room dividers, whatever is available. Additionally, screens or beamers for virtual presentations are also utilized. (Gürtler and Meyer, 2013, pp. 21–23); (Schallmo, 2017, p. 21)

Of course, the creation of prototypes, as well as some of the visual representations require material. The materials need to be free to use and easily accessible to everyone. Referring to both pictures above, the material could be stored in the red boxes. The following list describes materials which might be used in a DT-project: Pens, rulers, paper clips, glue, wooden sticks, tape, thread, Lego stones, textiles, play dough, plastic, foil, pipe cleaners, paper (in various strengths, colours and sizes), plastic cups, rubber bands, straws, markers (in various colours and sizes), crayons, colour pencils, post-its and sticky notes (in various colours), Styrofoam, bottles, scissors, knives, hole punchers and staplers. (Stanford d.school, 2010; Schallmo, 2017, p.21; Tschimmel, 2012) Displayed below is an exemplary stock of material for DT, published by the Stanford d.school.

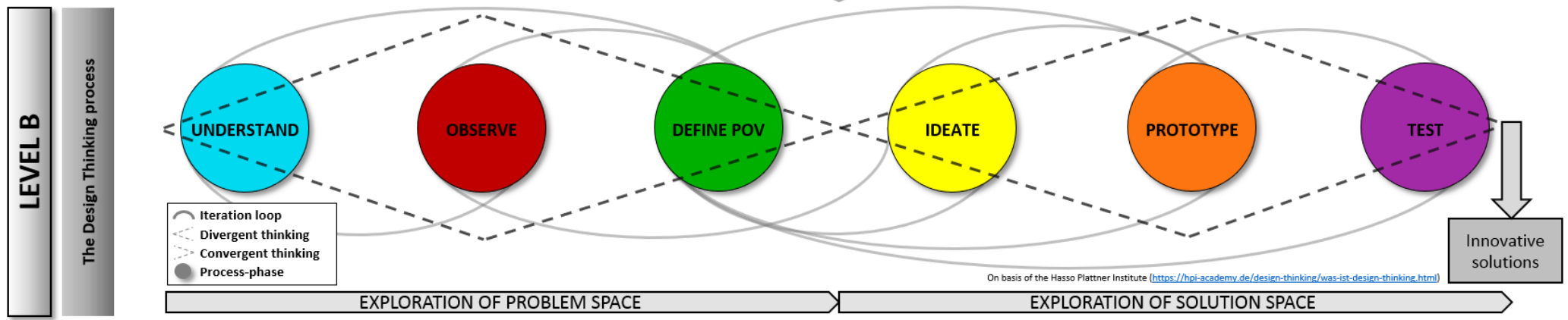


Figure 6: Exemplary stock of DT material [<https://dschool-old.stanford.edu/groups/k12/wiki/56b69/images/b1083.JPG#2048x1536>, accessed: 15.03.2019]

2.5 The regulatory framework for Design Thinking

LEVEL A	1.Key themes	User-focus	Problem(re-)framing	Collaboration and Diversity	Experimentation	Visualisation and Prototyping
	2. Mindset (Thinking style)	<ul style="list-style-type: none"> Be empathic Be curious Be unprejudiced Act social and be interested in your users 	<ul style="list-style-type: none"> Think free and unconstrained Embrace complexity and ambiguity Be open to the unknown 	<ul style="list-style-type: none"> Be open for different disciplines, perspectives and personalities Incite team- & „we“-spirit Be democratic and defer judgement Share knowledge Think integrative 	<ul style="list-style-type: none"> Be experimental, curious and explorative Be optimistic and energetic Be learning-oriented Failure is an opportunity to learn and do better 	<ul style="list-style-type: none"> Express yourself visually whenever it is possible Think by doing Test ideas whenever possible Always search for feedback
	3. Practices (Working style)	<ul style="list-style-type: none"> Immerse into the user's life, try to fully understand his needs and problems Use qualitative and quantitative research methods Include the user throughout the whole DT-process 	<ul style="list-style-type: none"> Question and challenge the initial problem, redefine and reframe it Synthesize and interpret the collected data, find patterns and dependencies Consider alternatives and think abductively 	<ul style="list-style-type: none"> Compile a heterogenous team Consider different perspectives and get inspired by your team members Reach a common understanding of the problem Collaborative learning within the team 	<ul style="list-style-type: none"> Work iteratively and gradually come closer to the solution Switch between divergent and convergent thinking Constantly build and test prototypes Start early with testing Fail early and often 	<ul style="list-style-type: none"> Make ideas and thoughts tangible to communicate them Visually display facts and stories Create experiences for the users and the team Use a inspiring and flexible environment
	4. Methods	<ul style="list-style-type: none"> Ethnographic research Observation and interviews User stories and journey mapping Empathy maps Feedback sessions 	<ul style="list-style-type: none"> „How-might-we-questions“ „Five why“ „Pain storming“ Perspective of View (POV) 	<ul style="list-style-type: none"> Personality tests Conscious recruitment Teambuilding exercises Cross-divisional events Implementation of a moderator 	<ul style="list-style-type: none"> Brainstorming techniques Reverse brainstorming Building on ideas of others 	<ul style="list-style-type: none"> Rough physical mock-ups Sketching, storyboarding, storytelling, role-playing and videos
Specifically important in:		●●●●●●	●●●	●●●●●●●●	●●	●●●●●●

Principles are to be applied in relation to the process and within the team



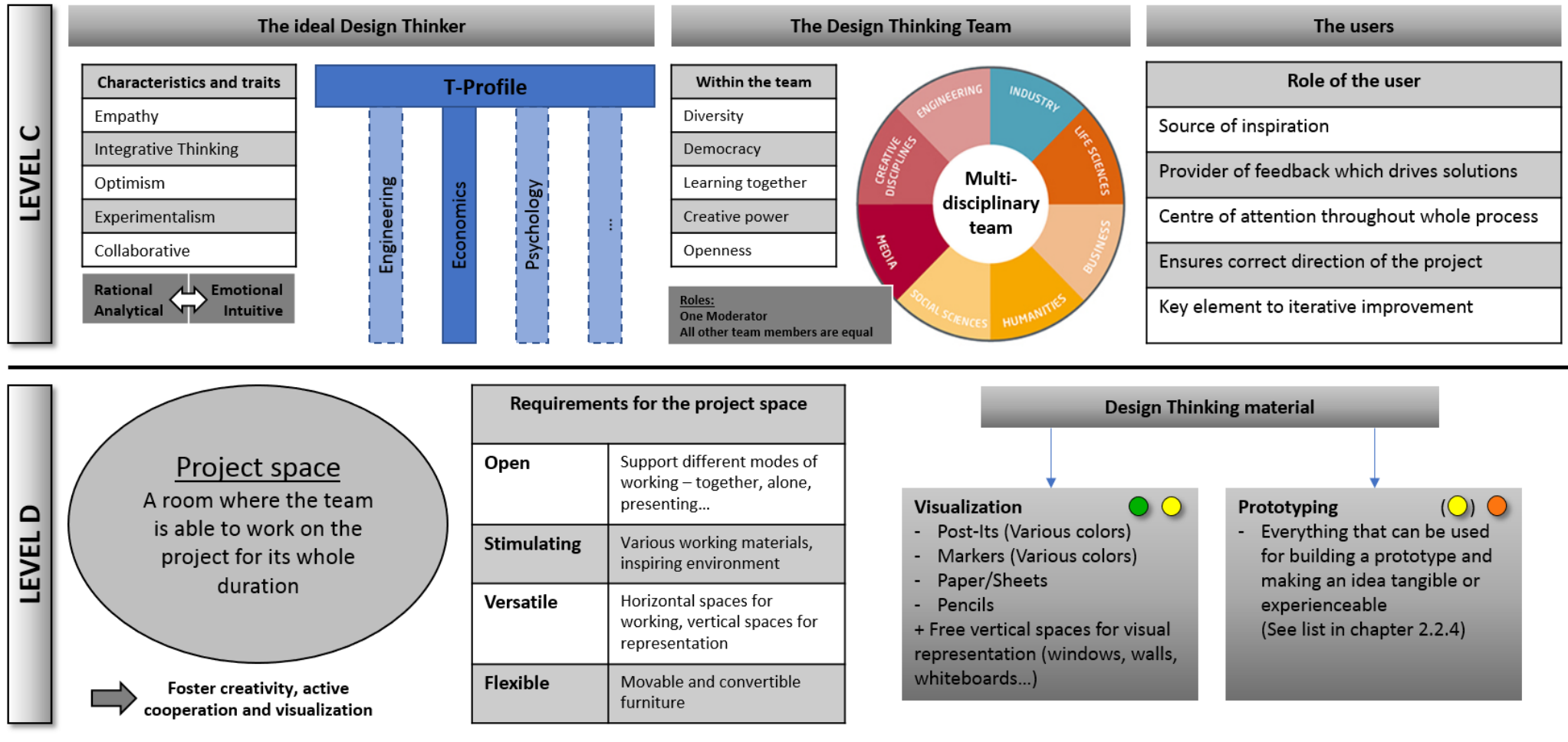


Figure 7: Regulatory framework for Design Thinking

The structure of the above displayed regulatory model is also supported by Gürtler and Meyers description – they declare the following elements as essential to DT: The understanding of DT as a working culture, which is reflected in the principles, an actual process, the “right humans” and flexible rooms. (Gürtler and Meyer, 2013, p.33)

2.6 Constraints and barriers to DT

Of course, Design Thinking is no flawless concept, neither is it immune to barriers within companies. There are several factors that have the potential to hinder the DT-process. Each project has its own difficulties – the barriers are often dependant on very specific circumstances. In the following table, some generally occurring barriers are described. (Hilbrecht and Kempkens 2013, p.361-362)

Participants	Moral, ethical or any other value-based problems with project content (For instance: Environmental pollution, connection to armaments industry, exploitation, etc.)
	Unwillingness of participants
	Personal tensions between participants
	Different perceptions and forms of communication (especially in multicultural teams)

These issues can be prevented by considerate recruitment and selection of the team members. Furthermore, to prevent the emergence of conflicts (between participants or objectives), one moderator with process and communication superiority should be elected.

Management / Company	Lack of transparency on project goals
	Lack of strong leadership and support for DT
	Internal political fights over influence and power
	Missing resources and financial means for the project

Successfully applying DT in a company requires support from management, as well as the will to really utilize DT – half-hearted engagement, for instance just to raise the company profile, most likely results in unsatisfying projects.

Process	Too narrow vision of the goal - limits creativity and flexibility which makes DT as procedure obsolete
	Time pressure
	Lack of acceptance

Limitations to the process, such as unrealistic time specifications, or an already narrowed down vision of the goal deprive DT of its explorative and creative character and therefore make it obsolete – again, resulting in unsatisfying projects.

Furthermore, the success and the utility of DT-projects are difficult to measure – unfortunately, it is often the case that executives presuppose detailed economic calculations (for instance: return on investment (ROI), return of capital employed (ROCE)) or analyses (for instance: SWOT) to accept a project. As the outcome of a DT-project is rather uncertain, it is barely possible to provide these calculations or analyses beforehand. In this case, convincing executives to bind resources, is only possible with support from above and new performance indicators. These could, for instance, be the rate of new product developments, the number of new product ideas and soft factors referring to the cooperation between co-workers and managers. (Förderer and Schill, 2018, p.71; McCarthy, 2017, p.91)

Concluding, a vital requirement for Design Thinking is that the team is allowed to act freely and in own responsibility, with strong support from the management – only then, DT can be utilized at its full potential.

3 The Design Thinking process

3.1 Existing Design Thinking process models

As outlined through the framework, DT does not only consist out of a process – however, to utilize and apply DT for creating innovations and new products/services or the improvement of already existing ones, a detailed proceed model is necessary. Before constructing the reference model, the most significant and notorious approaches to DT, specifically their processual descriptions, are evaluated to build a solid foundation for the reference model.

IDEO, its CEO Tim Brown and its founder David Kelley, the Stanford Design school (d.school) and the Hasso Plattner Institute (HPI) are considered to be the originators of the modern DT-discourse. The majority of the later published literature, academic as well as business-related, refers to and revolves around their explanations – therefore their processual approaches are utilized as basis and starting point for the reference model.

The evaluation lays a special focus on what is happening within the processes and subprocesses. The order as well the applied methods will pioneer the creation of the reference model. The proposed methods and techniques partially coincide between the models – to skip multiple explanations, the methods will be briefly explained in the description of the reference model.

3.1.1 IDEO and Brown's 3I Model

IDEO is an international design and innovation consulting company, as well as one of the strongest and most influential promoters of DT. (<https://www.ideo.com/pages/design-thinking>) Tim Brown, CEO of IDEO, and David Kelley, the founder, were amongst the first ones to use the term “Design Thinking” in the context of an intentional innovation and problem-solving context. Both have several publications on the topic of DT. The worldwide success of DT is closely connected to the rise of IDEO. (Hilbrecht and Kempkens, p. 349)

As the title already reveals, the “3I-Model” consists out of three phases: Inspiration, Ideation, and Implementation – “the continuum of innovation” as Brown (2009, p.18) expresses it.

Beneath, two visual representations of the process are to be found. The left representation was taken from Brown's explanation (2008), the right one from Chung and Kong (2016), which link it to IDEO. The representations differ, regarding the content they are congruent.

