FICTIONATION IDEA GENERATION TOOL FOR PRODUCT DESIGN EDUCATION UTILIZING WHAT-IF SCENARIOS OF DESIGN FICTION: A MIXED METHOD STUDY

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ABSTRACT

FICTIONATION IDEA GENERATION TOOL FOR PRODUCT DESIGN EDUCATION UTILIZING WHAT-IF SCENARIOS OF DESIGN FICTION: A MIXED METHOD STUDY

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Design process is an iterative activity that embodies research and planning, idea generation, evaluation and refinement, and finalization phases. Among these, idea generation is evaluated as having the highest impact on the quality of the final design solution since it is the phase that requires the generation of many (quantity), various (variety) and novel (novelty) ideas that will be further developed and resulted as the final product in the following phases of the design process. For the purpose of guiding and supporting designers in the design process and especially idea generation, various design methods and tools have been developed. However, these methods and tools are being criticized for 1) being ineffective in enhancing quantity, variety and novelty of the generated ideas, 2) not being experimentally tested by the researchers and 3) not being supported with illogical thinking, which is one of the essences of creative thinking.

This thesis aims to identify the needs of the idea generation process and offer a strategy for design students in order to foster the outcomes of the idea generation process. For this purpose, a mixed method research was conducted. The needs of the idea generation process were identified through observation and peer debriefing, a design tool (Fictionation) that integrates design fiction into idea generation was created and further developed through a pilot study, and workshops that adopt a quasi-experimental research model was conducted. The findings were evaluated by using the assessment technique that was developed within this thesis and interviews. The results have shown that the Fictionation tool is promising in terms of fostering the outcomes of the idea generation process by increasing quantity, variety and novelty of the generated ideas and achieving an efficient learning and teaching environment within design education.

Keywords: Idea generation, Design fiction, Design methods and tools, Design education, Divergent thinking

ÖZ

ÜRÜN TASARIMI EĞİTİMİNDE KURGUSAL TASARIMIN FARZETME SENARYOLARINI KULLANAN FICTIONATION FİKİR GELİŞTİRME ARACI: BİR KARMA YÖNTEM ARAŞTIRMASI

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Tasarım süreci, bünyesinde araştırma ve planlama, fikir geliştirme, değerlendirme ve geliştirme ve neticelendirme aşamalarını barındıran yinelemeli bir süreçtir. Bu aşamalar arasından fikir geliştirme, fazla sayıda (miktar), çeşitli (çeşitlilik) ve yenilikçi (yenilikçilik) fikirler geliştirmeyi gerektirdiğinden ve geliştirilen bu fikirler tasarım sürecinin sonraki aşamalarında daha da geliştirilip son ürün haline getirildiğinden dolayı, son ürünün kalitesine en fazla etki eden aşama olarak değerlendirilir. Tasarım sürecinde ve özellikle fikir geliştirme aşamasında tasarımcılara rehberlik etmesi ve destek olması amacıyla çeşitli tasarım yöntem ve araçları geliştirilmiştir. Ancak, geliştirilen bu yöntem ve araçlar 1) geliştirilen fikirlerin miktarını, çeşitliliğini ve yenilikçiliğini arttırması hususunda yetersiz kalmalarından, 2) araştırmacılar tarafından deneysel olarak test edilmemelerinden ve 3) yaratıcı düşünmenin esas niteliklerinden olan mantığa aykırı düşünme ile desteklenmediğinden dolayı eleştirilmektedirler.

Bu tez, fikir geliştirme sürecinin ihtiyaçlarını belirlemeyi ve tasarım öğrencilerine bir strateji önererek fikir geliştirme sürecinin çıktılarını geliştirmeyi amaçlamaktadır. Bu amaç için bir karma yöntem araştırması yapılmıştır: Fikir geliştirme sürecinin ihtiyaçları gözlem ve akran bilgilendirmesi yoluyla belirlenmiştir, kurgusal tasarımı fikir geliştirme ile kaynaştıran bir araç (Fictionation) oluşturulmuş ve pilot çalışma ile daha da geliştirilmiş ve yarı-deneysel araştırma modelini benimseyen çalıştaylar yapılmıştır. Bulgular, tez kapsamında geliştirilen bir değerlendirme tekniği ve yapılan mülakatlar vasıtası ile değerlendirilmiştir. Sonuçlar göstermiştir ki, Fictionation aracı, fikir geliştirme sürecinin çıktılarının miktarını, çeşitliliğini ve yenilikçiliğini geliştirmesi ve tasarım eğitimi bünyesinde etkili bir öğrenme ve öğretme ortamı elde etmesi bakımından gelecek vaat etmektedir.

Anahtar Kelimeler: Fikir geliştirme, Kurgusal tasarım, Tasarım yöntem ve araçları, Tasarım eğitimi, Iraksak düşünme

“In order to determine whether we can know anything with certainty, we first have to doubt everything we know.” René Descartes

To my wife Gamze

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LIST OF ABBREVIATIONS

ABBREVIATIONS

C- Sketch	Collaborative Sketching
FBS	Function, Behavior, Structure
METU	Middle East Technical University
NGT	Nominal Group Technique
IoT	Internet-of-things

CHAPTER 1

INTRODUCTION

1.1 Problem Background

People are surrounded by products: from simple paper clips to complex space shuttles. They may think on and wonder about how these products are thought of in the first place and produced in the end. Each product has been mulled over and produced by going through some specific processes. Just like baking a cake through applying a recipe, product design also has a recipe which is named *the design process* (Ulrich & Eppinger, 2012).

Of course, the design process is not as simple and straightforward as cooking. It is an iterative process that requires research, planning, analysis, synthesis, evaluation, and control. Furthermore, product development requires a multidisciplinary approach that is in need of the marketing, engineering and industrial design disciplines (Aspelund, 2014; Baxter, 1995; Ulrich & Eppinger, 2012).

The design process is composed of phases that follow each other. Although the process is generally represented successively, some phases may need to be repeated. There are different representations of the design process in the literature. While Baxter (1995) represents its phases as business opportunity, design specification, concept design, embodiment design, detail design, and design for manufacture, Ulrich and Eppinger (2012) represent these phases as planning, concept development, system-level design, detail design, testing and refinement, and production ramp-up, respectively. Aspelund (2014) represents them as inspiration, identification, conceptualization, exploration/refinement, definition/modeling, communication, and production.

The focus of this thesis is the *concept design phase* that is also named as *concept development, conceptualization* or *idea generation*. In the following chapters, this phase will be mentioned as the *idea generation process*.

Idea generation is one of the most important phases of the design process. It is evaluated as having a significant impact on the final design solution and innovation. The success of the idea generation process can be measured by the quantity, variety, and novelty of the generated ideas (Christian, Daly, Yilmaz, Seifert, & Gonzalez, 2012). A common understanding is that, the chances of generating better and innovative ideas increase as various possibilities are considered (Corremans, 2011).

All of the generated ideas for a specific design problem constitute a theoretical space named as *the design solution space*. Studies show that there is a significant relationship with the *size* and *variety* of the design solution space and the quality of the final design (Christian et al., 2012; Daly, Seifert, Yilmaz, & Gonzalez, 2016; Römer, Pache, Weißhahn, Lindemann, & Hacker, 2001). Therefore, generating various ideas increases the density of the design solution space and the chance to produce successful final products.

Another important aspect of the success of the idea generation process is *novelty*. Some ideas in the design solution space are obvious and can be thought of quickly by most of the people. On the other hand, less obvious ideas, which are novel ideas, need more time and effort to surface. These ideas are the ones that expands the boundaries of the design solution space and create less well-known and innovative parts within this space (Christian et al., 2012; Daly et al., 2016).

Another important consideration for the idea generation process is *fixation* that can occur as a result of two instances. Either, designers become attached to an early idea during idea generation and stop looking for other alternatives, or designers become attached to existing products that cause them to propose similar alternatives (Christian et al., 2012; Kavakli, Scrivener, & Ball, 1998; Linsey, Tseng, Fu, Cagan, Wood, & Schunn, 2010; Ullman, Dietterich, & Stauffer, 1988).

Design students encounter with the concepts of design process, idea generation, design solution space, novelty, variety, and fixation during their education for the first time. It is the aim of design education to bring design knowledge and skills to students in order to move them from being novice designers to expert designers (Cross, 2008; Dorst & Reymen, 2004).

In response to the need of enhancing quantity, variety and novelty, and eliminating fixation within the idea generation process; and guiding novice designers regarding their journey of reaching the expert level, various design methods and tools have been developed. Among examples of design methods may be cited brainstorming (Osborn, 1953), the nominal group technique (Delbecq & Van de Ven, 1971), brainwriting (Baxter, 1995), 6-3-5 (Shah, Vargas-Hernandez, Summers, & Kulkarni, 2001), c-sketch (Shah et al., 2001), gallery (Wright, 1998), Synectics (Gonçalves, Cardoso, & Badke-Schaub, 2014), TRIZ (Gonçalves et al., 2014), SCAMPER (Baxter, 1995), mind mapping (Aurum & Gardiner, 2003), checklist (Cross, 2008), and the morphological chart (Ritchey, 2005). Besides, Creative Whack Pack (Roy & Warren, 2019), Thinkpak (Lucero & Arrasvuori, 2010), Designercise (Haritaipan, 2019), IoT Service Kit (Haritaipan, 2019), PLEX Cards (Lucero & Arrasvuori, 2010), Oblique Strategies (Wölfel & Merritt, 2013), Design Heuristics (Christian et al., 2012), Meta Cards (Roy & Warren, 2019), IDEO Method Cards (Lucero & Arrasvuori, 2010), MethodKit (Haritaipan, 2019), i/o Cards (Carneiro, Barros & Costa, 2012), iD Cards (Roy & Warren, 2019), and Energy Trumps (Haritaipan, 2019) are examples of such design tools.