In short, Inspiration triggers the search for solutions by finding a problem or a need and converting it into an opportunity. Ideation stands for the creative part, generating and developing various ideas, as well as testing together with potential users from the target community. Implementation embodies the path of concepts from the project room to the real-life solutions and their destination, the market in most cases. Projects tend to loop back through these spaces more than once for refining ideas or solutions and trying new directions. Due to the highly explorative character of DT, the processes are rather of an iterative than a linear nature. (Brown, 2008, p.88-89)

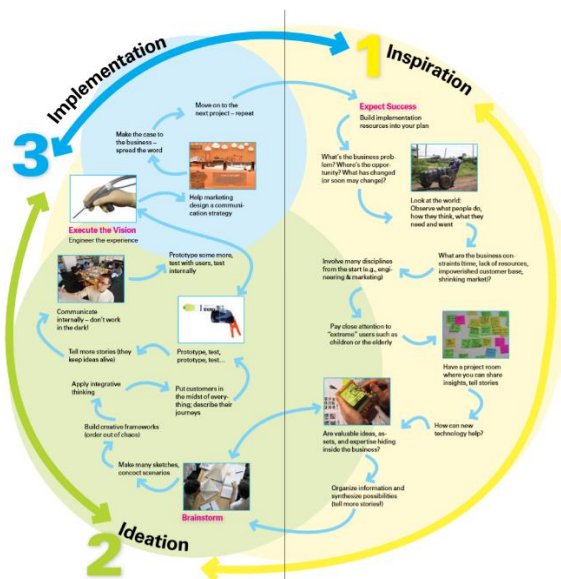


Figure 8: Brown's 3I-Model (Brown, 2008, p.88)

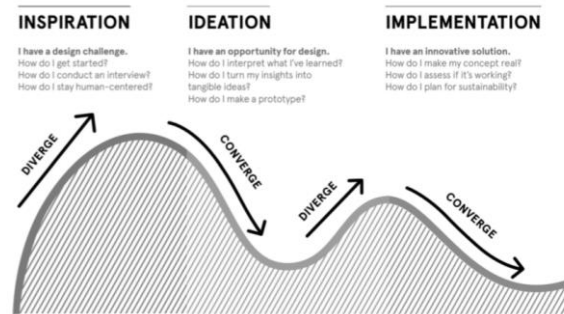


Figure 9: IDEO's 3I-Model (Chung and Kong, 2016, p.20)

1. Inspiration

The starting point for a DT-project, more precisely the inspiration phase, is called “the brief”. The brief is not clearly defined – it can reach from a simple idea, such as improving the customer experience with a certain product, over inventing completely new products or services for specific or non-specific problems, to the endeavour of improving strategies or processes. It could also just include the rough topic, e.g., the market segment, with the problem yet open to being found.

First, to create meaningful innovations a deep understanding of the users and their motivation is necessary. To achieve this understanding, the designers must immerse themselves into the lives of the users. (Chung and Kong, 2016, p.20-21) Building empathy and constant user involvement from the beginning is repeatedly stressed by both, IDEO and Brown. Seeing the world from the user’s perspective and relating to their emotions and feelings is described as

one of the most crucial factors in DT. Constantly involving users also ensures, that the problem to solve, is an actual problem of matter and that the users are satisfied with the way the solution is going to resolve it.

Through secondary research and design research, as much data as possible is collected. The next task is to synthesize and translate this data into key themes and lessons learned, which inform and direct the following steps. At the end of the inspiration phase, three to five clear summary sentences, should be formulated. (Brown and Wyatt, 2010, p.30)

Proposed methods and tools for Inspiration:

Observation (Accompanying the user's daily life, photo journals, user diaries)

Empathy (Empathy map, revising the problem from the user's perspective)

Interviews (Focus groups, single interviews, extremes, and mainstreams)

2. Ideation

The ideation is dedicated to generating as many ideas as possible out of the gathered data and the derived insight statements. Collaboratively the team decides which ideas to pursue – first prototypes are built and presented to the target users to obtain feedback for refining the solutions. The three key steps within ideation are synthesis, brainstorming, and prototyping.

To avoid confusion, synthesis already partially takes place at the end of the inspiration phase, the passing between inspiration and ideation should be interpreted as a fluid transition or “overlapping spaces”. (Brown, 2009, p.18) Synthesis stands for assessing the gathered data – In line with the insight statements and the feedback, these enable the team to discover first directions for possible solutions or opportunities for change. Again, this depends on whether there was a clearly defined starting point or just the search for improvement of any thinkable situation. (Brown, 2008, p.88-89)

The synthesis starts with “downloading” your learnings – present, sort, organize and discuss your findings within the group. Everyone should participate and share thoughts, stories, and feelings, generating a pool of group knowledge with many perspectives. A helpful tool to do so are individual Post-Its. These findings can now be clustered into groups to identify specific themes – e.g., recurring topics or problems. Supportive here are free spaces, such as whiteboards or walls where the sticky notes can be grouped into the different themes. The

final stage of synthesis requires moving from insights to opportunities by creating “How might we...?” questions. IDEO recommends these questions because they are clear on the goal yet open-ended and therefore not restricting imagination. (Chung and Kong, 2016, p.22)

On the basis of the “How might we...?” questions, ideas for solutions are now to be brainstormed. To brainstorm successfully and find the “top ideas”, seven rules, provided by IDEO (<http://www.designkit.org/methods/28>) must be adhered to.

1. Defer judgement – Good ideas can emerge from anything.
2. Encourage wild ideas – Don’t focus on constraints of materials and technology, wild ideas often bring creative leaps.
3. Build on the ideas of others – In conversation, use “and” instead of “but”.
4. Stay focussed on the topic – Avoid diverging beyond your scope.
5. Have one conversation at a time – Building on ideas works far better if everyone pays full attention.
6. Be visual – Drawing, sketching and writing on Post-Its.
7. Go for quantity – Aim for as many ideas as possible.

Basically, the objective of the brainstorming is to generate as many ideas as possible – according to IDEO, up to 100 ideas in a 60-minute session is realistic. Afterwards, the ideas are assessed; usually many of them can be discarded quite quickly, some need to be further discussed and evaluated – in the end, a few to build on should remain.

Prototyping, the next step, is a very effective and efficient way to test ideas; Beginning with low-cost rough prototypes helps to evaluate the potential of the idea as a solution in realistic situations. It also supports further reducing the ideas from brainstorming, until the most promising ones are left. The essential part of prototyping is creating tangible solutions - which then are presented to and discussed with the target customers. The received feedback is utilized to refine the right variables, which after one iteration are improved and tested again.

Through repeating the test-feedback-improve cycle numerous times, the solutions continuously improve, while ensuring that any changes are in line with the customer's imagination. The main advantage of this procedure is that it prevents investing significant resources into a solution that ultimately will fail. In DT failure is considered as an opportunity to learn and improve - “Fail early and often to succeed sooner.” (Brown, 2009, p.18)

Proposed methods and tools for Ideation

Storyboarding (Customer Journey Map, Visualization)

(Rapid) prototyping (focus on functionality, feedback-and-improvement sequences)

Testing (Receiving feedback on prototypes, integrate it in the next iteration)

Guidelines: Get as much feedback as possible on everything (storyboard, prototype...), integrate feedback and iterate

3. Implementation

In the last phase, the finalized concept is turned into reality. After being approved by the stakeholders, a fully conceived action plan, including implementation, maintenance, and evaluation, is formulated. Simultaneously, strategies for communication, sustainability, and growth are to be developed.

Again, the spaces tend to overlap – final prototyping in the form of live prototypes and pilot programs before the full market launch are advocated. This ensures conformity and feasibility, and enables final refinements, if necessary. Furthermore, the business model for selling your solution is also to be improved this way.

Another important part of this phase is the measurement and evaluation of your results. By doing so, the business impact is demonstrated, and it provides feedback on your practices. These lessons learned, offer the possibility to enhance and benefit your future projects.

It should be noted here, that this phase is usually not conducted by the DT-team. Other departments, such as marketing and sales are usually more experienced when it comes to product launches and advertising. (Brown, 2009, p.23) Therefore, this phase will be excluded from the reference model, as it is no task of the DT-team.

Proposed methods and for Implementation:

Live Prototyping

Pilot Programs

Measure and Evaluate

3.1.2 Hasso Plattner Institute and the Stanford Design school

The HPI and the Stanford d.school both are dedicated to forming the designers of tomorrow – this includes teaching Design Thinking as an own study program.

Hasso Plattner, the founder of SAP, an international software company and the market leader in company software, is a strong supporter of DT. (<https://www.sap.com/corporate/de.html>) Due to IDEO, he first came in contact with DT in 2005 and was immediately thrilled. He sponsored the building of the first d.school in Stanford, and in 2007 he brought the concept to Germany – to the Hasso Plattner Institute in Potsdam, which is also sponsored by and even named after him. (Gropp, 2012)

Beneath, the process model of the HPI is displayed. At the HPI, DT is seen as a human-centered design process, with the capability to improve any area of life. (Hasso Plattner Institute, 2019)

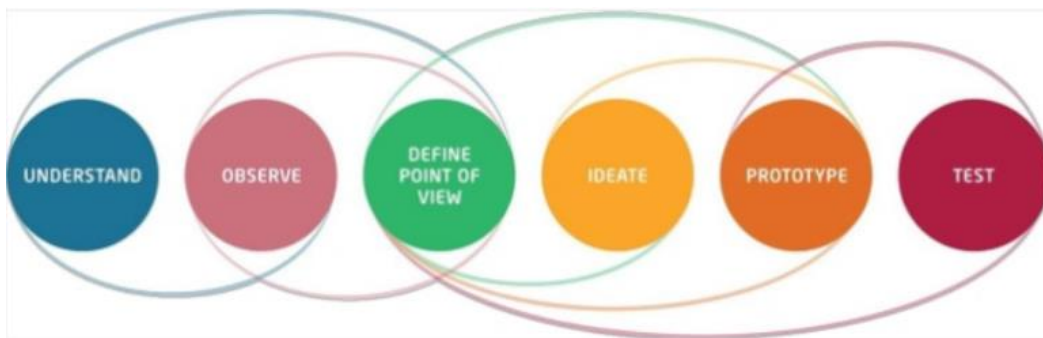


Figure 10: Design Thinking process (Plattner et al., 2009)

Again, the starting point of the DT-process is not clearly defined. It can be an analytical, yet open question without giving any indication what the solution (product/service/process) might be. Plattner refers to it as hypothesis - similar to the former reviewed model, the starting point could also roughly describe the topic, so that problem still has to be discovered. (Plattner et al., 2009, p. 115; Hilbrecht and Kempkens, pp. 356–357)

1. Understand

The first step builds the foundation for all the following steps. It requires the team to acquire a common understanding of the hypothesis and the problem associated with it. This includes understanding the task, defining the problem, discovering who the problem concerns and how this specific group interacts with it. (Plattner et al., 2009, p. 115)

At the end of the understand phase, the following questions should be clarified:

What's the problem and the social reality to it?

Who are the target users?

What is necessary for the success of the project?

Proposed methods and tools for Understand:

 5W-Questions (who, what, when, where and why)

2. Observe

The observe, or also research phase, is meant to build an understanding for the users, their needs and feelings, and what is important to them – to empathize with them.

The Stanford d.school (2010) process guide describes how to empathize with users:

- Observe: Observing the users and their behaviour within the problem context is one of the most valuable information sources.
- Engage: In this context, engaging means interviewing and conversating with the users after observing them. Confronting them with what was observed (foreign perception), often brings valuable insights as it is seldom congruent with the users own perception regarding their actions. Prepared questions can be asked, but the conversation can deviate from them. Every action should be questioned with a “Why?” to get a deep understanding. It is very helpful to conduct engagement in the problem environment.
- Watch and Listen: Observation and engagement can also be combined – for instance, by directly asking a user to complete a task and to describe what he is doing as they perform or interact.

In addition, secondary research can be utilized to gather further data.

3. Define Point of View (POV)

The define-phase, also synthesis phase, is necessary for the team to find and define a common point of view. To do so, the discoveries and insights from the observe phase are analysed, interpreted and evaluated. This generates a uniform knowledge base, from which further information for the process can be drafted. (Plattner *et al.*, 2009, p. 120)

To start, each team member narratively presents his findings; The presented information is then discussed in the team to find connections and important insights. It is suggested to visually capture all information and results in pictures, post-its and journey maps, which then can be utilised to separate relevant from irrelevant information – clustering the information in certain topics and “building the synthesis”.

Additionally, and even more importantly, the define phase then results in a point of view (or multiple POVs). These explicitly define the challenge to address, “a meaningful and actionable problem statement”. Of course, the problem has already been formulated in the first phase, now it is getting complemented with insights and particular user needs – this displays an important characteristic of this DT approach: the problem is continuously increasing in accuracy, by adapting it more and more to the actual user. (Stanford d.school, 2010)

A good POV has to fulfil the following criteria:

Clear focus and problem-frame

Informs criteria for posterior evaluation of competing ideas

Empowers and supports decision making within the team

Inherits the real user needs

Discrete and not broad

Proposed methods and tools for Define POV:

Storytelling

Customer Journey Mapping

Personas

4. Ideate

The fourth phase is meant to discover solutions for the identified problems. Especially in this early stage of the design project, the objective is to generate as many alternatives as possible in a given time, to have a possibly large range of ideas to choose from. At this point of time, there is no single best solution – this determination will follow later, through testing with users and feedback.

A multidisciplinary team offers various perspectives and different strengths, which increases the creativity and innovation potential in the ideating phase – the Stanford d.school (2010) emphasises “fluency (volume) and flexibility (variety)” for the idea portfolio, furthermore the design team has to bear in mind that the examination of the ideas is yet to come, therefore, similar to IDEO’s rules, judgement should not be involved in the ideation phase.

Proposed methods and tools for Ideate:

Brainstorming

Bodystorming

Mind Mapping

Sketching

In the transition from ideating to prototyping the DT process guide (Stanford d.school, 2010) recommends a further process, referred to as considered selection: For the selection, designate three voting criteria. These can be chosen as the team or the project requires them, for example, according to their potential economic success or also more open, such as “the most likely to delight the user”. Up to three ideas are forwarded to prototyping. This way the innovation potential remains distinctly higher as if the majority of the team agrees solely on one idea.

5. Prototype (& Test)

The selected ideas are iteratively developed into tangible solutions, to test them with potential users. Constructing artefacts, the user can interact with, drastically improves the feedback, the team-intern understanding as well as the communication flow. (Plattner *et al.*, 2009, p. 123) Prototyping and Testing are deeply intertwined, therefore these two should be seen more like a tandem, not two different processes. The feedback from testing incites the next iteration, in which it is integrated into the new or improved prototype. This cycle continues until a solution is satisfying; Or discarded – especially in this phase a loopback to any point in the process is possible. (Stanford d.school, 2010, p.5)

A key element here is to prototype, test and iterate systematically – each prototype should test a certain variable and answer a particular question. It is important to determine what and how a variable is to be tested before creating or reworking the prototype; The scenario and the test execution should be carefully planned.

A prototype can be anything experienceable for the users – for instance, a role-playing activity, a storyboard or a gadget that the user can utilise to solve the beforehand identified problem scenario. Ideally, it should be tangible to maximise the user responses in form of emotions, actions and feedback.

The prototypes are adjusted to the progress of the process, starting with low-resolution and -cost prototypes, without committing too many resources and effort into one single solution. By doing so, the team can learn possibly fast from them and gets the chance to investigate

different possibilities. Along the prototype and test cycle, the prototypes are continuously improved. . (Stanford d.school, 2010, pp. 5-6)

Possible prototypes:

3D-Models (Scrap models out of paper, wool, glue, wood, straws etc.)

Drawings

Role-plays

Stories

6. Test

Testing refers to demonstrating solutions and prototypes to users and having them deal with it in the problem context. As already mentioned above, testing is an essential part of prototyping, iterating between these two is one of the key elements of DT. Testing brings novel feedback, which then, in turn, is integrated into the next iteration of the prototype. Through this continuous integration of feedback, testing incites and informs the next iterations.

Testing works best when the user intuitively uses and or misuses the prototype – it is very important to capture the reactions and to value the questions they might have. The prototypes should be created in a way that feels like an experience the user is reacting to, rather than an explanation that the user is evaluating. Furthermore, bringing more than just one prototype to test gives the users a basis for comparison – which has the potential to reveal latent needs and to find out what is appealing and what not. (Stanford d.school, 2010, p.6)

3.1.3 The 4D - Double Diamond model

A further, and the last to evaluate, important approach to DT is the Double Diamond design process model, developed by the UK Design Council in 2005.

It is specifically interesting because originally it was not developed as an approach to DT – this connection followed later. (Tschimmel, 2012, pp. 9–10) McCarthy (2017) utilizes the Double Diamond to describe DT – it unites different perspectives, tools and processes, which are typically utilized in design, into a method for identifying problems and iteratively developing solutions for those.

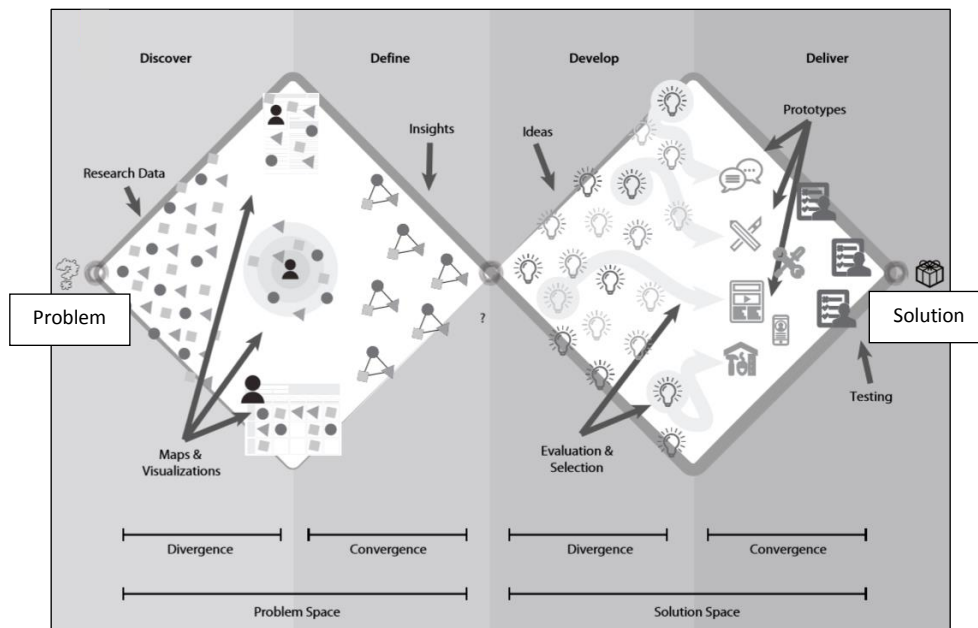


Figure 11: The Double Diamond in DT context (McCarthy, 2017)

The double diamond model is separated into problem and solution space – under the assumption that both these spaces require the same amount of time and resources. The diamond shapes can be attributed to divergent and convergent thinking, which are essential in creative processes and design. The combination of these two is represented by the diamond shape. In the double diamond model this process happens twice, first to confirm the problem definition and second to create the solution. To discover the best ideas, these processes are iterative – ideas are developed, tested and refined several times, with weak ideas dropped within the process. (Davies and Wilson, 2015; Design Council, 2015),

The four phases

The information which will be presented in the following was derived from different publications, as well as the homepage of the Design Council (Davies and Wilson, 2015; Design Council, 2015), scientific publications (Tschimmel, 2012) and management related press (McCarthy, 2017).

The starting point of the Double Diamond is represented by a problem, that users encounter when interacting with your product, or an opportunity, which can be described through a social trend, a new technology, new market opportunities, or simply a question. The possibilities to find and formulate a starting challenge are numerous.

1. Discover – insight into the problem:

The objective of this exploratory phase is to acquire a deep understanding of the problem, the end users and their behaviour, in order to find the right problem to solve or the right question to ask. As this model is ought to provide a valuable solution for their problem, it is vital to be empathic – “being the user” and experiencing the world, or the specific scenario, out of their perspective. (That way, it is desired to realize when, how and why users experience which problems.)

The before mentioned sources propose different methods for gathering information in this phase. They all agree that it is highly important to lay special focus on the customer, to understand his behaviour and needs. (Design Council, 2015)

Proposed methods and tools for Discover:

Observation (User diaries, user shadowing)

Interviews and discussions

Empathy (Empathy Maps, Customer Journey Maps)

Due to the risk of accumulating too much information, it is advisable to strictly limit the time and the number of topics in this phase.

2. Define

The objective of the define-phase is to find a clear definition of the problem that has to be addressed, and to formulate an according design-question.

The before collected information, as output of the discover-phase, is analysed and synthesised. By converging on key areas, clustering the information into themes the amount of information is reduced – now it is important to pick out the most important problems or opportunities, which, for instance, could be found through a systematic rating of the different topics. A customer journey map is an eminently helpful tool here. Basically, it is a flowchart, in which all the single steps, actions, tasks and contact points of the customers with the product or service are visually displayed. The delight and pain-points within the journey are to be marked, which facilitates finding the customers true motivation, wishes and frustration regarding the discussed topic.

The proposed techniques for this step are the before mentioned customer journey mapping (including the marking of delight and pain points), discussions in focus groups, using assessment criteria and clustering information, for example with sticky notes. It is noteworthy, that especially through the feedback, many more problems become obvious; So that the initial and predefined problem might not be as relevant as initially assumed, what partly leads to a loopback into the first phase – displaying the iterative character of the Double Diamond model.

However, at the end of this phase, which embodies the intersection between the two diamonds, a tangible statement of what has to be solved must be formulated. (Design Council, 2015; McCarthy, 2017)

3. Develop

After the problems are clearly defined, the project can shift into the third phase. As this is a divergent phase again, the objective is to generate many possible solutions. These design-led solutions are developed, tested and iteratively refined by multidisciplinary teams, using methods like brainstorming, sketching, role-playing and most importantly, prototyping. While brainstorming, evaluation of the ideas is strictly forbidden, and every idea is accepted.

Afterwards, every idea should at least briefly be discussed before being discarded. The remaining ideas can be further developed and rated. The criteria for the rating can be adjusted to the requirements of the project. McCarthy (2017) highlights, that the process should preferably be continued with a portfolio of ideas, not just one.

The next step is to transfer the ideas into functional prototypes and present them to users in the design-question context. Iteratively, feedback and reactions of the users have to be interpreted and integrated, to repeat the test with an improved prototype – until the solution is satisfying. Making the solutions tangible for the users represents a superior way of communication that eases the understanding for both parties. During the iterative process of prototyping and testing, it is important to thoroughly document the tests and every change to measure their impact. (Design Council, 2015)

Proposed methods and tools for Develop

Brainstorming

Sketching
Role-Playing
Prototyping

4. Deliver

As soon as the prototype reaches a satisfying level, it can be tested in the field – firstly, within a small area and only a few people, depending on the trend then in a larger scale, and finally, the project can be fully launched. The final customer feedback helps to evaluate the product in the field, as well as integrating last improvements if necessary. (Design Council, 2015)

3.2 Comparison of the different process models

As already discussed in the chapter before, the variety of interpretations of DT make it appear a rather difficult concept – this impression is carried on to the process models as well, at least on first sight. The visual representation of the discussed approaches is completely different for each of them – but through a more detailed investigation of the processes a rather similar scheme stands out. During the evaluation, it became apparent, that the beforehand assumed differences are by far not as significant as suggested by the differing representations.

Essentially, the three models all describe a rather equal process.

To begin, the team is supposed to understand the prerequisites of the problem, including the market, the technology and the perceived constraints. (1.) Following up, users are observed in real life situations, using a variety of ethnography techniques to develop empathy and get a feeling for their problems. After observation, the users are interviewed to review the problem from their perception and to clarify unsettled questions. (2.) The gathered information is reviewed and synthesised, and one or multiple points of view are created for reframing and determining actual problems. (3.) For the defined problems, many alternative ideas for solutions are created. (4.) The ideas are used to create diverse prototypes, which are iteratively tested. Feedback is gathered and used to modify and improve the prototypes with each iteration. This loop is systematically repeated until a solution is satisfying. (5.) Lastly, a business plan is set up, the prototype solutions are transferred into reality, field tested and then launched. (6.) (Note: The last phase is not task of the DT-team anymore, therefore it will not be part of the reference model.)

Furthermore, as stated in all the three descriptions: The phases are not occurring linearly, the project can move back and forth between different phases – Iterating is specifically emphasised in ideating, creating prototypes, testing and adapting prototypes.

The process description of the Hasso Plattner Institute represents this procedure quite well, and as it is the most detailed and structured approach, their six-phases model was utilized as a foundation for the reference model.

3.3 BPMN 2.0 – The selected modelling language

The Business Process Model and Notation 2.0 (BPMN 2.0) is the leading standard for visualisation of business processes. The BPMN initiative standardized various modelling languages, creating an easily understandable form of representation and communication. It is maintained by the Object Management Group (OMG) and has been defined as an international standard by the International Organization for Standardization (ISO) under the number ISO/IEC 19510:2013. (ISO/IEC, 2013)

In BPMN 2.0, business processes are described in the form of a process diagram, with a chronological sequence of events, decisions and tasks. BPMN is utilized within a variety of companies, to map processes and facilitate communication and cooperation internally and externally. (Object Management Group, 2011, p. 21; Schlauderer and Overhage, 2017)

Due to the wide applicability and commonness, the BPMN 2.0 standard was chosen for the creation of the reference model. In the following section the utilized elements, as well as own adaptations are briefly explained. The utilized software for modelling is ARIS Express. (<https://www.ariscommunity.com/>) In the following, all of the utilized elements are depicted and explained.
















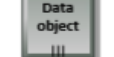


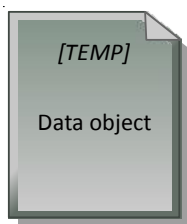
	Start event	Unspecified event, marks the start of a process.
	Conditional start event	When the specified condition is fulfilled, the process is started.
	Intermediate timer event	Sets a time frame for the following process.
	End event	Unspecified event, marks the end of a process.
	Compensation end event	Marks end of the process instance and the looping back to a certain other process, determined by the conditions.
	Task	A task is a work unit, the job to be performed. Due to the variability in this process model, only tasks without a specified task type will be utilized.
	Collapsed task	A collapsed task is indicated by the + Symbol on the bottom of the task. These tasks are utilized, if further explanation is necessary or if the task is too complex to display it all at once. This enables the model to vary between different levels of detail.
	Call activity	A call activity represents a globally defined task, which can be utilized within different parts of the model.
	Exclusive gateway	Exclusive gateways indicate a decision – the flow follows the one branch that fulfils the conditions. When merging, it awaits one incoming branch to complete before triggering the outgoing flow.
	Inclusive gateway	Depending on the conditions on or more branches are activated. All active incoming branches must complete before merging again.
	Parallel gateway	When splitting the sequence flow, all outgoing branches are activated simultaneously. When merging parallel branches, it waits for all incoming branches before triggering the outgoing flow.
	Complex gateway	Utilized when the splitting and merging behaviour is so special or complex, that the other gateways are not sufficient for describing it.
	Data object	Depending on the arrow direction, the data object is representing In- or Output of the tasks. Furthermore, in this process model, data objects are also used to represent physical output.
	Data collection	A collection data object represents multiple data objects or a collection of information.
	Data store	A place where the process can read or write data. It persists beyond the lifetime of the process instance.
	Sequence flow	The sequence flow connects processes, start and end events.
	Process In- and Output	Describes the in- or output of a process, depending on the direction.
	Annotations	Connects annotations with further information to different parts of the model.

Figure 12: Utilized BPMN elements (Elements from Aris Express)

3.3.1.1 New declarations for the reference model

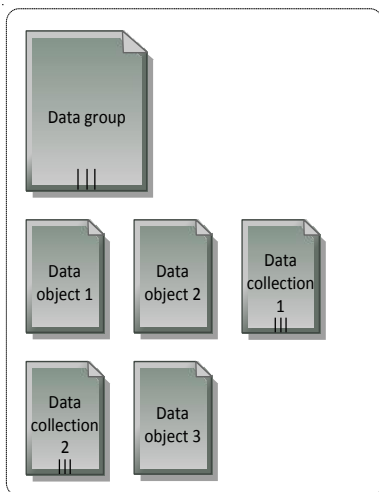
Design Thinking has the peculiarity of producing high quantities of physical output. The physical output is displayed by the data objects and specified by the title; or if necessary further annotations.

An inconvenient issue with the physical output in DT is, that a major part of it is destroyed or changed throughout the process. (F.e.: accumulations of Post-Its) To indicate that an object is (probably) not going to remain in its current form throughout the rest of the process, a *[TEMP]* stamp (for temporary) is placed below the top border.



Temporary artefacts:

The *[TEMP]* stamp marks the object as a temporary artefact. The information, that these artefacts contain, might be of importance at a later point of time again. Therefore, after completion, the temporary artefacts trigger a call-activity which is supposed to save the information in form of a photo-document. (See 4.3.4 Save and Store)



Data group:

The data group includes all the other elements (objects and collections) that are displayed beneath it at once. If the whole content of the data group is required in another process, the data group alone is displayed as input, which describes that all the elements in the group are utilized as input. (For an example, see output of 4.2 and input of 4.3)

The objective is to reduce the amount of single in- and outputs and their corresponding arrows, as well as an improved overview.