The commonality of these methods and tools is that, they all aim to provoke divergent thinking, which is the essence of idea generation: the idea generation process adopts a divergent approach in which various alternatives are generated, and followed with a convergent approach in which the evaluation of the alternatives and the selection of the best alternative are made in the following phases of the design process (Fricke, 1996; Liu, Bligh, & Chakrabarti, 2003).

1.2 Significance of the Study and Contribution to Knowledge

Despite the availability of these methods and tools, designers, especially novice designers struggle to produce diverse and novel ideas and generally, their efforts end up with fixation (Bruseberg & McDonagh-Philp, 2002; Christian et al., 2012; Linsey et al., 2010; Sio, Kotovsky, & Cagan, 2015; Vasconcelos & Crilly, 2016). Besides, as one of the findings of the research carried out for this thesis has shown, during the idea generation process, design students may have problems in thinking in a divergent manner due to not being able to free themselves from the concerns of the following phases of the design process. Although designers have the opportunity to think and produce freely in the idea generation process in a divergent manner, there are also some constraints that should be considered afterward. After generating concepts and ideas, designers should also consider issues such as production methods, cost, ergonomics, material possibilities, interaction, and distribution and develop the product accordingly (Bloch, 1995; Crilly, Moultrie, & Clarkson, 2009). These constraints, possibilities and considerations might create a cognitive barrier for students such that they cannot think freely and produce ideas in a divergent manner in the idea generation process.

Experienced designers perform the design process intuitively (Corremans, 2011; Cross, 2008; Dorst, 2008; Lawson, 2005). They have their own styles that they have subconsciously composed through the acquired methods, tools and insights during their education and professional life (Corremans, 2011; Dorst, 2008). Besides, design students, who can be considered as novice designers, should be guided throughout the design process with feedback, critiques, and methods (Gonçalves et al., 2014). However, there are some criticism to the design methods and tools. According to some researchers, some of the available design methods and tools require extensive training to understand and perform. Furthermore, these methods and tools have not been experimentally tested in terms of their effect to the outcomes of the design process (Christian et al., 2012; Haritaipan, 2019; Shah, Kulkarni, & Vargas-Hernandez, 2000). Besides, many of the available design methods and tools are being criticized for being ineffective since they provide the guidance that is already being applied by the designers. Besides, many researchers evaluate design methods and tools as lacking in terms of illogical thinking. They argue that design methods and tools should contain illogical thinking strategies such as dreams and fantasy in order to foster creativity (Haritaipan, 2019; Kris, 2000).

In the light of this information, it can be derived that design students are in need of a guidance that can be applied easily, foster creativity through illogical thinking, and help them to isolate themselves from the subsequent concerns of the design process in order to focus on idea generation in a divergent manner towards proposing various and novel ideas.

In response to these needs and determined problems, this thesis contributes to the knowledge by examining the nature nurture, methods and tools of design and design fiction and provides 1) a design strategy that adopts illogical thinking, 2) a design tool that aims to guide designers and design students in terms of expanding the design solution space by increasing the quantity, variety, and novelty of the generated ideas and eliminating fixation, and 3) an assessment technique in order to experimentally test the effectiveness of the design tools.

1.2.1 Design Strategy to Integrate Design Fiction into the Idea Generation Process

Design fiction is a new concept in the design literature, which suggests that designers can think in terms of an imaginary world where constraints, rules, and limitations are defined by themselves (Bleecker, 2010). This imaginary world can be considered as a kind of laboratory where designers reevaluate the features of the real world in a fictional world. The conditions of this fictional world might provide the designer with an appropriate environment to think differently than it is possible in the real world (Franke, 2010; Tanenbaum, 2014).

The studies on design fiction are mainly comprised of articles and conference papers that define the design fiction concept and explain the role of design fiction for the design context by using some representations of fictional objects and products (Auger, 2013; Bleecker, 2010; Blythe & Wright, 2006; Franke, 2010; Grand & Wiedmer, 2010; Knutz, Markussen, & Christensen, 2014). Besides, there are few studies that utilize design fiction as a method as part of a design project (Candy & Dunagan, 2017; Celi & Formia, 2015; Kelliher & Byrne, 2015).

The scope of this thesis is the idea generation process within industrial design education. Although industrial design is a problem-solving process that aims to create a better quality of life through products, systems, services and experiences (WDO, 2020), all the design fiction studies remain in the fictional side of design fiction without offering strategies and methods regarding the real-world issues of industrial design.

Since imaginary worlds could be used as laboratories where alternative scenarios to the real world are explored, design fiction has the potential to be beneficial for the idea generation process in terms of eliminating constraints and creating a fictional world where designers could generate ideas more freely in a divergent manner. Integrating design fiction into the idea generation process has the potential to develop design solutions and therefore designed objects by aiding the expansion of the design solution space and the production of novel ideas.

1.2.2 Design Tool (Fictionation) to Generate Various and Novel Ideas

To propose an effective design tool that aims to integrate design fiction into the idea generation process, the common features and required criteria for design fiction studies need to be investigated. These features are *what-if scenarios* and *experiments*.

All design fiction studies have a common imaginary *what-if* scenario that allows for the birth of fictional worlds where possible futures or alternative presents are created (Knutz et al., 2014). Besides, all design fiction studies are based on experiments in which what-if scenarios create the suitable environment to explore, produce, and develop new things (Knutz et al., 2014; Niedderer & Roworth-Stokes, 2007).

Furthermore, there are some required criteria for a design fiction study:

- It should have a *what-if* scenario.
- It needs tools, methods, and practices.
- The tools, methods, and practices should enable the representation, visualization and documentation of the experimentation process.
- The experimentation should involve seeking answers for a series of questions and testing a series of hypotheses (Grand & Wiedmer, 2010; Markussen & Knutz, 2013).

Considering these common features and criteria and investigating various design methods and tools, this thesis offers a design tool named Fictionation that involves various idea generation cards containing various what-if scenarios. Fictionation was designed in a way as to facilitate the visualization and documentation of the experimentation process while seeking for design alternatives. The purpose of the tool is to enable the expansion of the design solution space by assisting design students in producing various and novel ideas so as to improve their final design solutions.

1.2.3 Assessment Technique to Measure the Effectiveness of the Idea Generation Process and Proposed Design Methods and Tools

Having knowledge on the usability, applicability, and effectiveness of a chosen method is more important than having knowledge about various existing methods. Therefore, a method should be tested to evaluate its effectiveness, usability, and applicability in a certain scenario (Corremans, 2011).

To assess the effectiveness of the Fictionation tool, a new technique that is based on the studies of Shah, Vargas-Hernandez, & Smith (2003) and Nelson, Wilson, Rosen, & Yen (2009) was developed. Their assessment technique is significant in terms of evaluating the novelty and variety of the proposed ideas. However, it involves some procedural problems and mathematical errors. For the purpose of eliminating these problems, this thesis offers a new assessment technique that adopts quantitative content analysis strategies (Krippendorff, 2004; Margolis & Pauwels, 2012; Van Leeuwen & Jewitt, 2001). The technique also includes the integration of the FBS ontology (Gero & Kannengiesser, 2014; Sarkar & Chakrabarti, 2006). This assessment technique was also used in the measurement of the effectiveness of the Fictionation tool. Furthermore, it can be used both by design students and design educators for evaluating the effectiveness of the idea generation process, and by researchers for assessing a new idea generation method that they have proposed.

1.3 Aim and Research Questions of the Thesis

This thesis aims to offer a strategy for design students towards expanding the design solution space by increasing the quantity, variety, and novelty of the generated ideas (Figure 1). By increasing quantity and the number of the generated ideas, design students may have new possibilities to work on. However, increasing the number of the generated ideas is not enough to expand the design solution space (quantity). Newly generated ideas should differ from the previous ones in order to create new possibilities (variety). Furthermore, these newly generated ideas should be different from the ones that are generally offered by other designers in order to be innovative (novelty).

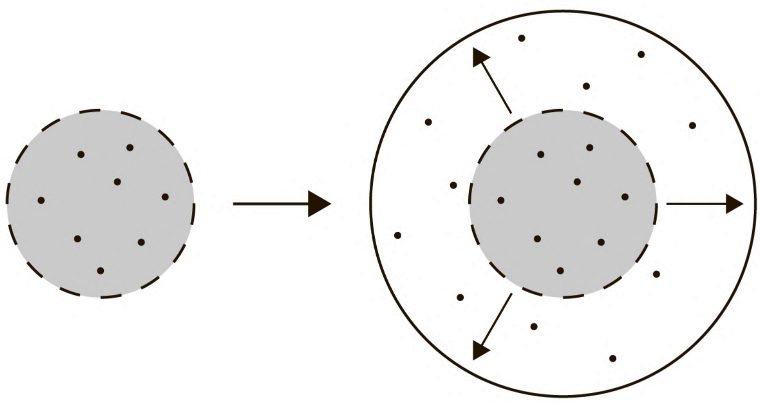


Figure 1. Expanding the boundaries of the solution space to achieve variety and novelty

Corresponding to this aim, the main research question and the sub-questions of the thesis are as follows:

The main research question is:

- How can the performance of design students in terms of quantity, variety and novelty be increased during the idea generation process?