Layers: The process model is displayed on different levels, the layers. The first layer represents the top-level six-phases process. In the second layer, each of the six phases is explained in an own process model. The third layer functions equally, processes within the second layer that require further explanation are displayed in own process models. The layers are displayed in each model at the right bottom corner.



4 The Design Thinking reference model

As concluded in the former summary, it is reasonable to break the Design Thinking process down to six phases – equally as the HPI-process model, which is utilized for the ground structure. Underlying to the application of the process are, as outlined in the descriptive framework, the inclusion of the five principals and the adherence to them. Furthermore, the fitting people have been selected before – and a suitable project space, fulfilling the described requirements, is provided – to put it brief: the conditions, as described by the regulatory framework, need to be fulfilled.

As the already existing models revealed, a DT-project can be initialized for a variety of objectives. The application scenarios are numerous, although, the majority of the processual descriptions in the literature refer their models to the creation of innovative products and services or the improvement of such. Therefore, this process model is also oriented towards the creation of innovative products or services as solutions, and optionally the improvement of existing ones. As this still leaves room for many variations, the process description is kept rather generic. In case a different procedure is advised for a specific type of project, it will be described at gateways, through annotations in the model or explanations within the text.

Strategic overview of the DT-process

On the top level, the whole six-step DT-process is displayed.

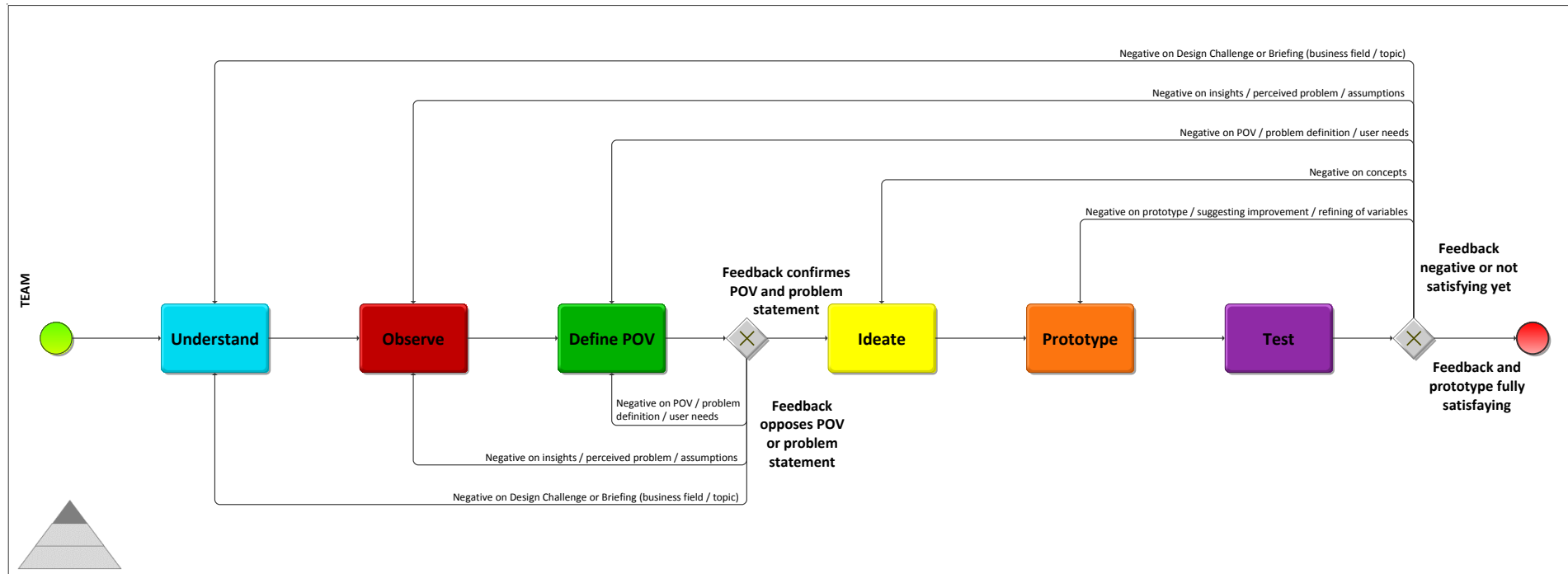


Figure 13: Top-level Design Thinking process

(Based on the Hasso Plattner Institute (2019) and Thoring and Mueller (2011))

In this process model, the iterations only occur after receiving feedback, which is scheduled within the third and the sixth phase. It should be noted here, that iterations can theoretically happen at any point of time within the process. To remain a clear overview the iterations were placed at the two key points, where they usually are to be expected.

In the following, each of the six processes (and their subprocesses) is explained in detail.

4.1 Understand

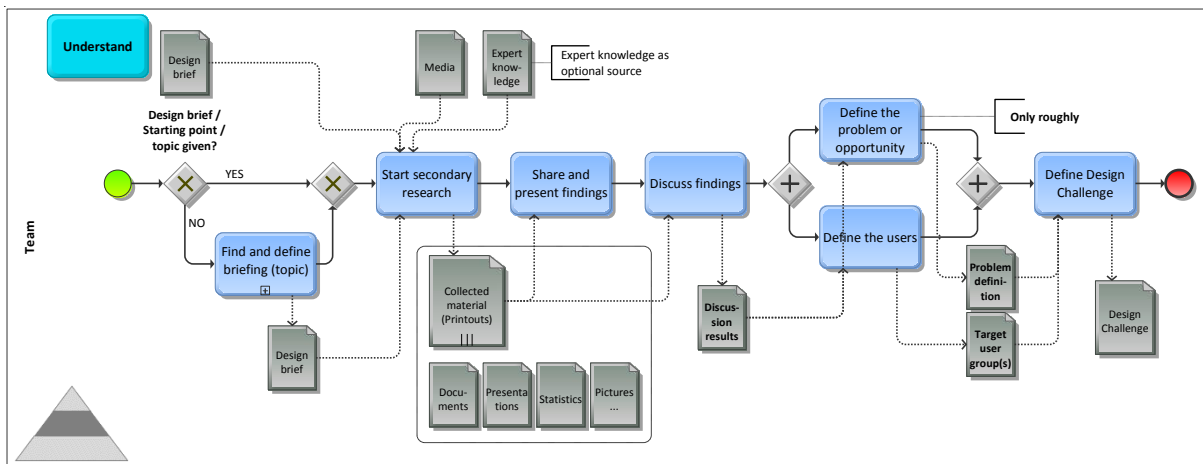


Figure 14: 1. Understand

The starting point is represented through the Design Brief. Throughout the literature, it is rather undefined what exactly initiates a DT-project. Possible contents for the Design brief might be: (Brown, 2008, pp.88-89; UK Design Council, 2015; Plattner *et al.*, 2009, p. 115)

- A rough description of the topic, with the problem or opportunity yet to be found (f.e.: a business field or a market segment)
- A problem that users encounter when interacting with your product/service or the direct task of improving an existing product or service
- An opportunity, described through a social trend, new technologies or market opportunities
- An analytical question without any indication on the solution (f.e.: How can we improve the experience of concert visitors?)
- A description of a problem or problematic situation (f.e.: drivers looking at their phones)

In general, the Design brief simply is ought to provide something to engage on. Depending on the company and its business field it can totally deviate. In case there is no clear starting point, this model offers a resolution – the DT-team creates its own Design Brief. (Schallmo, 2017, pp. 61–65)

4.1.1 Find and define briefing

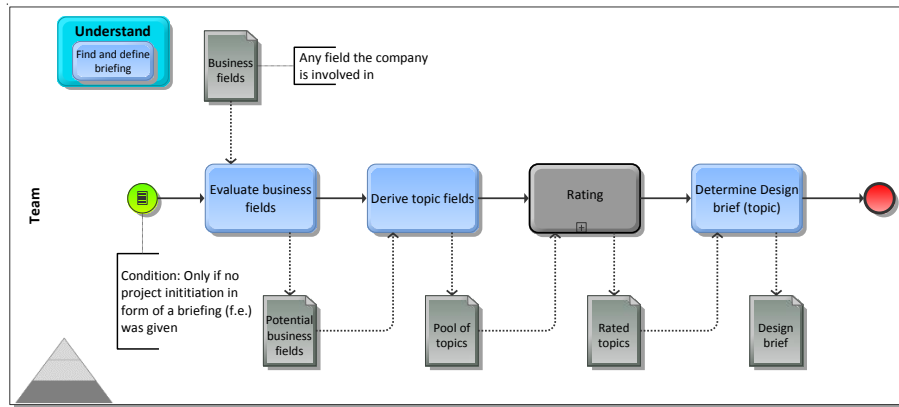


Figure 15: 1.1 Find and define briefing

This subprocess is only necessary if no Design brief as project initiation was given. In short, the team evaluates the different business fields of the company, derives possible topics and compares them. The one with the highest potential (Decided through democratic voting, see 4.1.1.1 below) will be defined as the Design Brief.

4.1.1.1 Rating

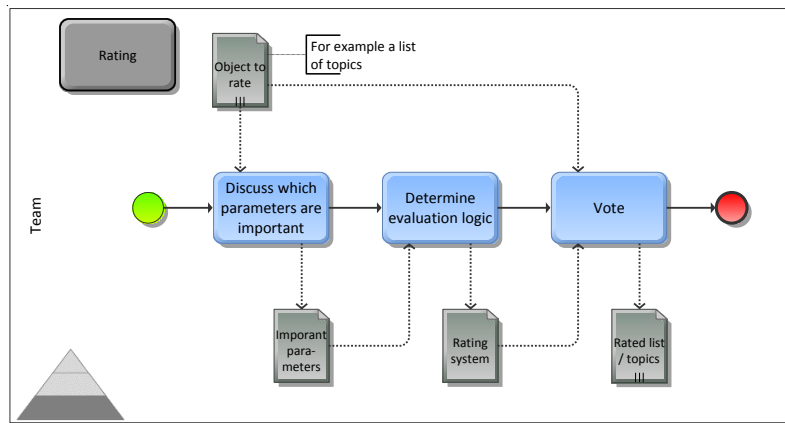


Figure 16: 1.1.1 Rating

The input of rating is a list, for instance of different business fields, topics or ideas. The team collaboratively decides which parameters regarding the objects to rate are important. These are evolved into an evaluation system, weighing the different parameters according to their importance – the team is free to determine this logic however they prefer. Lastly, the team votes and each object on the list receives a score. Rating is defined as a Call-Activity, it will appear at other points again in the model, without explanation then.

As soon as the briefing is provided, each team member starts with collecting general information (from various sources, internal and external) and conducting research on the topic for him/herself. Optional, expert knowledge can be consulted. The findings are shared

and discussed with the other team members – with the intention to establish a problem or an opportunity and the social reality to it. Furthermore, the target group and the users are identified, as accurate as possible. At this moment, the problem or the opportunity is only defined broadly; Throughout the first half of the DT-process, it will become more and more exact. (Hilbrecht and Kempkens, p. 356)

Out of the collected material, the defined problems/opportunities and the target group a Design Challenge is to be formulated. The Design Challenge might contain wishes for not existing solutions, and complaints with existing solutions or experiences. The key question which the Design Challenge should answer is: How can we improve [WHAT] for [WHOM]? (For instance: How can we improve the training experience at the gym for elderly people?)

Note: The Design brief can already be very similar to the Design Challenge – the main goal of the understand phase is, that the team achieves a common understanding of the problem/opportunity.

Goal of “Understand”	Input	Output
Establish the problem, collect information and achieve a common understanding of it and define the people who are concerned by it	Design brief Media Expert knowledge	Collected material (printout) Design Challenge
Further sources: (Gürtler and Meyer, 2013, pp. 26–27; Thoring and Mueller, 2011, pp. 3–4; Plattner <i>et al.</i> , 2009, pp. 115–117)		

4.2 Observe

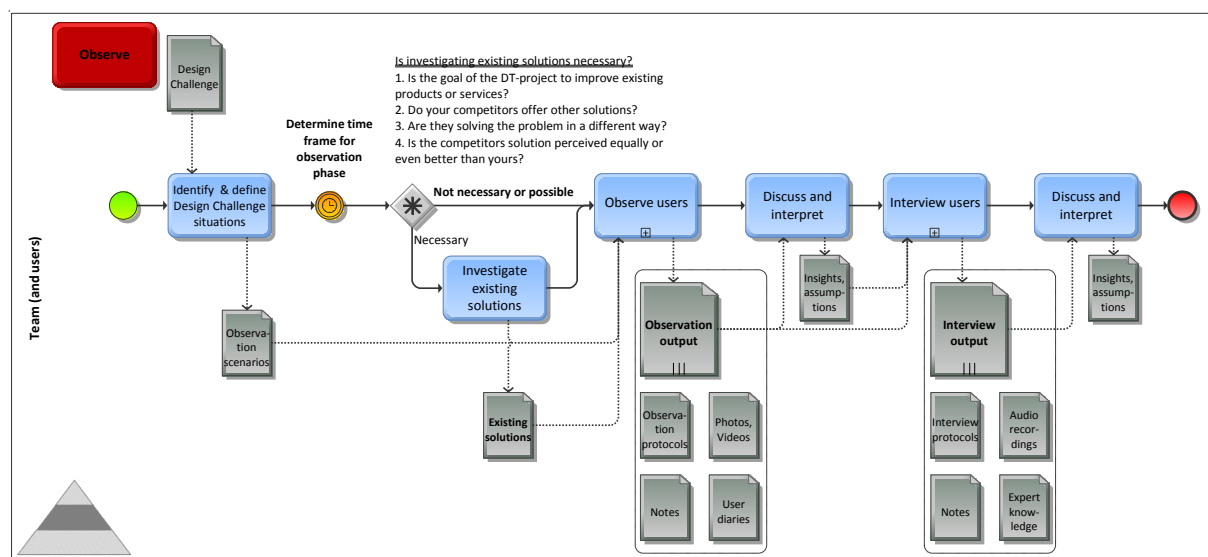


Figure 17: 2. Observe

Out of the Design Challenge, the team identifies potential Design Challenge situations – referring to situations where the best observation results in the problem or opportunity context might be made. “Observe” is mostly a divergent phase, great amounts of data are gathered – to stay focussed and avoid spending too much time, the time frame for this phase is limited.

Before starting with the observation, it is questioned whether investigating existing solutions makes sense. This decision depends on a variety of factors, especially the type and goal of the DT-project. In general, if the goal of the project is already settled – to improve an existing product or service, investigating whether there are similar solutions (by competitors) is obligatory. Especially if these solutions are perceived as equal or better than the own solution. Consequently, the observation needs to be focussed on observing users utilizing the product in whichever context it was originally designed – in line with an adjustment of the interviews. (Schallmo, 2017, pp. 73-76)

Nonetheless, in DT-projects, it is often the case, that the exact problem or opportunity is yet to be determined – meaning that the problem/opportunity the solution will ultimately be designed for is not found yet. The observation reveals current workarounds and pain-points, which are addressed in the second half of the DT-process. (McCarthy, 2017, pp. 86-87)

4.2.1 Observe users

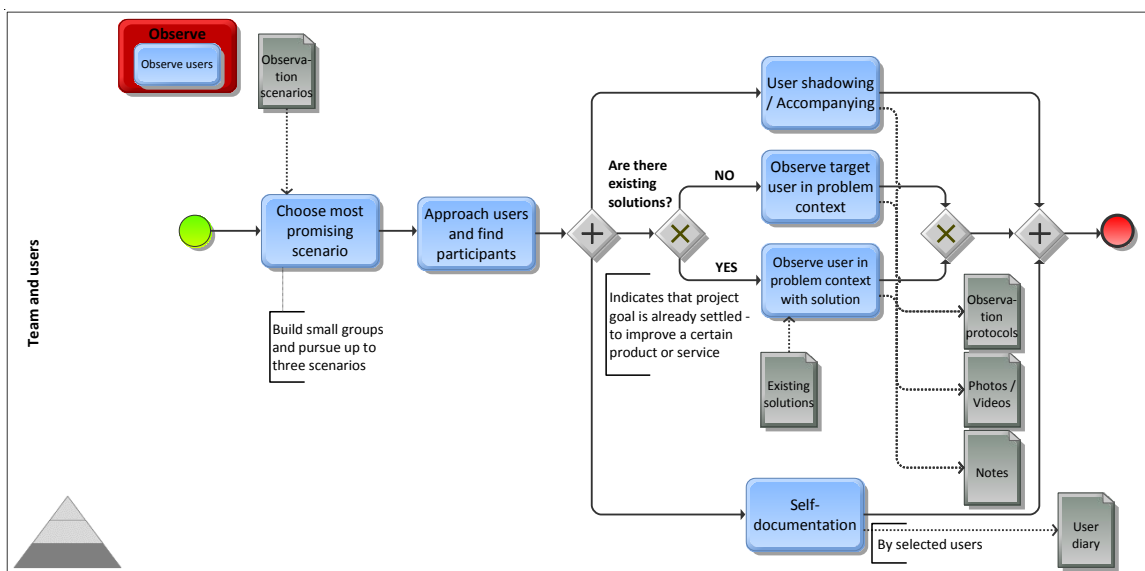


Figure 18: 2.1 Observe users

Potentially, each of the identified situations could be pursued – often it is only one specific situation. Due to limitations in time and resources, it is adequate to utilize the most promising

ones – also, it is questionable whether the difference between the scenarios is so high that an actual different result could be expected. Best practice is building small groups, each responsible for a specific situation to observe. (The groups can also observe the same situation, just with different users.)

Before starting the observation, users should be approached and asked for their participation. This does not only facilitate observation but also interviewing and communication.

Observing users in the problem context is best conducted through user shadowing. User shadowing refers to accompanying the user throughout the whole design challenge situation. Everything that is observed is documented in an observation protocol, and if possible, also on video and photographs. In case the project is ought to improve an existing solution, the users are observed while interacting with and using the different existing solutions.

An observation protocol should have the following form: (On basis of (Stanford d.school, 2019, p. 7)

Date/time:	Place:	Observer:
Activity of the user:	Description of the activity:	Description of the user's motivation:
Which activity does the user perform?	How does the user perform the activity?	Why does the user conduct this activity? Why in this way? (→ Own assumptions)
Activity 1	...	...
Activity 2		
...		

Afterwards, the observation protocol can be complemented with pictures and videos for each activity. Furthermore, participating users should write a user diary. Basically, it is an observation protocol based on the problem context, written by themselves. Through the description of their own perception, a better understanding of the connection between motivation and action is available. In the next step, the team interprets and discusses their observations. First insights and assumptions are drawn.

4.2.2 Interview users

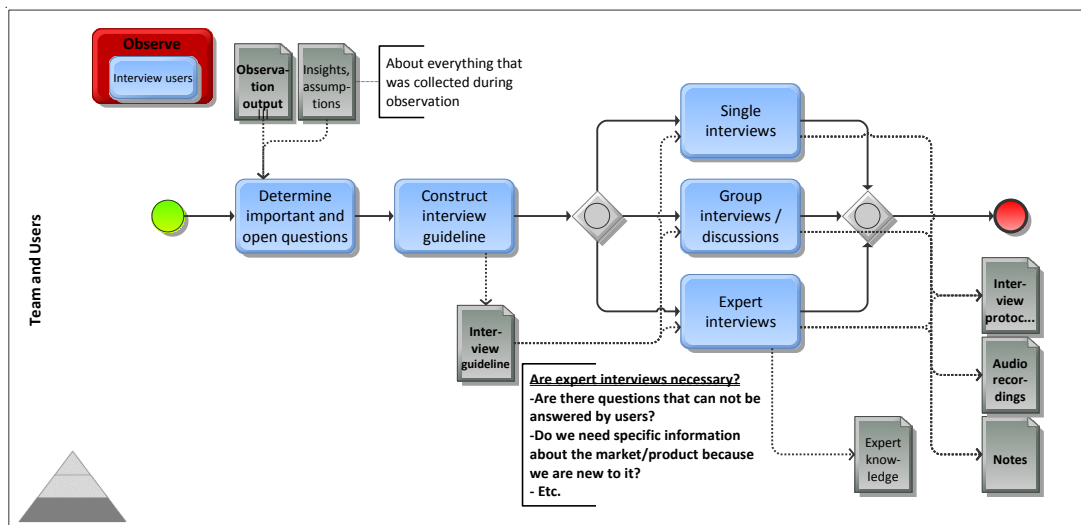


Figure 19: 2.2 Interview users

Based on the complemented observation protocol and the interpretations, the team determines which questions are to be answered, as well as which assumption they want to have confirmed or disconfirmed. An interview guideline, which should be constructed before starting the interviews, ensures that the right questions (or groups of questions) are asked in a rationally structured order. In DT, an interview should rather feel like a conversation, not a questionnaire, therefore take time and let the people build stories.

Interviews can be held with single users or in groups, or both. Optionally, experts can be consulted. To make the most of the interviews, Curedale (2013, p. 128) and the (Stanford d.school, 2019, p. 10) give a list of recommendations for interviewing users:

- Question every action with a “Why?”, to get a deeper understanding.
- Directly ask for specific situations, don’t use “usually” when asking a question. (F.e.: “Tell me about the last time you [situation/activity] ...?”)
- Confront the users with your observations and compare the “foreign perception” with their own. (Inconsistencies between saying and doing – interesting insights)
- Ask for the user’s experiences, their opinion, their feelings and thoughts.
- Pay attention to non-verbal communication. (Body language, facial expressions)
- Permit breaks, reflection is very important in these interviews.
- Ask neutral and non-suggestive questions.
- Avoid binary questions. (Questions that can be answered with one word)
- Don’t ask too complex questions, make them short and concise.

The whole interview is to be documented in an interview protocol. To secure that nothing is missed, it should be at least two interviewers. Furthermore, if the interviewees consent, a video or an audio recording should be made.

An interview protocol should have the following form: (On basis Schallmo, 2017, p.72)

Date/time:	Place:	Observer:
General questions (To start the interview)	Comprehensive questions (To understand the user's wishes, complaints and motivation)	Specific questions (To build a deep understanding of the user)
<i>For example:</i>		
What's your name? How old are you? ...	What do you like about [situation/activity] ...? Why?	What was your best experience with [situation/activity] ...? Why?
Answer 1	Answer 2	Answer 3
How often do you [situation/activity] ...?	What do you miss in [situation/activity]? Why?	How would you describe your ideal [situation/activity] ...? Why?
Answer 1.1	...	...
...

Aside from these standard questions, questions concerning the observations and derived assumptions are also to be integrated into the protocol and asked.

To conclude the Observe-phase the results are discussed and interpreted again, adding further insights and confirmed assumptions.

Goal of "Observe"	Input	Output
Collect information about the user; Develop an understanding for the situation and the users (including their actions, emotions and feelings)	Design Challenge	Observation and Interview protocols, videos, photographs, audio recordings, notes etc.
Further sources: (Schallmo, 2017, p. 73; Stanford d.school, 2010, p. 2, 2019, pp. 9–11)		

4.3 Define Point of View

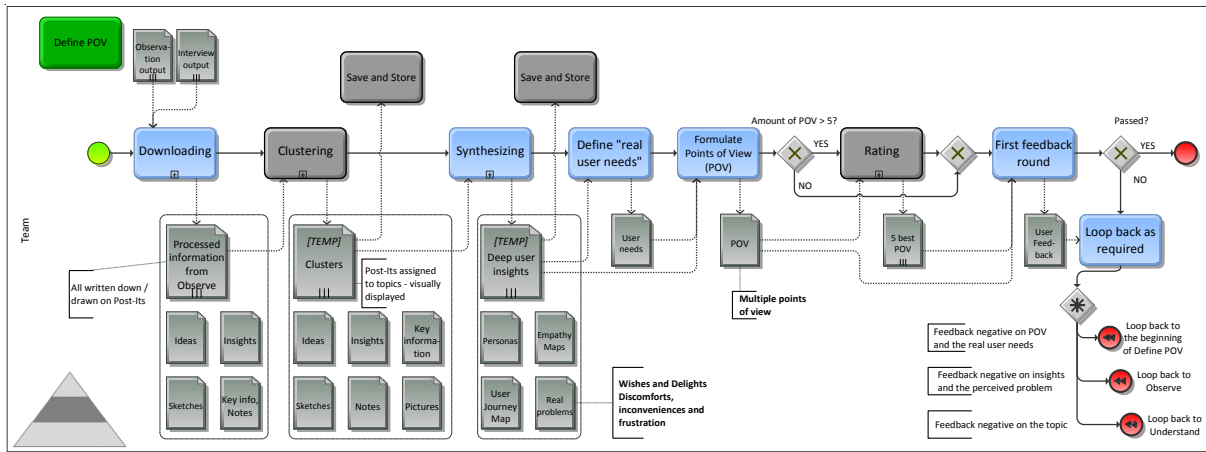


Figure 20: 3. Define POV

The Define POV phase directly devotes itself to all the output of observation and interviewing.

4.3.1 Downloading

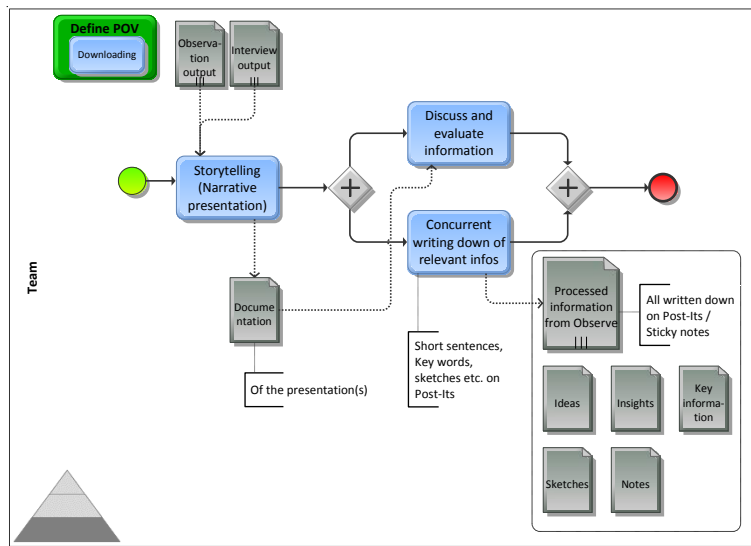


Figure 21: 3.1 Downloading

To begin, each separate group from the former phase (observing different situations or scenarios) narratively presents all their derived information and results. It allows the team to catch up; even if all team members were working in the same fieldwork, their experiences probably differ and provide different insights. Each content of the presentations is briefly evaluated and discussed within the team. While doing so, each team member is supposed to take notes on Post-Its and write down everything that appears relevant in his/her opinion. Short sentences, keywords or sketches which concisely sum up important information, assumptions and insights are exactly what is required for the following steps. After downloading, a large number of Post-Its should have been created. These represent the (for

this moment unorganized) pool of group knowledge to inform the further steps. (Stanford d.school, 2019, p. 13)

4.3.2 Clustering

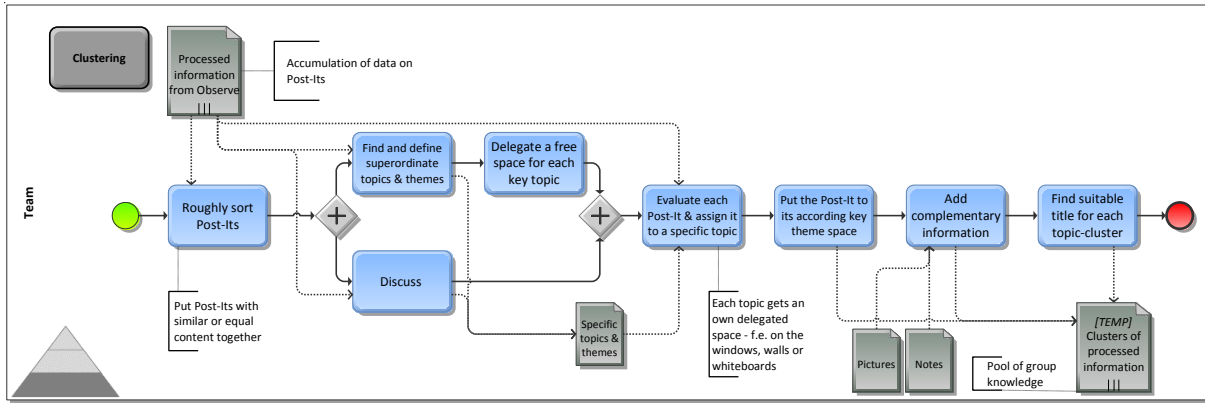


Figure 22: 3.2 Clustering

The Post-Its are now supposed to be sorted into groups. Each of the groups should represent a specific topic. Through rough sorting and further discussion, topics and superordinate key themes are identified. For each of the topics, a specific area within the project room is delegated. In DT, all vertical planes can be used as areas for visual representation – for instance windows, walls or whiteboards. Clustering is defined as Call-activity.