The sub-questions are:

- What are the needs of design students in terms of guidance and support in fostering the outcomes of the idea generation process?
- What are the various design methods and tools available to be used in design education? What are their limitations and strengths?
- How can the performance of design students in terms of the outcomes of the idea generation process be assessed?
- To what extent does the Fictionation design tool affect the quantity, variety and novelty scores of design students?
- In which ways does the Fictionation design tool affect the idea generation process and design education?

1.4 Scope of the Study

It was mentioned in the previous sections that design students, who can be considered as novice designers, should be guided throughout the design process. Idea generation is one of the most important phases of the design process and it is regarded as the creative part of the design activity. This situation places idea generation in the heart of design methods and design tools related with creative thinking.

As mentioned earlier, design students need guidance and support to become isolated from the subsequent concerns of the design process and focus on idea generation in a divergent manner towards proposing various and novel ideas. The author of this thesis has an interest in creative thinking and idea generation methods and tools. Therefore, the guidance that is needed by novice designers was corresponded with an idea generation tool. For this purpose, a literature search that investigates creative thinking methods was conducted. For the purpose of eliminating the detected problem of some students not being able to free themselves from the constraints of the design process, *what-if* scenarios of a newly emerging concept, *design fiction* was determined as having potential as a strategy in terms of creating a fictional world where rules and restrictions are determined by the designer. Consequently, idea generation within design education, creative thinking and design fiction constitute the scope of this thesis (Figure 2).

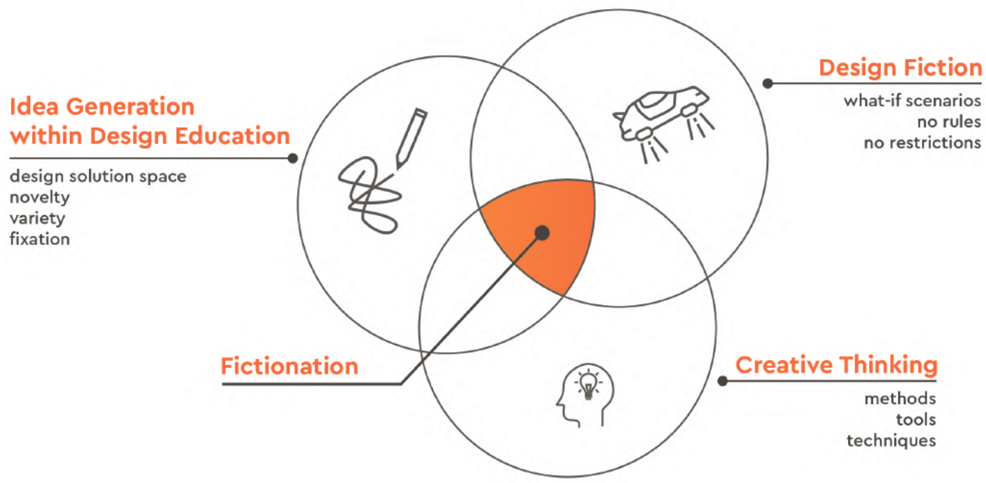


Figure 2. Scope of the thesis

1.5 Methodology of the Study

A mixed method research, which was composed of a series of studies that includes both the collection, analysis and integration of qualitative and quantitative data, was conducted for this thesis. The three studies composing the research were: Needs Assessment Study; Development of the Fictionation tool; and Implementation of the Fictionation Tool (Figure 3).

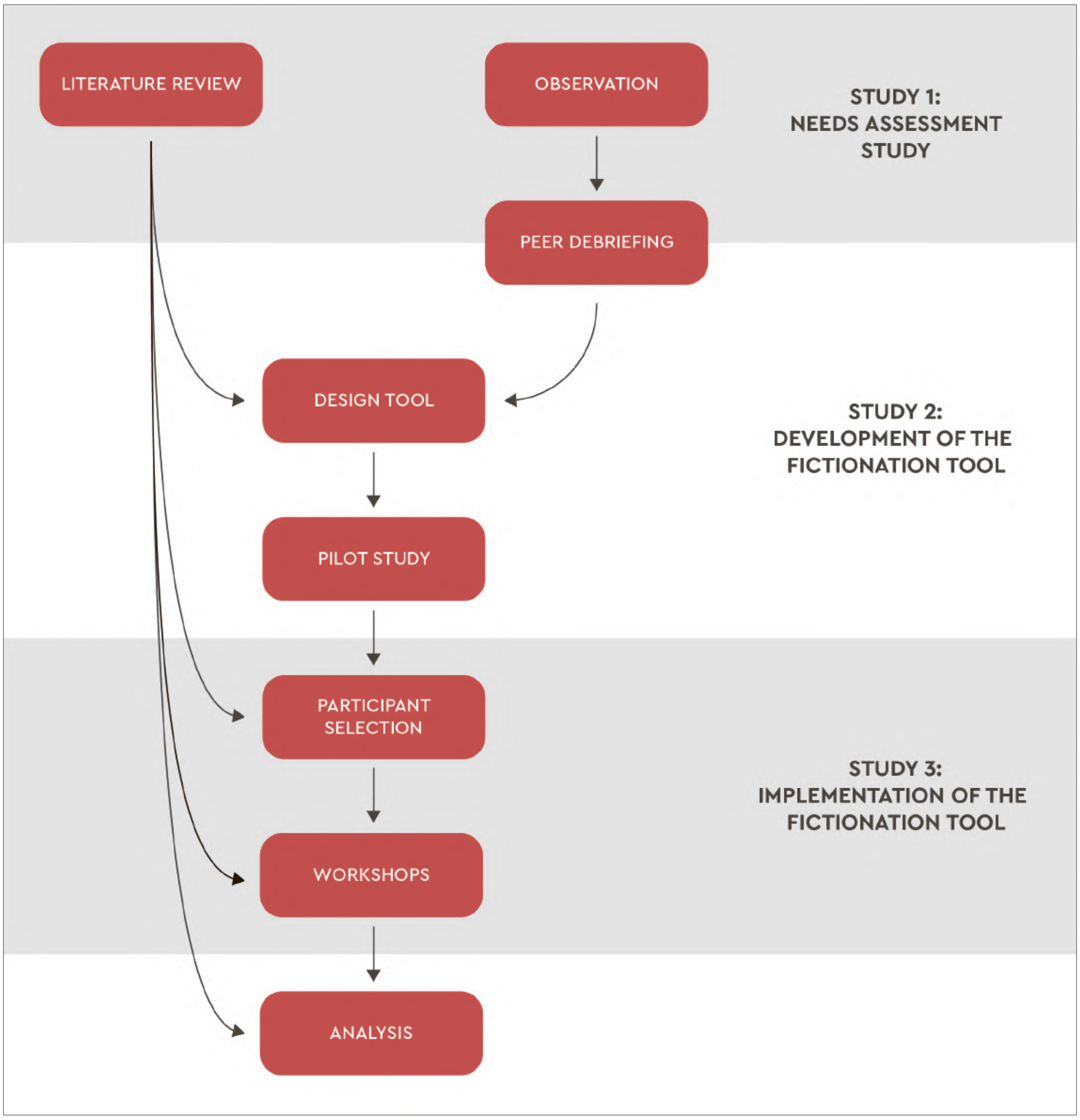


Figure 3. The methodology of the research composed of three studies

Study 1. Needs Assessment Study: The first study was carried out to assess the needs of design students in terms of guidance and support regarding the idea generation process. For this purpose, an undergraduate industrial design studio project was observed with the aim of determining how students carry out the idea generation process, the difficulties that they encounter during the process, and how they perform in this process. Following the observation, peer debriefing sessions were conducted to investigate idea generation deeply.

Study 2. Development of the Fictionation Tool: The second study was the development process of the Fictionation design tool. Together with the outcomes of the observation and peer debriefing sessions and the literature reviews on creative thinking and design fiction, the Fictionation tool was prepared. Furthermore, the tool was tested and further developed through a pilot study.

Study 3. Implementation of the Fictionation Tool: The third study was the implementation of the tool. First, a prior achievement analysis was made to the idea generation sketches of the observed students for the purpose of calculating their novelty and variety scores through the assessment technique that was developed within this thesis. These scores made way for the selection of the participants of the workshops in which the Fictionation tool was tested. Then, through conducting a quasi-experimental study, the Fictionation tool was implemented with the selected participants within a series of workshops that contained a control and an experiment group. Following the workshops, interviews were conducted with the participants of the experiment group.

Based on the analysis of the results, the usability, applicability, and effectiveness of the Fictionation tool were assessed. The usability and applicability of the tool were assessed by considering the opinions declared by the participants during the interviews. Besides, the effectiveness of the Fictionation tool was assessed by both considering the results of the interviews and comparing the results of the control and experiment groups that were obtained through the assessment technique that was developed within this thesis.