The Post-Its are one by one assigned to a topic. After all Post-Its are organized, each of the topics/key themes is titled – the title should precisely sum up the whole topic. These organized topics are called “clusters”. Beneath, a schematic arrangement of the topics and Post-Its is displayed. The different colours could, for instance, represent the different team members – or already a logic for structuring, the team is free to use them however they prefer. (Stanford d.school, 2019, p. 14)

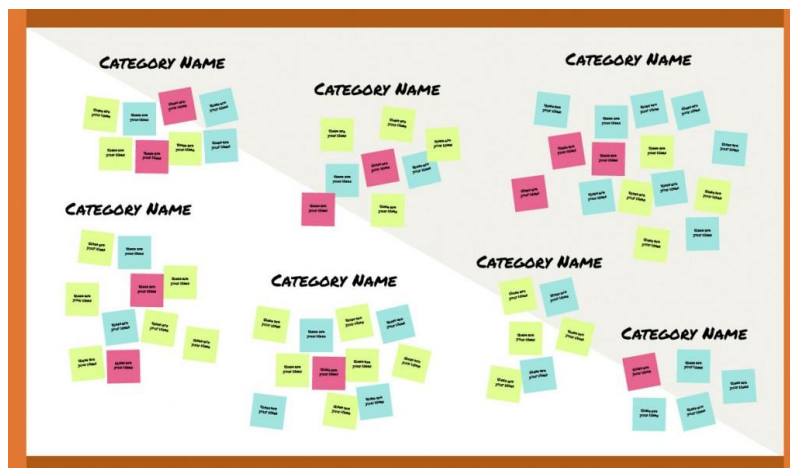


Figure 23: Exemplary organized clusters [<https://imagebox.com/design/human-centered-design-a-powerful-tool-for-brainstorming/> accessed 05.04.2019]

These clusters can now be complemented with pictures, drawings and further data. By now, the team has created an organized pool of group knowledge. As the clusters are only existing for a temporary time (temporary artefact), they must be photographed and systematically stored in the data storage. Clustering is a Call-activity because the same procedure is required later for the brainstorming output again.

The picture below exemplarily shows how complemented clusters could look like.



Figure 24: Exemplary complemented clusters [https://thedarkhorse.shop/products/design-thinking-workshop-class-28-03-29-03-2019 accessed 05.04.2019]

4.3.3 Synthesizing

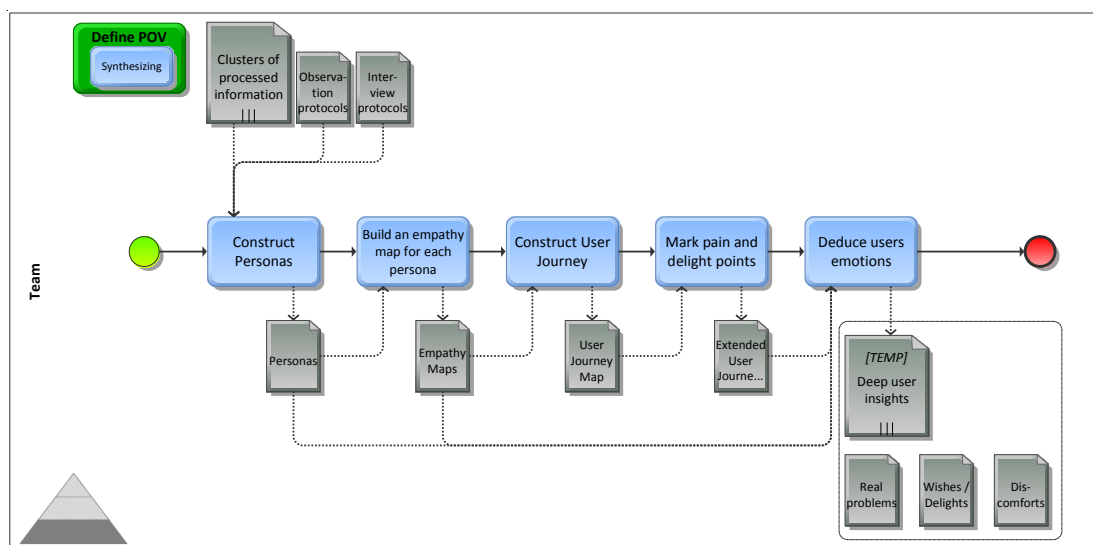


Figure 25: 3.3 Synthesizing

In synthesizing, the user as a human is integrated into the gathered and assessed information – the objective is to extract meaningful patterns and insights from the “raw material”. (Brown,

2009, pp. 42-43) Through building detailed user profiles, comprehensive and as close to reality as possible, the real user needs are derived. These reveal actual issues to resolve, the POV. (Point(s) of View)

Personas: To begin, the team describes at least two personas. Personas are fictive persons, which represent a specific part of the users. A persona is described by a full name, a visualization (picture) as well as features such as age, profession, living situation etc. – to make it appear possibly realistic.

Personification (exemplary, on basis of (Plattner *et al.*, 2009, p. 167; Stanford d.school, 2019, p. 17)

Name	Alex Jeffords
Age	26
Sex	Male
Profession	Student
Hobbies	Sport, Music, Programming, ...
Living situation	Flat in the city centre, basic furniture, ...
Family	Single, parents living in the countryside, ...

In the next step, the persona is complemented with emotional content – a list of questions which might be used to emotionalize the persona (Curedale, 2013, p.224):

Seeing?	What does the user see and how does he perceive his environment?
Hearing?	What does the user hear from his surroundings?
Thinking?	What does the user think, what bothers him?
Saying?	What does the user talk about, and how does he behave in the public?
Worries?	What concerns the user? What are his biggest barriers/fears/problems?
Delights?	What makes the user happy? What does he want to achieve? What motivates him/her?
Job to be done?	Which problem does he have? Which needs do these problems create? Which task does the user have to complete (because of the problem)? What solution would be important for him?

Concrete needs, desires, emotions and opinions in the direct problem context are derived from the clusters, observation and interview material.

Regarding the list of questions and characteristics, not the full spectrum needs to be answered to advance – it can be adjusted to the needs of the project and the team. (Schallmo, 2017, p.84)

Empathy Maps: An empathy map is used to visualize the personification and emotionalization of the persona. It helps to further deepen the understanding and empathy towards the user.

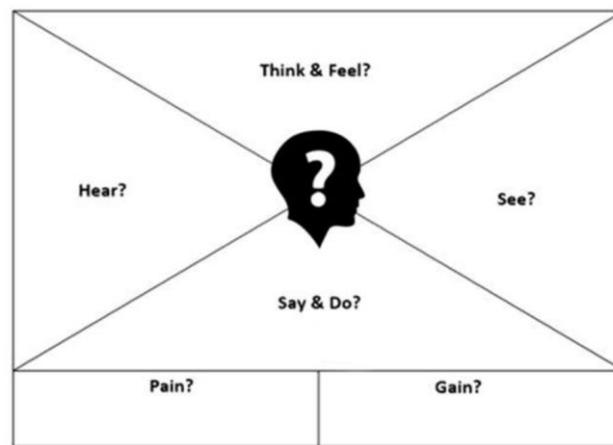


Figure 26: Empathy Map (Chung and Kong, 2016, p.20)

An empathy map depicts all four channels of perception – referring to the problem situation and the frame around it. Within the pain and the gain field, all negative and positive aspects regarding the problem context (experienced within and related to it) are written down: (Stanford d.school, 2019, p. 15)

Pain (=Worries)	Gain (=Delights)
Worries	Pleasure
Frustration points	Joy
Barriers to reaching specific goals	Goals
Fears	Wishes
Problems	Motivation

User Journey Map: In essence, a user journey map is an illustrated timeline of all activities, contact points, behaviour and emotions resulting from the user experience within and around the problem context – the user journey map is created from the user’s point of view. (McCarthy, 2017, p.88) It is a further method to visualize the user in the context of the Design Challenge. User journey maps can be extremely detailed – depending on the project, the team needs to discuss which variables, and which frame the journey map is supposed to cover. The journey maps can be created from observation and interview material, or directly by a user. (Stanford d.school, 2019, p. 16)

Within the journey, the pain and delight points are marked. Pain points mark specifically negative experiences within the situation or with the product/service; the delight points, the

positive ones. Again, the journey map is to be complemented with Post-Its and pictures. (Design Council, 2015)

User needs: The empathy map and the user journey map are the foundation for revealing pain points and problems, therefrom the concrete user needs are derived. All the work beforehand, ensures that the user needs are based on actual problems and desires of the users. The user needs are divided into different categories, depending on the problem/opportunity, the following can be answered up to a certain degree. (Schallmo, 2017, p.88)

Functions: Which functions does the user expect and want from the solution?

Requirements: What does the user require from the solution?

Experiences: Which experiences does the user want to make with the solution?

Point of View (POV): Together with the user needs, multiple POV (points of view) are formulated. A POV explicitly describes a specific problem (pain-point) from the view of the user and what he/she would expect from a solution to resolve or eliminate the problem. It is an actionable and guiding problem statement, that focusses on specific users, their needs and the insights that have been uncovered until now.

A good POV needs to fulfil the following criteria: (Stanford d.school, 2010, p. 3)

1. Clear focus and Problem frame
2. Inspires the team
3. Informs criteria for the evaluation of competing ideas and empowers decision making
4. Inherits the real user needs
5. Concrete and not broad (Prevents the team from trying to develop solution concepts “that are all things to all people”) (Stanford d.school, 2019)

First Feedback round: Lastly, the POVs are presented to various users (it should not just count for a few) – and checked whether they can relate with it. Depending on the feedback, the process can either continue and forward to the next phase, or the team needs to iterate. To which process they have to loop back is depending on the feedback – and should be clarified and discussed within the team. When looping back, it is essential to stay optimistic and

energetic – the loopback does not mean failure, it symbolizes learning. (Thoring and Mueller, 2011, p. 6)

Goal of “Define POV”	Input	Output
Develop a deep understanding for the user and the problem; Define actionable problem statements: the POVs	Summarized results from Observe	Personas, Empathy Maps, User Journey Maps, User needs and POV
Further sources: (Plattner <i>et al.</i> , 2009, pp. 120–122)		

4.3.4 Save and Store

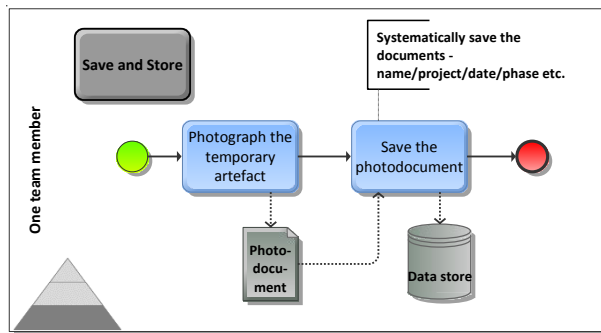


Figure 27: 3.4 Save and Store

Most of the physical output in the Define POV phase is destroyed by further progress of the project, therefore all of it needs to be saved in the form of photographs, which are systematically stored.

4.4 Ideate

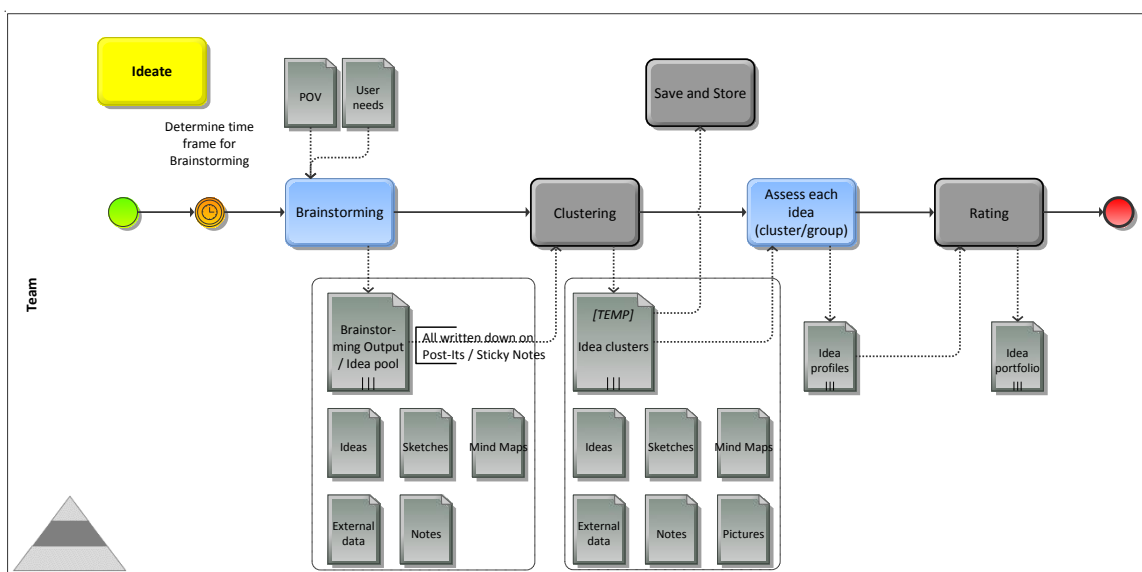


Figure 28: 4. Ideate

The ideate phase represents the transition from identifying problems into exploring solutions. It is meant to generate a large quantity of alternative solutions for the problems that have been discovered, researched and defined within the first half of the DT-process. As ideation is a divergent process, this phase is time limited.

4.4.1 Brainstorming

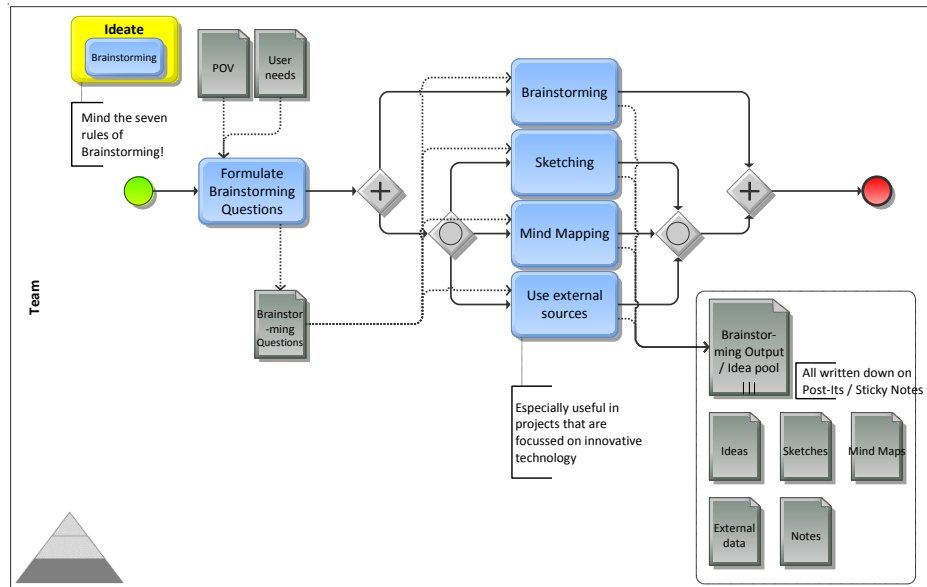


Figure 29: 4.1 Brainstorming

Before beginning with the creation of ideas, the POVs and the user needs are reviewed, to determine what actually is required from a potential solution. This step is not always necessary, usually, the POVs and user needs are descriptive enough – it is just a suggestion that supports the focus on the right content.

For the creative creation of ideas, various techniques besides and within brainstorming might be used. Including external sources, such as patent databanks, market research data or publications by universities are viable options as well, especially in DT-projects that are focussed on creating innovative technologies.

During brainstorming (or one of the other techniques) ideas are captured in written or graphical (sketches, drawings) form on Post-Its. IDEO (<http://www.designkit.org/methods/28>) and the (Stanford d.school, 2019, p. 28) describe seven rules, essential for successful brainstorming.

Rules for brainstorming:

1. Defer judgement – Good ideas can emerge from anything.

2. Encourage wild ideas – Don't focus on constraints of materials and technology, wild ideas often bring creative leaps.
3. Build on the ideas of others – In conversation, use “and” instead of “but”.
4. Stay focussed on the topic – Avoid diverging beyond your scope.
5. Have one conversation at a time – Building on ideas works far better if everyone pays full attention.
6. Be visual – Drawing, sketching and writing on Post-Its.
7. Go for quantity – Aim for as many ideas as possible.

Ideas can be discussed and further developed while brainstorming – creating even more Post-Its belonging to the idea. However, it should be considered that the ideas are assessed after brainstorming as well, and the emphasis is supposed to be on volume and variety during brainstorming. (Stanford d.school, 2010, p. 4) Be aware of when you generate ideas and when you evaluate ideas – only mix these two intentionally. This phase fully uncovers the strength of the diverse background and multiple perspectives of a multidisciplinary team.

After the brainstorming (including the other utilized techniques), the ideas are supposed to be clustered and displayed on free spaces again. The effort for grouping the ideas into different topics is considerably lower as in the Define POV phase, as great parts of the output are already assigned to specific ideas during the brainstorming. Still, some of the ideas might be similar or not connected to any of the other topics, thus the clustering process is still included.

4.4.2 Assess each idea

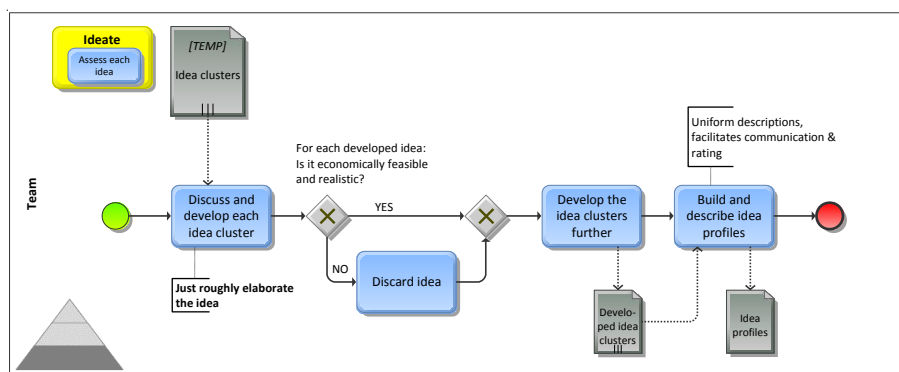


Figure 30: 4.2 Assess each idea

Each idea or idea topic is to be assessed: Through further development of the idea and discussion more information or details are added – in the form of Post-Its, drawings or pictures. The assessment also includes sorting out ideas. Although DT is encouraging “wild and creative” ideas, ideas that are simply not possible to realize, not feasible in economical means

nor suitable for the solution, need to be discarded. In this regard, there might be space for interpretations, therefore the team members should consent on the removal of ideas.

Idea profile: Every idea/idea group that remains after assessing is to be described in a uniform way – the idea profile (Based on Liedtka and Ogilvie, 2011, p.209). The idea profile facilitates rating the ideas, as well as communicating them.

An idea profile should contain:

1. The title of the idea
2. Which need does the idea fulfil? Which problem does the idea solve?
3. Vague description of what the implemented idea might look like (or more precisely if already known)
4. Potential issues
5. How does this idea create a competitive advantage?

After uniformly describing the ideas, the ideas are supposed to be rated. Three voting criteria should be designated – these can be chosen however required and wanted by the team. For instance, “Most likely to delight user” is as legit as potential economic success in DT. (Stanford d.school, 2010, p. 4) Up to five ideas are forwarded to Prototyping. Through utilizing a portfolio instead of just the single best idea, the innovation potential remains higher and uncertainties can be secured.

Goal of “Ideate”	Input	Output
Generate many alternative ideas for the identified problems; Select the best ideas to forward them to prototyping	POV User needs	Idea clusters Idea portfolio

4.5 Prototype and Test

Prototyping and testing are considered deeply intertwined processes, therefore they are displayed together. The prototypes are always adjusted to the progress of the project, in the early exploration the prototypes are only rough, low-resolution prototypes to test the functionality and acceptance of an idea. This enables quick learning and the investigation of various possibilities. “Fail often and fail cheaply.” - to stay at a low-resolution early on in this phase allows to pursue many ideas and to learn from them without committing to early into a specific direction.

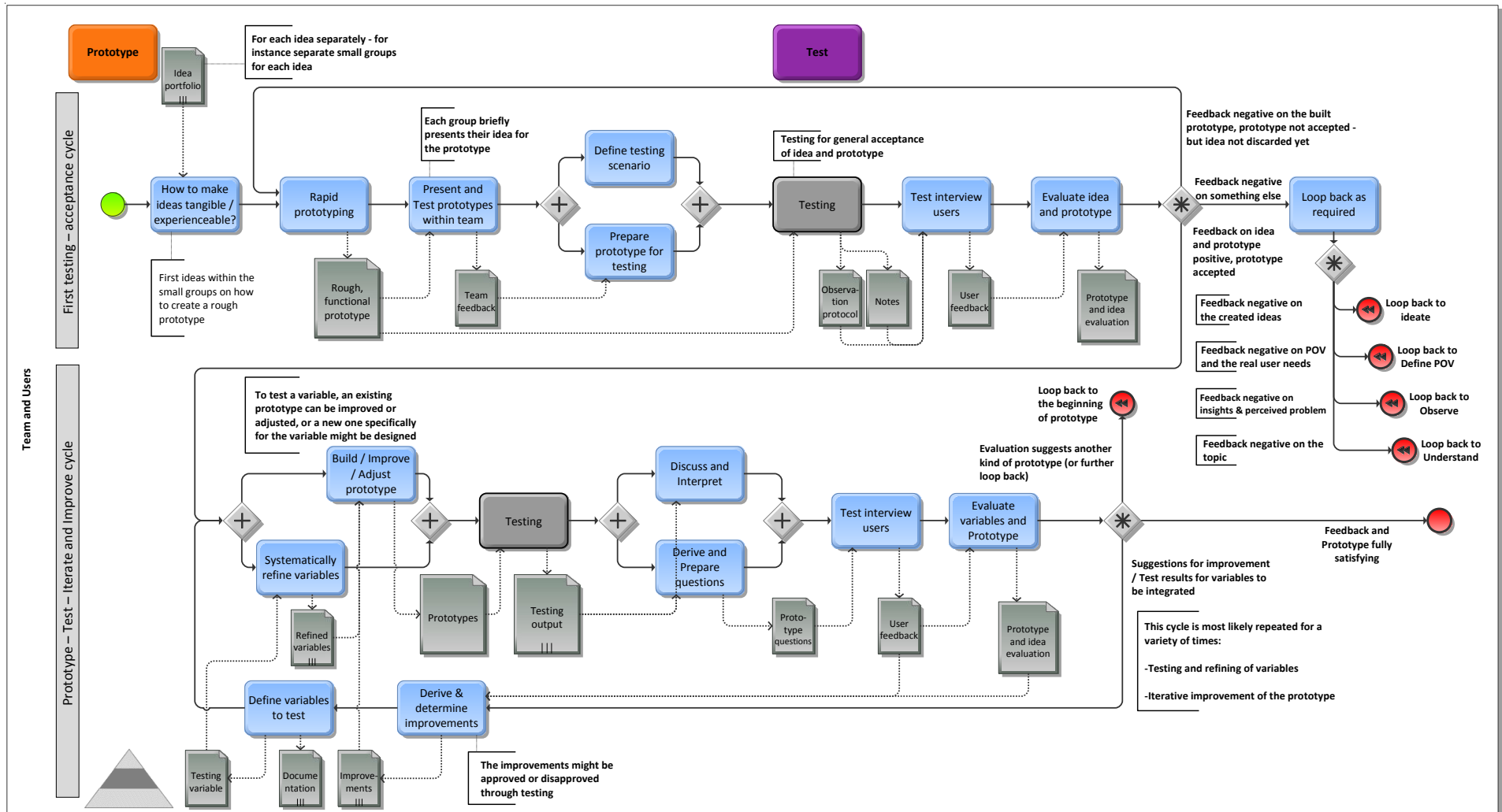


Figure 31: 5. Prototype and Test

First testing – Acceptance cycle:

The first cycle is supposed to test whether an idea and the according prototype (although the prototype is of secondary importance here) have potential and head towards the right direction.

To begin, the team splits up into smaller groups, which are all dedicated to one specific idea – or divided sections of a larger idea. (Schallmo, 2017, p.103-105) The team can split the ideas up however they prefer (for instance: each small group builds a different type of prototype). As an introduction, each group recapitulates their assigned (or chosen) idea and determines how it possibly could be made tangible and or experienceable. Provided with the DT-material (see chapter 2.4.4), the groups build one (or more) rough prototypes, with focus on explanatory design – meaning that the prototype communicates the idea concept in an understandable and relatable form.

A prototype basically is anything that embodies an idea – from physical objects the user can interact with, over role-playing activities or videos to drawings, sketches and stories.

For instance, for the development of a solution in the form of an app, prototypes could be drawings of the interface with separate drawings for the different functions.

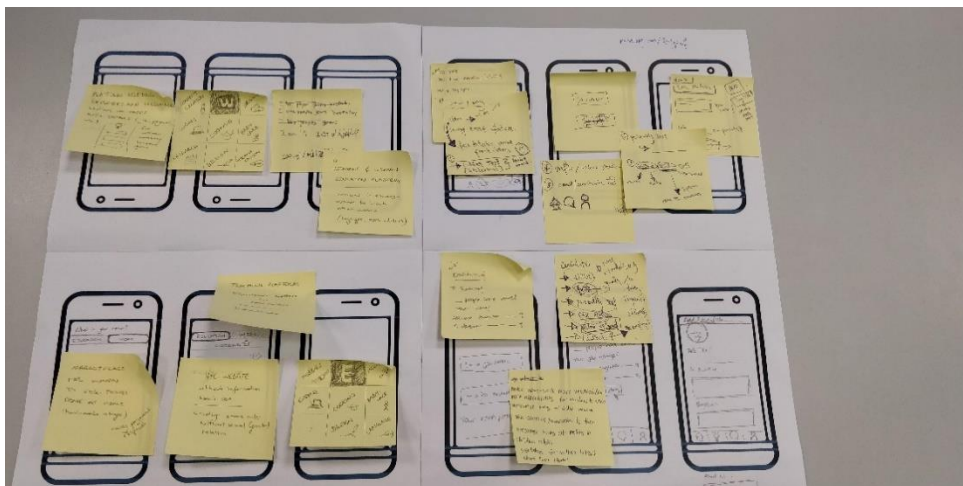


Figure 32: Drawings for the creation of an app [<https://xaltius.tech/design-thinking-from-idea-to-prototype/>, accessed 07.04.2019]

For the development of specific services or improvements to services, a role-playing activity with play-figures is a viable option. Later on, the idea can be tested within real human interaction.



Figure 33: Role-Play activity for the creation of a service [<https://sidlaurea.com/2013/10/21/out-of-the-box-and-then-back-in-again-the-abc-of-design-thinking/>, accessed 07.04.2019]

In a short period of time (approximately an hour) each group builds one or more rapid prototypes. These are presented to the team, tried out and discussed. Before heading out into the field to test with users, the feedback from other team members is integrated and the prototypes are prepared for testing. While doing so, the team determines an ideal testing scenario for each of the prototypes. Depending on which question a prototype is supposed to answer, the testing scenario needs to be adjusted. In this case, as simply the idea concept is supposed to be tested, the original problem context represents the best testing scenario. Unfortunately, this option is not always practical or feasible – therefore the groups must provide or create a scenario as close to reality as possible. (Stanford d.school, 2019, p. 35)

4.5.1 Testing

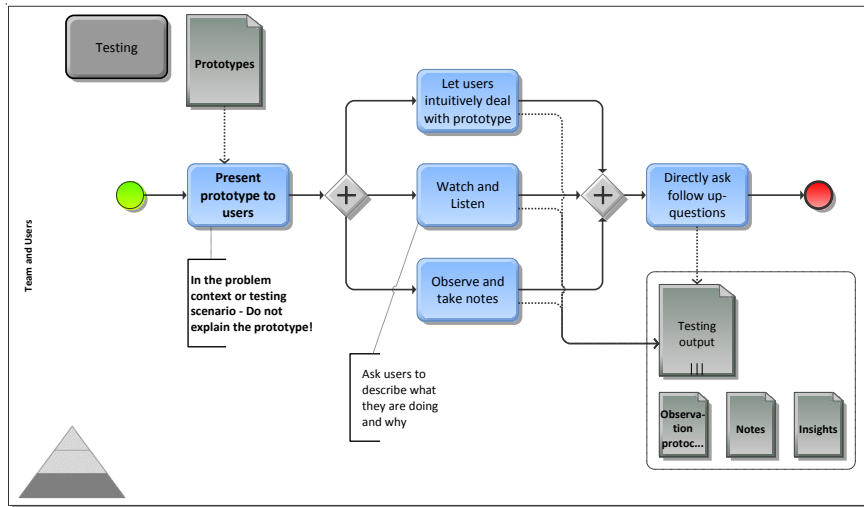


Figure 34: 5.1 Testing

The prototype(s) are presented to the users in the testing scenario. The prototype is not explained, it is important that the users intuitively use and misuse the prototype. Let the users describe what they are doing, and especially why, while they are dealing with the prototype. The whole testing is captured in a testing protocol. If the users agree, the testing should be captured on video, as reviewing might reveal further insights.