1.6 Structure of the Thesis

This thesis is composed of eight chapters. Chapter 1 Introduction presents background information regarding the identified problem and presents the response of the thesis to this problem by clarifying its aim, research questions, research methodology, scope, significance and contribution to knowledge.

Chapter 2 presents a literature review on nature, nurture and methods of design. The chapter explores the nature of design considering it as an activity, a result and a process. It gives information about the nurture of design through explaining the current situation and aims of design education. Finally, it presents design methods and tools, classifying them and providing examples.

Chapter 3 gives information of about a relatively new concept for design literature, design fiction. It presents its value, approaches, and conducted studies.

Chapter 4 presents the methodology of the study by defining it as a mixed method study. It presents the adopted research model and data collection and analysis techniques that were used within the three studies of the research.

Chapter 5 presents the first study of the research, needs assessment study, which was composed of observation and peer debriefing stages. It presents details about the process and results.

Chapter 6 presents the second study of the research, development of the Fictionation tool. It presents the preliminary version of the tool together with the design guidelines and production process. Furthermore, it presents the results of a pilot study that was conducted to test the tool and the revised version of the tool.

Chapter 7 presents the third study of the research, implementation of the Fictionation tool, which was composed of two stages: prior achievement analysis and workshops. It presents the factors considered while deciding on the participants within the prior achievement analysis and details and results of the workshops that were conducted with the determined participants.

Finally, Chapter 8 presents a discussion and summary of the findings through revisiting the research questions. It also gives information about the encountered limitations and suggestions for further studies.

CHAPTER 2

NATURE, NURTURE, METHODS AND TOOLS OF DESIGN

The main focus of this chapter is design methods and tools. However, in order to comprehend the context of design methods and tools within design activities, the nature and nurture of the design will be mentioned beforehand. This chapter will give a general overview of the nature of design involving its definition, its activities and process; the nurture of design involving educational issues regarding the design profession; and the methods and tools of design involving various examples that are being used within the design activity.

2.1 Nature of Design

A design is a response to a need or problem that needs to be solved. This response is a process that includes planning and forming ideas and making choices considering the evolution of the proposed ideas that will be concluded with an end result (Cross, 2008). Heskett defines design as "design is when designers design a design to produce a design" (Heskett, 2001, p.18). Within this definition, the word *design* is used both as a verb and a noun. The first, third, and fourth usages are noun, and the second usage is a verb. While the noun conditions connote the field of design, a plan or intention, and the finished product respectively; the verb condition connote the action within the act of designing. With regard to these definitions, it can be concluded that design is an activity, a result, and a process.

2.1.1 Design as an Activity

The verb condition of the word design is designing that is used to describe the carrying out of the design activity. As mentioned in the previous paragraph, people have always responded to their needs and designed tools and artifacts throughout history. Except for the natural formations, everything around people is the result of a design activity, whether they are completely new contributions to everyday life, or they are the refinement of a previous artifact (Aspelund, 2014; Cross, 2008; Lawson, 2005; Ulrich & Eppinger, 2012).

Before the modern industrial era, the word *designing* was being used for describing the making of an artifact, referring to traditional craft-based activities. Generally, there was no prior activity before the production. However, with the start of the modern industrial era, making an artifact shifted from a craft-based to an industrialized production, and designing it and producing it are now considered as separate activities. In the making of an artifact, or producing of a product through industrial machinery, a prior designing activity is needed, composed of planning, drawing, modeling, and testing. Whereas designing was measured with minutes or hours before the modern industrial era, in some cases, it is measured with months or years within the industrial era, such as the activities of designing electrical and electronic products. Design and the activity of designing have become a professional activity together with the industrial era (Cross, 2008; Lawson, 2005).

There are many activities within the design activity itself. Designers have to make investigation, exploration, generation, evaluation, and communication within the design activity. The details of these activities will be mentioned in Section 2.1.3 *Design as a Process.*

The comprehensiveness and versatility of the design activity gave rise to the creation of various fields that produce different outcomes such as architectural design, graphic design, industrial design, interior design, fashion design, urban design, and landscape design (Findeli, 1990; Lawson, 2005; Salama & Wilkinson, 2007). Among these design-based disciplines, this thesis concentrates on industrial design, and it should be noted that from now on, the words *design,* together with *design activity*, *design outcome,* and *design process,* refer to industrial design and its activity, products, and process in the rest of the thesis.

Industrial design is a creative activity that deals with industrially manufactured objects (Rampino & Gorno, 2011). For many years, the task of industrial designers was seen by managers as covering up or *gift wrapping* a product when its technology and technical features were determined. Thus, the product would be shown up in the market by its technology alone. However, nowadays, merely the technology of the product is not enough on its own to ensure commercial success. The functionality of the product (ergonomics, user-friendliness, and interface design), together with its aesthetic appeal (form, color, feel, sound), maintenance, safety, and cost, play an important role in the success of the product. Many large companies are using industrial designers to satisfy customer needs and to differentiate their products from their competitors in the market (Ulrich & Eppinger, 2012).

2.1.2 Design as a Result

The noun condition of the word design describes the outcome of the design activity. While an architect produces large-scaled products, which are the buildings that people live and work in, a graphic designer produces two-dimensional images, and an industrial designer produces relatively small-scaled products, which are the items that people use in everyday lives (Salama and Wilkinson, 2007; Lawson, 2005). Just as the outcome of a design activity might be a tangible product, it might also be some drawings that aim to communicate with the producer (Cross, 2008).

The end result of the design activity generally depends on a design problem that is either demanded by a client or discovered by the designer. Whereas the client might be a big company that is in need of an innovative product to increase their market share, it might be an individual person as well (Lawson, 2005).

The problems that designers deal with are described as ill-defined (Rittel & Webber, 1973; Simon, 1973) problems. In contrast with the well-defined problems such as math problems that have a clear objective, a correct answer, and standard rules and ways to reach that correct answer, ill-defined problems are vague, complex, unstable, inconsistent, solution dependent and there is no certain answer to the problem as true or false but convenient or inconvenient (Baxter, 1995; Cross 2008; Lawson, 2005; Ulrich & Eppinger, 2012). Despite there being no standard ways to solve ill-defined problems as in the case of well-defined problems, there are commonly adopted ways of dealing with them among designers. This common ground has enabled researchers and designers to evaluate the design as a process.

2.1.3 Design as a Process

The creation of an outcome as a result of the design activity goes through some processes. Aspelund (2014) associates this process to a path. He states that "there is a path all designs take on their journey from the world of imagination to the world of objects" (Aspelund, 2014, p. 2). This path is called the design process. As the design process generally shows similar characteristics among design-based disciplines, it is called the product development process within the industrial design profession (Cross, 2008).

The design process consists of several phases that lead the product from an initial idea in mind to a place at a showcase. It is an iterative process that sometimes requires loops and abandoning in case of experiencing flaws (Aspelund, 2014; Baxter, 1995; Cross 2008; Ulrich & Eppinger, 2012). Cross (2008) represents the process through a simple four-stage model that consists of the exploration, generation, evaluation, and communication phases (Figure 4).

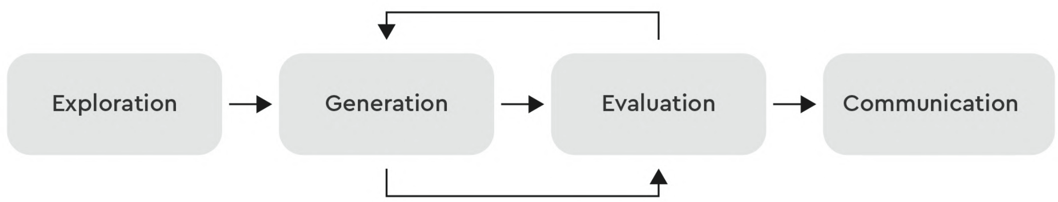


Figure 4. Four-stage model of the design process (adapted from Cross, 2008, p. 30)

In this model, while the exploration phase involves research and an effort to explore the design problem, the generation phase involves the generation of ideas and concepts, and the evaluation phase involves criticisms and refinements of the generated ideas. Finally, the communication phase involves the presentation and description of the design to the producer (Cross, 2008).

Although the diagrammatic representations of the product design process help to understand the activities that are conducted within the process, they fail to represent the degree of complexity of the process. Apart from the represented phases, the process includes iterations, information handling, and abandoning (Wright, 1998). Furthermore, the fact that the phases are presented as structured and ordered does not mean that every designer should follow these phases in the exact structure and order in order to reach a solution. Besides, it does not guarantee that following these phases in the right direction will result in a successful solution (Baxter, 1995; Cross, 2008).

Many other researchers have offered various models of the design process. French (1985) offered a more detailed model of the process in which he represented four main activities and four outputs. His model starts with a statement of a need and continues with an analysis of a problem considering this need. After making the problem statement, he offers to make conceptual designs followed with a selection of these concepts. Following the determination of the concept, he offers to make embodiment solutions following with design detailing and production of working drawings (French, 1985).