A testing protocol might have the following form (based on Schallmo, 2017, p.110)

Date/time:	Place:	Observer:
Interaction with prototype	Reaction of the user	Thoughts of the user
How does the user utilize the prototype, which activities does he/she perform?	How does the user behave while interacting with the prototype	Statement of the user what he thought while performing the respective activities
Alex sits down and takes the prototype with one hand...	He seemed surprised...	On first look, I did not understand how to use the prototype, because...
Activity 2	...	...
...		

After the testing, ask follow-up questions, such as:

What did you like the most about [...]?

What bothered you about [...]?

What would you improve and why?

The first impressions from testing the low-resolution, rapid prototype(s) reveal whether the tested idea should be pursued or if others might be more favourable.

If the idea concept (represented through the prototype) seems to be appealing, it is forwarded to the “prototype-test-iterate and improve-cycle”. Otherwise, the team can either try the same idea with another prototype or discard the idea and move on to another one. It is also possible, that after testing various ideas, the feedback reveals that a loop back to any other phase might be necessary.

Prototype-Test-Iterate and Improve cycle

The team defines which variable or which part of the prototype they want to test, adjust and improve the prototype to it, and then test again. This time, the testing output is briefly discussed, and urgent prototype specific questions are prepared. As it is best to interview the users just shortly after the tested the prototype, the discussing could for instance be done while the participants take a break.

This interview is referred to as test-interview. Its protocol should have the following form (Schallmo, 2017, p.110):

Date/time:	Place:	Observer:
Positive features	Changes and negative features	Open questions
What delighted the user? What did he/she like?	What would the user change? What did he/she dislike?	Which open questions does the user have?
Easy to use...	Reduce size to pocket size...	...
Positive feature 2	...	...
...		
Ideas		
Which ideas does the user have? (Replace ..., Adapt ..., Combine ..., Miss out ..., ...)		
Add feature xy...	...	...

Lastly, the prototype in line with its feedback is evaluated. Depending on the feedback, the team either iterates, loops back, or the DT-project is finished, and the prototype can be forwarded to other departments which turn it into reality and place it on the market.

A key element in this second cycle is to prototype, test, iterate and improve systematically – each prototype is supposed to test a specific variable and answer a particular question.

Therefore, it is important to determine what and how a variable is to be tested, before reworking, refining and testing the prototype. During the iterative process of prototyping and testing, each test is to be thoroughly documented to measure the impact of changes and adjustments. Within this cycle, the team continuously learns more about the prototypes, the problem and the users. The feedback from testing incites the next iteration, in which it is integrated into the improved prototype. Through repeating the test-feedback-improve cycle numerous times, the solutions constantly improve, while ensuring that any changes are in line with the user's imagination. This cycle continues until a solution and the according prototype are fully satisfying and ready to be released. (Stanford d.school, 2010, pp. 5–6, 2019, pp. 33–38)

Goal of "Prototype and Test"	Input	Output
Build prototypes out of ideas and evaluate them together with users; Iteratively improve solutions until they are satisfying and finished	Idea portfolio	A satisfying and (hopefully) successful solution
Further sources: (Brown, 2009, pp.53-57)		

The steps that follow afterwards, are to be done by other departments. Sometimes, prototypes need a team of specialists to bring them to live, furthermore, the market launch including all advertising and product placement is better conducted by a larger group of experts in the respective departments. (Brown, 2009, p.23)

5 Evaluation

The evaluation simultaneously fulfils Hevner's guideline (2004), completes the construction of the reference model (Fettke and Loos, 2004) and lastly, deals with the final research question.

As many publications and articles suggest, DT has by now fully arrived in industry and business – a variety of multinational companies, neither dependant on the size nor the branch, have adopted it. Up to half of the companies, which are listed at the DAX, utilize Design Thinking. (Zydra, 2014)

Thus, the question arises whether the reference model is able to display the application in practice. The evaluation was conducted in a German upper-class automotive manufacturer. The reference model was presented to an employee who participated in Design-Thinking-projects (and in respective training for DT as well). As the interview partner wished for anonymity, he and the company will not be named in the following part.

The interview partner participated in a few projects and workshops where Design Thinking or Design Thinking methods were applied. For the direct comparison with the reference model he referred to a Design Thinking project which was supposed to improve the user's experience when interacting with the MMI (Multi Media Interface) – the infotainmentsystem in the car. In essence, to improve the user-friendliness.

As introduction, the process model was presented to the interview partner. After briefly talking him through the phases, the interview partner agreed and confirmed the top-level structure of the reference model – in their schoolings it was taught similarly.

Although in practice, neither in the project he referred to, nor in other projects he participated, the process model and its six phases were fully utilized.

Understand: The understand phase was completely left out. The Design Challenge was provided through the project context. Furthermore, determining the target users is not necessary as they are already familiar, especially because large companies like these have specific departments which are solely focussed on market and customer research.

Observe: The Observation was conducted internally with colleagues and within the team. Most of the team members and other participating employees are actually driving a car from the respective manufacturer. Thus, they considered themselves users – which are even more

critical and judging than standard users. A further advantage of conducting the project with interns, is that there are no issues with the confidentiality.

Existing solutions from the two main competitors are constantly investigated and evaluated by departments specifically created for that task. The evaluation of these and further information were provided in a variety of documents.

The actual observation of the internal users was conducted parallel with the interviewing – the team sat together in a car, each one jumped into the role of the driver for a certain time and utilized the system for different causes (Connecting with their phone, navigating, radio, telephoning etc.) while driving – to make the situation possibly realistic. Notes were taken about what each of them perceived as issue or disturbing, including discussions about why the specific functions are bothering them and what could be improved. The “protocols” of that, were as far not as meticulously as the reference model prescribes, although each function that seemed potentially improvable (or row of functions to achieve a specific goal) were captured in pictures and precisely described.

Define POV: The Define POV phase is also altered and slimmed down in comparison to the reference model. The findings were presented and discussed within the team, while writing down important information. Each improvable function was declared as an own topic and received a space on whiteboards. The topics were complemented with the Post-Its and the affiliated pictures. The team did not create personas, empathy maps or user journeys. The user needs and POVs, were directly derived from the clusters, each describing the issue in the following manner (exemplary):

- Goal: Connecting the phone via Bluetooth and playing music.
- Procedure: Activating Bluetooth on the phone, navigating through the car menu to activate it's Bluetooth as well; Start the media player on the phone, play desired song.
- Issue: Navigation through the menu distracting, Bluetooth button not obvious/easy to find; Looking on the phone for starting the media player even more distracting, especially while driving.
- POV: The functionality of the media player needs to be improved to ease the connecting and avoid distraction while driving through looking at the phone.

The team defined multiple POVs, which in a further discussion were connected when possible. In case there are too many POVs the team would vote, in this example, voting was not necessary as the amount of POVs was relatively low. (Most of the derived POVs were connected in some way and dependant on the same issue.)

Ideate: On basis of the POVs ideas were brainstormed. The ideate phase was almost completely confirmed by the interview partner. Especially in the Design Thinking workshops, the procedure and the methods, as described in Ideate, were utilized. Referring to the project, the only difference was, that the ideas were not framed and described by idea profiles.

Exemplary ideas regarding the above described POV were:

- Instantly establish Bluetooth connection as soon as the entertainment system is started.
- Launching the media player in the entertainment system automatically provides access to the phones media
- Speech control...

Prototype and Test: The prototypes for the idea were created partially simultaneous and shortly after the brainstorming. For the both projects, the starting prototypes were mostly drawings, displaying the improved functionality, how to navigate through the menu to get there and the structure of the displayed/contained functions and options. Moving on to prototyping and testing, the interviewee confirmed that especially the prototype – test – iterate and improve cycle is conducted as described on the model. The testing was done only team-internally, and thus, the cycle was finished only after a few iterations.

The exact description of what to change and improve, described on a detailed basis and visually supported through drawings of the respective menus and functions, were handed over to the IT-department with the responsibility of programming the entertainment system. After they were finished, the prototype of the improved system was tested with the team members on the computer (simulation of the entertainment system). The team found a few minor adaptations, which in turn were integrated again – at this point, the solutions were satisfying, and the project was finished. However, a lot of bureaucratic different steps are necessary before the solution is actually integrated into the successor of the current model.

To sum up, the interview partner confirmed the use of Design Thinking, in a significantly slimmer version than the reference model would provide. Nevertheless, the modus operandi of this project could have been fully displayed by the reference model – with skipping and leaving out certain steps.

It is noteworthy, that the exact application depends on a variety of factors – the project content, the team's experience and confidence with the methods as well as the state of knowledge prior to the project start etc. In many cases, the first three phases are neglected, because the user needs or POVs are provided by other instances, for example those who are solely responsible for market and user research. The interviewee furthermore mentioned, that especially in Design Thinking workshops, which are utilized for the quick creation of creative ideas for a variety of problems, the methods and the process as described in Ideate, Prototype and Test are almost equal.

According to the interviewee, Design Thinking is, at least currently, mainly used for service-related solution finding. A further DT-project which he mentioned, was the creation of an internal schooling tool for executives and managers. Unfortunately, he did not participate in this project – and thus, could not provide further information.

The reason behind the focus on service-related solutions, are the current trends in this branch. The tremendously growing amount of electrical parts, which all need to work together at once, requires the car's information technology to process data from various systems and interfaces all at once. Together with the automated driving and electric mobility, the complexity of a modern car is heavily increasing. Therefore, the current trends in automotive companies are rather focussed on approaches that embrace, connect and frame whole car concepts, such as Systems Engineering and Simultaneous Engineering. In both these concepts a strict requirements-management is pursued, which defers the compatibility with Design Thinking and its creative character. The narrow vision for the conception of car parts through company guidelines (economical, safety, constructive) and restrictions by the law hinder the implementation of DT in projects like these.

On a side note, the interviewee mentioned that he has the feeling that DT has not fully arrived in their company yet – currently, it does not have the backing and support it would probably require. In his opinion, the reason behind this was that within this branch, specifically the

Germans, are still too rigid, inflexible, and unwilling to change and break out of old process-structures which worked for a long time – although it seems to change steadily.

To conclude the evaluation, the reference model was able to fully display the applied Design Thinking – and thus, is seen as accepted.

6 Conclusion

To finalize this thesis, the initially formulated research questions are critically reviewed. The first question, *“What is Design Thinking and how can the concept be understood?”*, is respectively answered by the regulatory framework in chapter two.

The evaluation of different interpretations, as well as analyses regarding DT, revealed, that DT is more than just a user-centred process to create innovations and solve problems. It is constituted by five principles, which are reflected through mindsets and practices. In order to successfully conduct DT and improve innovativeness and creativity, the principles are meant to be anchored within the process, the team, and the whole company. Furthermore, Design Thinking requires the right people, as well as an own creative space to function at its best. The constructed framework provides a thorough overview. (p.23)

The second research question, *“What should a process/reference model for Design Thinking look like?”*, is responded by the reference model in chapter four.

The reference model describes the procedure of Design Thinking in detail. For the creation, three famous processual approaches have been evaluated, to build a solid foundation for the model. Within the model, the different approaches, with ambiguous descriptions and totally deviating representations of the Design Thinking process, are united into an actionable process model. Fortunately, the evaluation of the different approaches revealed, that each of the processes, from an abstract point of view, basically describes the same process.

On the top-level, the DT-process is described by six phases. (Understand, Observe, Define POV, Ideate, Prototype and Test) Each of the phases respectively is described by an own process model – equally as complex subprocesses within these process models. Through this division, the process model is separated into three layers – each with a higher degree of detail.

As each of the evaluated and integrated approaches was mainly focussed on the development of innovative products and services or the improvement of those, these will represent the limitations of the reference model. The mentioned improvement of strategies or processes in 2.3 Application scenarios, are not within the competence of the reference model; These would definitely require further research, resulting in adaptations and adjustments to the reference model.

The third research question, *“How is Design Thinking practised in international companies?”*, is dealt with in the evaluation of the reference model in chapter five.

The evaluation demonstrated, that the reference model is capable of displaying the modus operandi in practical appliance – although the DT-project, on which the comparison was based, utilized a slimmed-down version of the reference model and evaluated it only in the context of service-improvements. Still, based on the project, as well as further DT-workshops, many methods and processes, especially within the Ideate, Prototype and Test phase, could be confirmed. Furthermore, the evaluation revealed, that the constraints and barriers, as described in 2.6 – such as the missing support from the management, are representing realistic obstacles to the implementation of Design Thinking.

Moreover, the application, specifically which processes and methods are utilized, depends on a variety of factors. These application parameters are for instance the content and objective of the project, the team’s experience and knowledge prior to the project start. Furthermore, the assumption arises, that DT is also dependant on the branch in which it utilized. These particular dependencies and application parameters became apparent through the evaluation of the reference model. Both represent an important subject for further investigation. Thus, additional research through evaluation in regard to the differences in application is necessary – to differentiate and categorize the dependencies and influences on the application of the reference model.

Finally, Design Thinking represents an overall promising concept – correctly implemented and applied it contains a lot of potential for many companies, especially considering the user-driven markets nowadays.

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Attachements

Poster of the Design Thinking process model