Baxter (1995), Ulrich and Eppinger (2012), and Aspelund (2014) offered similar models that consist of phases that start with either the recognition of a need, an opportunity or an inspiration, followed by a design specification or concept development phase. After this phase follows a refinement phase that includes embodiment design or detail design, and finally takes place the production phase.

In brief, the design process ideally consists of four primary phases: research and planning, idea/concept generation, evaluation and refinement, and finalization.

- Within the research and planning phase, background research about the project is conducted, the design problem is analyzed, and a project brief is prepared that identifies the target, goals, and constraints regarding the expected outcome. This phase serves as a guide for the forthcoming phases of the design process.
- Within the idea generation/concept development phase, designers offer various solutions to the defined problems. It is important to explore many alternatives regarding the project within this phase.
- Within the evaluation and refinement phase, it is expected to evaluate the offered ideas and concepts offered in the previous phase and make the necessary refinements on selected ones.
- Finally, the selected ideas are developed in terms of design and finalized for production. The finalization of a project can be a presentation, an exhibition, or production (Aspelund, 2014; Ulrich & Eppinger, 2012).

Among the phases of the design process, it is indicated that the concept development phase is one of the most critical phases as it shapes the whole process of product development and eventually the final product. This phase is chosen as the focus of this thesis. This phase is also called the idea generation phase, and it will be mentioned as such in the rest of the thesis.

2.1.3.1 Idea Generation Phase

Within the design process, generally, an idea generation phase comes after the research phase. This is the phase in which several alternatives for the functional and styling principles of the product are developed, and that demands the greatest creativity among the phases of the design process. Within the idea generation phase, designers are expected to generate as many design alternatives as possible without being critical (Aspelund, 2014; Baxter, 1995), therefore this effort also requires a certain process to be followed.

The idea generation process is evaluated as having the highest impact on the quality of the final design solution. Without an efficient idea generation process, the remaining phases would be built upon a weak base; therefore, designers may not have the opportunity to reach a desired solution at the end (Christian et al., 2012; Corremans, 2011; Shroyer, Lovins, Turns, Cardella, & Atman., 2018).

2.1.3.2 Instruments of the Idea Generation Process

People may think that designers deal only with computers in this digital era. However, freehand sketching is a powerful tool for designers, especially for the idea generation phase. Before computers, sketching covered the whole design process, however, through the creation of computers, the success of rendering pushed sketching towards the early phases of the process the way that it is being used in idea generation (Eissen & Steur, 2012).

To make sketches, designers only need a pencil and paper. Therefore, it is a cheap but effective process. Computers can be used during the idea generation process as well. However, since one of the purposes of idea generation is to generate as many ideas as possible, using computers to visualize an idea is a more time-consuming activity compared to sketching. Moreover, sketching enables designers to make refinements on it; however, rendering is something like a definite and unchangeable output. Therefore, using computers in the subsequent phases of the design process is more appropriate (Briggs et al., 2012; Eissen & Steur, 2012; Waanders, Eggink, & Mulder-Nijkamp, 2011).

Apart from visualizing the ideas in mind, through sketching designers also;

- Communicate with others. Drawing is like a language. Describing an idea to other people is more comfortable using drawings rather than words (Tovey, Porter, & Newman, 2003; Van Eck, 2015).
- Documents the ideas in mind. It is a fast and efficient way to record the ideas as they come to mind (Schenk, 2014; Tovey, 2012).

- Generate new ideas. While making sketches, new ideas come to mind that can be explored through further sketches (Goldschmidt, 1994; Tovey et al., 2003; Waanders et al., 2011).

2.1.3.3 Features of a Fruitful Idea Generation Process

According to researchers, the design process contains two kinds of manners: divergent and convergent. While a divergent manner requires the generation and exploration of several ideas in the search for concepts, a convergent manner requires an evaluation of and selection among the generated alternatives (Corremans, 2011; Lawson, 2005; Liu et al., 2003; Shah et al., 2003). The design process may contain either a divergent step followed by a convergent step or multiple divergent and convergent steps that happen successively (Figure 5).

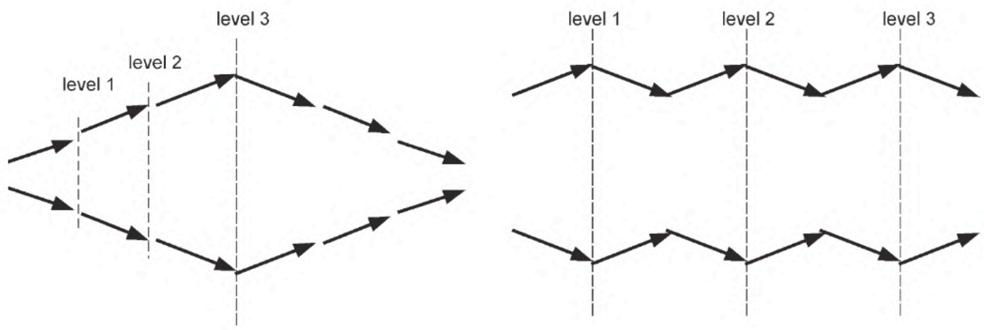


Figure 5. Divergent and convergent steps within the design process (Liu et al., 2003, p. 346)

Among these manners, the divergent manner is suitable for the idea generation process. Designers should generate many design alternatives to create a diverse pool of options to evaluate and select from inside in the following phases of the design process. A common understanding in the literature is that the chance of reaching a better solution increases when more alternatives are considered (Christian et al., 2012; Corremans, 2011; Shah et al., 2003). This situation is similar with the *double diamond model* of design thinking. Design thinking is an approach that places the user in the center of its strategy through adopting a multidisciplinary collaboration to produce innovative products, services, processes, systems and businesses (Menial & Leifer, 2011). The double diamond model offered by Design Council presents two successive divergent and convergent steps that comprise of four phases: discover, define, develop and deliver (Figure 6). While the phase of discover requires an investigation about the problem, the phase of define requires a synthesis and a problem definition regarding the gained information from the discovery phase, the phase of develop requires the generation of various solutions in response to the design problem and the final phase, deliver, requires the testing and selection of the best alternative.

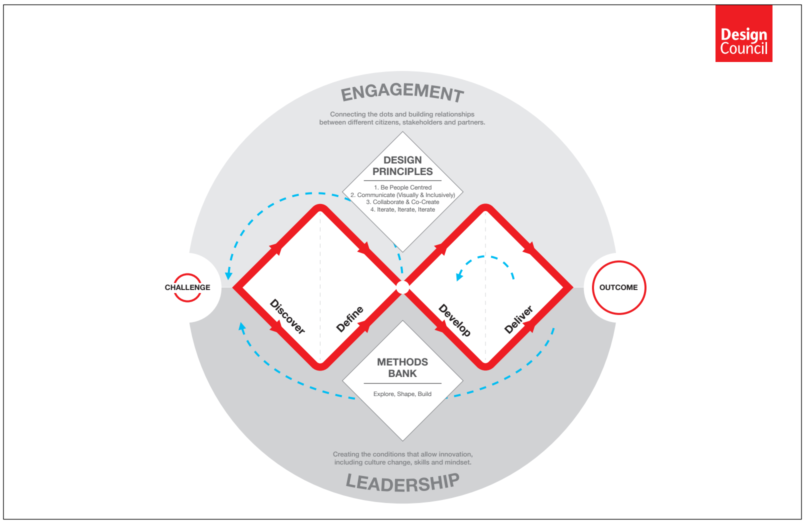


Figure 6. The double diamond model of design thinking (https://www.designcouncil.org.uk/news-opinion/what-framework-innovation-design-councils-evolved-double-diamond

2.1.3.4 Design Solution Space

The whole of the generated ideas in the idea generation process composes a theoretical space named the *design solution space.* In this solution space, there are obvious ideas as well as novel ideas. Obvious ideas are the ones that can be thought of quickly by most people. However, novel ideas require more effort to discover. These novel ideas are the ones that enlarge the boundaries of the design solution space and create new possibilities for the forthcoming phases of the design process and final solution (Figure 7). Studies show that there is a significant connection between the size and variety of the design solution space and the quality of the final design solution (Christian et al., 2012; Saunders & Pourmohamadi, 2009; Shah et al., 2003).

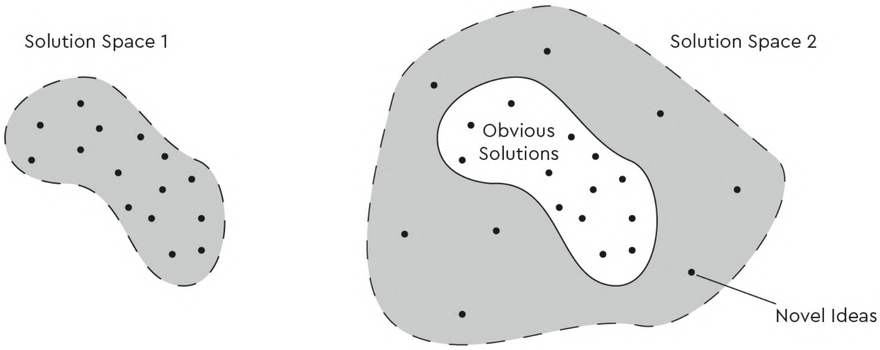


Figure 7. Novel ideas enlarge the boundaries of the solution space

To enlarge the design solution space, designers generally refer to solutions from previously solved similar design problems and try to adapt these solutions to the related design problem (Sarkar & Chakrabati, 2017). This act of searching for an inspiration harbors a risk, which is called fixation.

Fixation is a term that belongs to the experimental psychology literature. It is an effect in which being exposed to examples, or certain aspects of an object might hinders the generation of creative ideas and leads to the offering of similar solutions like those in the exposed examples one is exposed to (Gonçalves et al., 2014; Pertulla & Liikkanen, 2006; Purcell & Gero, 1996; Vasconcelos & Crilly, 2016). Apart from becoming attached to existing products, designers might also become attached to an initial idea that they have generated themselves, and cannot generate alternatives (Christian et al., 2012; Linsey et al., 2010). Therefore, fixation should be eliminated in order to foster divergent thinking and generate novel and various ideas.

2.2 Nurture of Design

As the nature of design moved from the traditional craft-based activities to the modern industrialized activities, the nurture of design presented a progressive move from workplaces into universities. Nowadays, it is commonly accepted that designers need a formal instruction and an academic study that is conducted in an educational institution (Cordan, Görgüş, Numan, & Çinçik, 2014; Dikmen, 2011; Lawson, 2005) in order to train in the profession and gain professional competence.

2.2.1 Setting of the Design Education

In many disciplines, the courses in universities are conducted in a typical teacher-centered classroom environment where instructors give lectures and assign homework and evaluate the performance of the students by exams (Karslı, 2015). However, design education is mainly conducted in studios where there is an interactive environment where students can share intellectual and social processes and get feedback and guidance from their instructors as well as from their classmates (Güngör, 2005).

In the design studio, students are expected to learn by doing, by solving hypothetical design problems that are assigned by their instructors (Dorst & Reymen, 2004; Lawson, 2005; Oh, Ishizaki, Gross, & Do, 2013). While instructors can be seen as masters, the students can be seen as apprentices as the instructors transfer their knowledge and experiences to students. Under the guidance of a master, students have the opportunity to solve design problems actively and explore new solutions (Schön, 1984). Another role of the instructors claimed by Dutton (1991) is the role of the user. While instructors (users) evaluate the projects of the students (designers), they enable them to look from the perspective of the user and orient the product accordingly.

Furthermore, the design studio is the place where students have the opportunity to practice for real-life situations: the processes of the projects composed of phases of research, idea generation, evaluation, and communication are mainly the same as what the students will encounter with while working as an industrial designer after they graduate (Afacan, 2012).

2.2.2 Aim of the Design Education

Through bringing real-life situations into the design studio, design education aims to bring students to a certain level of design ability before they graduate. In his pioneering article, Cross (1990) clarifies these abilities as

- producing novel ideas and extraordinary solutions;
- working with uncertain situations and incomplete information;
- using imagination and foresight to overcome practical problems;
- making drawings and modeling to solve design problems;
- working on ill-defined problems;
- adopting strategies that are solution oriented;
- adopting inductive and deductive thinking; and
- using visual media to communicate.

According to Durling, Cross and Johnson (1996) and Kuloğlu and Asasoğlu (2010), one of the important objectives of design education is to bring students the ability of perceiving, interpreting and communicating the environment differently. This objective can be achieved through creative thinking. Supplying students design problems in which they can perceive and interpret the concepts in an extraordinary way enables them to become more creative.

According to Torrance (1969), creativity is looking and thinking from a new perspective by which original and unknown ideas are created, and design education should place creativity in the hearth of their program. Despite the long-elapsed time since Torrance has presented the importance of creativity, it is still significant nowadays. A study conducted by Cartier (2011) presents that most of the 4th year students prioritize creativity in design education and they demand to experience more methods to develop creativity.

Many researchers argue that creativity is a skill that can be developed through education. While Denel (1981) interprets creativity as a skill that is not hereditary, and Lawson (2005) interprets it as a form of thinking, both arguing that it can be taught, acquired and improved.

Through obtaining design knowledge and skills and building a repertoire of experiences that can be used in encountered design problems, design students make way to become an expert designer (Dorst & Reymen, 2004). Through adopting cognitive psychology, Dreyfus and Dreyfus (1980) developed a model that represents skill acquisition. Within this model, skill acquisition consists of five stages: novice, competence, proficiency, expertise, and mastery. Corresponding mental functions of these skill levels are presented in Table 1. As presented, each skill level requires development in a mental function, and these developments lead to reaching mastery in a discipline.

Table 1. Mental functions of the skill acquisition model (adapted from Dreyfus & Dreyfus, 1980)

Skill Levels / Mental Functions	Novice	Competent	Proficient	Expert	Master
Recollection	non-situational	situational	situational	situational	situational
Recognition	decomposed	decomposed	holistic	holistic	holistic
Decision	analytical	analytical	analytical	intuitive	intuitive
Awareness	monitoring	monitoring	monitoring	monitoring	absorbed

Over the years, the names of the skill levels have changed, and in 2004, took their final form as novice, advanced beginner, competent, proficient, and expert (Dreyfus, 2004). As students move from the novice to the expert level, they start to gain an awareness and a holistic approach, and solve the encountered design problems intuitively, without knowing exactly how they do it (Cross, 2004). Within the expert level, the actions in the design process become automatic steps and routine practices. Thus, expert designers can easily overcome complex design problems (Corremans, 2011; Cross, 2008; Dorst, 2008; Van Dooren, Boshuizen, Van Merrienboer, Asselbergs, & Van Dorst, 2013).

Design education aims to enable the factors that make the students move from the novice level to the expert level. Although there are many contributing factors within this aim, such as aptitude of the students, design curriculum, effectiveness of the learning environment, the expertise of the instructors (Curry, 2014), this thesis focuses on the factor of teaching methods and strategies.

As argued by Andreasen (2003), Daalhuizen, Person and Gattol (2014), and Gonçalves et al. (2014), design students should be guided with methods and tools within design education. In this way, they will have a productive learning environment and an opportunity to constitute a method mindset that they can utilize when encountered with new design problems. Furthermore, Methods and tools can be a source to find ways for improving the creativity of students. As Christian et al. (2012), Conradie, Nafzger, Vanneste, Marez, and Saldien (2015), and Goncalves et al. (2014) expressed, design students should be supported with methods and tools in order to inspire them in the creativity process.

2.3 Design Methods

A design method is a plan of action and a way of working to overcome design problems (Wallace, 2011). To guide novice designers, whether novice or expert, in handling the complexity of the modern industrial era and the design activities, various design methods have been offered.

Design methods can be as conventional as drawing and making sketches since it aids the design activity (Cross, 2008; Goldschmidt, 1994; Tovey et al., 2003). However, in the design literature, more unconventional ways are regarded as design methods. They consist of various procedures, techniques, aids, and tools, and they aim to support the design process by bringing rational procedures. While procedures are the descriptions and steps of the method, techniques involve required media for the implementation of the method such as drawing, speaking, and role playing; aids are the supportive equipment and resources of the method such as computers and moderators, and tools are the mediums that are used to enhance the efficiency of the method (Baxter, 1995; Cross, 2008; Jones, 1980; Wright, 1998).

There are various design methods. Some of them are new inventions that are adapted from different disciplines such as management sciences and psychology, some of them are specifically developed and revised in time, particularly for the field of design, and some of them are the formalizations of the techniques that are already used by the designers. In any case, they have two standard features: they formalize some procedures of design activity, and they reveal design thinking (Cross, 2008). Through the formalization of procedures, they aim to widen the solution space, enhance creativity, and eliminate fixation. Besides, through revealing design thinking, they aim to reflect the thoughts into charts and diagrams in order to both document them and communicate with others.

Jones (1980) regarded the designer as an explorer who searches for the unexplored treasures of a solution space against a design problem. Since idea generation is the phase in which various solutions are generated, and it is regarded as the heart and the mysterious and creative phase of the design process, many of the developed design methods focused on this phase and aimed to enhance the effectiveness of idea generation (Aspelund, 2014; Baxter, 1995; Christian et al., 2012; Corremans, 2011; Cross, 2008; Shroyer et al., 2018).

The issue of design methods within design research should be approached through a classification. Several attempts have been made to classify design methods. Jones (1980) grouped 26 methods considering their purposes under four categories that show similarities with the phases of the design process: methods of exploring design situations, methods of exploring problem structure, methods of searching for ideas, and methods of evaluation.

Besides, VanGundy (1988) analyzed 105 design methods and grouped them, considering the phases of the design process. He classifies the methods considering whether they are conducted within a group or individually, whether they are performed verbally or silent, and whether they require forced or free associations. In one respect, he offered to classify design methods considering their procedure, technique, and tools.

Cross (2008) classified design methods into two categories: creative methods and rational methods. This classification is found to be most appropriate, since other attempts group design methods considering the phases of the design process, all the same claiming that they can be used within the other phases of the design process. Therefore, some design methods will be investigated in the following section by using Cross's classification. Creative methods and rational methods should not be seen as opposites. Indeed, they both aim to enhance creativity and offer a way of working to reach better outcomes. They differ by their approaches. While creative methods are freewheeling, rational methods adopt a systematic approach in their procedures.

2.3.1 Creative Methods

Creative methods are the ones that aim to promote creative thinking through creating an appropriate setting to enhance the flow of ideas and to eliminate mental blocks for the purpose of enlarging the solution space (Cross, 2008). The most widely known examples of creative methods are brainstorming, Synectics, and mind mapping (Aurum & Gardiner, 2003; Cross, 2008; Gonçalves et al., 2014; Shroyer et al., 2018; Wright, 1998). Many methods have been developed based on the techniques of these methods.

2.3.1.1 Brainstorming

Brainstorming might be the most well-known design method, transferred from the field of advertising. It was developed by Alex Osborn in 1953, and the main aim of this method is to generate as many ideas as possible (Aurum & Gardiner, 2003; Cross, 2008; Gonçalves et al., 2014; Wright, 1998). It is conducted within a group of four to eight people. Besides, there should be a moderator to manage the session in order to present the problem statement and supervise the procedure (Figure 8).

Figure 8. Photograph of a brainstorming session (Uludag, 2019)

There are four rules in a brainstorming session that were determined by Osborn (1953).

- There should not be any criticism.
- Many ideas should be generated.
- Freewheeling is welcomed.
- The generated ideas should be combined and improved.

The session starts with the presentation of the design problem by the moderator and the members are asked to think a few minutes and write or draw their ideas that pop into their minds. Then the moderator asks members to read or describe some of their ideas to the other members of the group. The quality of the ideas is not essential in this stage of the session, therefore, there should not be any criticism in order not to hinder spontaneity and creativity since the critical thinking tends to suppress the creative thinking (Nutt, 1984). Following this stage, each member is asked to be inspired by and build on the ideas of the other members. Through inspiring, combining, and improving the ideas of the other members, it is aimed to achieve many different ideas. The session should last around 20 to 30 minutes. Following the session, the moderator collects all the ideas and arranges a different session for their evaluation (Aurum & Gardiner, 2003; Cross, 2008; Gonçalves et al., 2014; Wright, 1998).

Many new methods were founded on the base of brainstorming, such as nominal group technique, brainwriting, 6-3-5, c-sketch, and gallery.

2.3.1.1.1 Nominal Group Technique

The nominal group technique (NGT) was developed by Delbecq and Van de Ven in 1971 (Shroyer et al., 2018). It is a variation of the brainstorming method that differentiates in terms of the procedure followed.

NGT starts with the presentation of the design problem by the moderator. The members are asked to generate ideas on their own for a period of time. Then they are asked to share their ideas with the other members. In this process, the moderator writes down all of the ideas on a board. Later, a discussion session starts, and each member is asked to comment on the written ideas. Finally, a ranking session is conducted, and each member is asked to rank their favorite ideas. Through all members declaring their rankings, an overall ranking is achieved (Aurum & Gardiner, 2003; Shroyer et al., 2018).

2.3.1.1.2 Brainwriting

Brainwriting differs from brainstorming in terms of its communication media. While brainstorming requires verbal communication, brainwriting requires written communication (Linsey, Claus, Kurtoglu, Murphy, Wood & Markman, 2011). Based on a design problem, each member of the group writes down their ideas in a specific period of time and hands them over to another member of the group. This process can be repeated several times, and in this way, members have the opportunity to encounter new ideas in each round and offer various combinations and improvements (Baxter, 1995). An advantage of this method compared with the brainstorming was declared by Aurum and Gardiner (2003) as members of the group not having to wait for their turns to comment on the ideas of the others, as is the case in brainstorming. Furthermore, brainwriting offers more anonymous communication than brainstorming. Therefore, members might feel freer while commenting on the ideas of the other members.

2.3.1.1.3 6-3-5

6-3-5 method was developed by Rohrbach in 1969 (Shah et al., 2001). This method presents similarities with brainwriting; however, it brings some rules to the process. While 6 refers to the number of the members in the group, 3 refers to the expected number of ideas in each round, and 5 refers to the minutes that are given for each round. Furthermore, the method offers the usage of a sheet that contains a matrix of cells that have three columns and six rows (Figure 9) (Wright, 1998).

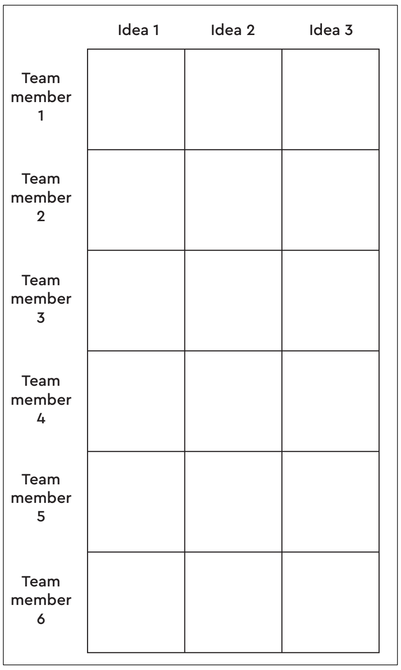


Figure 9. 6-3-5 idea sheet (adapted from Wright, 1998, p.120)

Within this method, members get a sheet, and they are asked to describe three ideas in five minutes by using textual representations. Then members handle the sheets to another member, and they are asked to inspire and develop the ideas that are passed to them. Within each round, members can see and inspire from the ideas of other members. This exchange is repeated for five more rounds, and at the end, a total of 108 ideas have been generated (Linsey et al., 2011; Shah et al., 2001; Wright, 1998).

2.3.1.1.4 C-Sketch

The Collaborative Sketching (C-sketch) method was developed by Shah in 1993 (Shah et al., 2001). This method is almost the same as the 6-3-5 method. However, it requires sketching to describe an idea instead of textual representations. The process proceeds similarly as it is in the 6-3-5- method. The advantage of C-sketch over 6-3-5 was indicated by Linsey et al. (2011) as the usage of sketching making it ambiguous to understand what other members tried to describe in their sketches. This situation may lead to the generation of new ideas due to misinterpretations of the ideas of other members.

2.3.1.1.5 Gallery

Gallery is another method that takes its roots from brainstorming. It is a method that is conducted within a group and it produces visual outcomes such as sketches unlike the nominal group technique, brainwriting, and 6-3-5. Within this technique, members make sketches on their own considering a design problem. After a specific time, they hang their sketches on a wall or put them on a big table in order to discuss them with other members. After the discussion phase, members continue generating ideas on their own through utilizing the inspirations that they have gained by seeing other ideas. Then a review session is conducted again. If needed, idea generation continues, if not, members select the promising ideas for further development (Linsey et al., 2011; Shah et al., 2001; Wright, 1998). One advantage of the gallery method over C-sketch was indicated by Wright (1998) as it gives the opportunity to see all the proposed ideas of each member simultaneously instead of seeing the ideas of one member in each session.

2.3.1.2 Synectics

Synectics is another most well-known design method that follows brainstorming. It was developed by William J. J. Gordon in 1961 (Gonçalves et al., 2014). Synectics adopts the usage of analogies. Similar to brainstorming, Synectics is conducted within a group. However, it differentiates from brainstorming by demanding members to work collaboratively to reach to a solution rather than generating many ideas (Cross, 2008).

The Synectics session lasts much longer than a brainstorming session and demands members to use specific types of analogies, which are direct analogies, personal analogies, symbolic analogies, and fantasy analogies (Baxter, 1995; Cross, 2008).

- Direct analogies involve the usage of biological analogies in order to find a solution to a design problem. For example, plant burrs gave inspiration to the Velcro fastening.
- Personal analogies require members to put themselves in the position of the product and imagine what it would be like to function in the way that the product is required to. For example, what would it be like to be a door handle?
- Symbolic analogies require members to use poetic metaphors to find solutions to design problems. For example, the wildness of a sports car.
- Fantasy analogies require members to try to imagine magical or impossible wishes to find solutions to design problems. For example, we need a door that can disappear when it recognizes us.

The usage of such analogies is expected to lead to unusual and novel solutions. As it is in the case of brainstorming, many new methods were developed based on Synectics, such as TRIZ and SCAMPER.

2.3.1.2.1 TRIZ

The TRIZ method was developed by Genrich Altshuller in 1984. The name of the method represents the first letters of the Russian word group which can be translated to English as the Theory of Inventive Problem Solving (Gonçalves et al., 2014).

The TRIZ bases on the analysis of existing patents. Altshuller and his colleagues investigated more than a million patents in different fields in order to identify similar patterns that are used in the problem-solving process. There were 40 similar patterns that were identified such as division, taking out, asymmetry, merging, inversion, strong oxidants, porous materials, and feedback principle (Figure 10). All of these aims to offer designers some invention principles that they can utilize while trying to find solutions to related design problems. (Christian et al., 2012; Gonçalves et al., 2014; Shah et al., 2000).

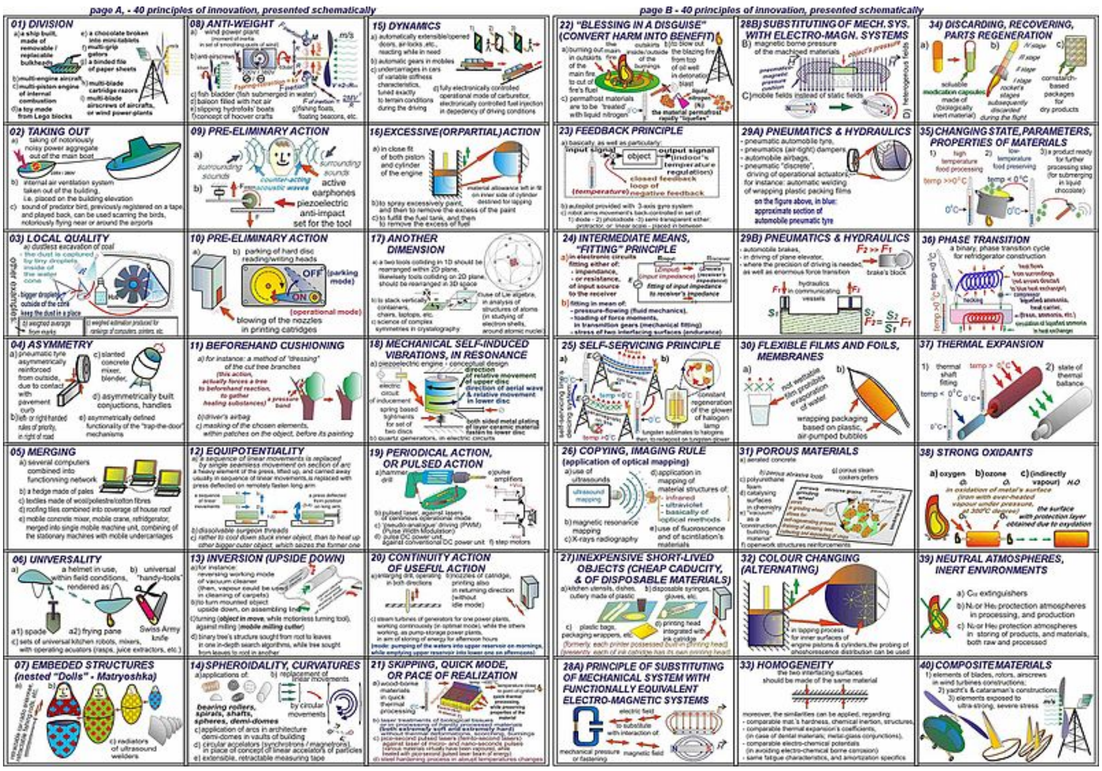


Figure 10. 40 principles of TRIZ (retrieved from https://commons.wikimedia.org/wiki/File:40_principles_of_TRIZ_method_225dpi.jpg

2.3.1.2.2 SCAMPER

The SCAMPER method was developed by Bob Eberle in 1971. It is an acronym of the words substitute, combine, adapt, modify/magnify/minify, put to other uses, elaborate/eliminate, and reverse/rearrange (Baxter, 1995; Moreno, Blessing, Yang, Hernandez & Wood, 2016).

SCAMPER offers a checklist that can be utilized in the design process to stimulate or transform ideas. The items in the checklist make the designer to evaluate various modifications of the product in order to find a better solution (Baxter, 1995; Moreno et al., 2016). An example of a SCAMPER work that explores solutions for a door latch is illustrated in Figure 11

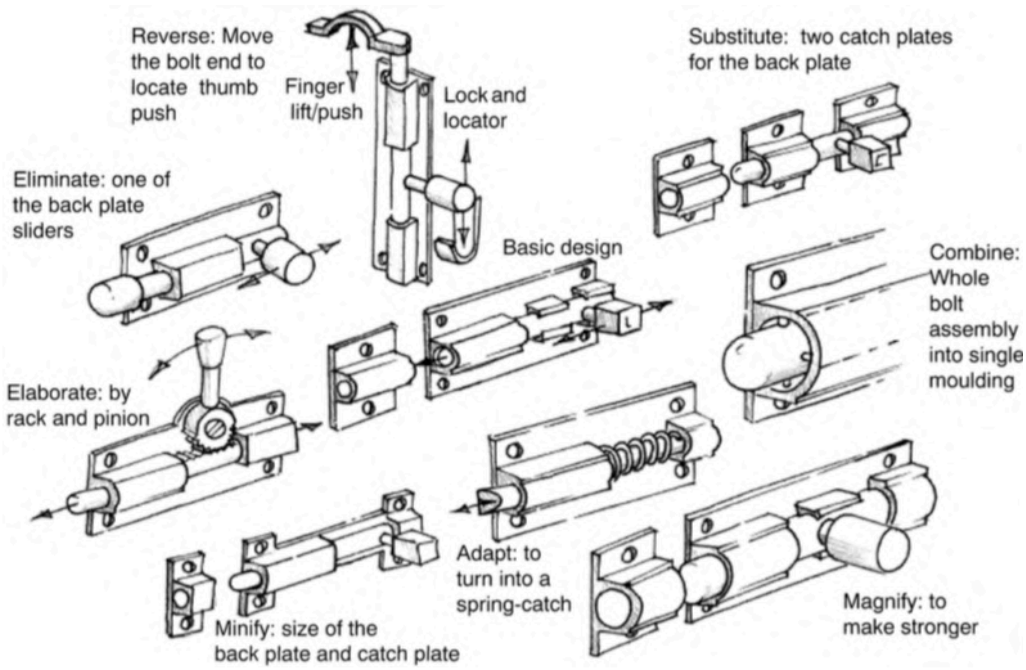


Figure 11. An example of a SCAMPER work (Baxter, 1995, p. 90)

2.3.1.3 Mind Mapping

Another creative method is mind mapping. This method helps to externalize the related ideas in the brain into a large sheet of paper through making connections between concepts. The method can be conducted by individuals or within a group. A main idea or the design problem is written in the center of the paper and by branching out sub-topics an overall map that shows the related concepts of the design problem is obtained. Seeing the overall map with connections between concepts, helps the generation of new ideas by enabling the creation of new associations that might not be thought of before (Aurum & Gardiner, 2003; Gonçalves et al., 2014;

Wright, 1998). Figure 12 presents an example of a mind map that was produced for the design of the Trent 800 engine by Rolls Royce engineers (Wright, 1998).

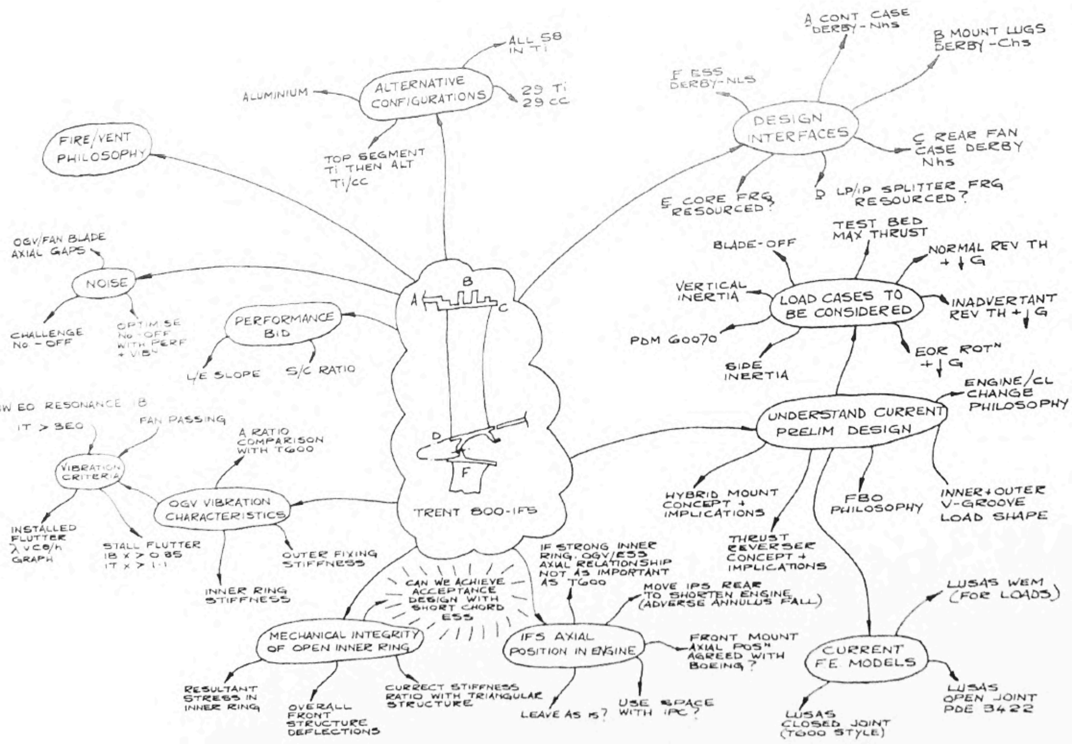


Figure 12. A mind map for the Trent 800 engine by Rolls Royce engineers (Wright, 1998, p. 123)

2.3.2 Rational Methods

Rational methods have aims similar to creative methods, these are increasing creativity, widening the solution space and offering a way of working in terms of design activity to reach better outcomes. However, rational methods adopt a more systematic approach compared to creative methods. Furthermore, rational methods are more commonly regarded as design methods than creative methods (Cross, 2008). Indeed, even the methods such as 6-3-5, c-sketch, TRIZ and SCAMPER that were founded on creative methods, can be regarded as rational methods since they bring a systematic approach to the process through offering a matrix, or such specific sources that allow inspiration. The most widely known examples of rational methods are the checklist, objectives tree, function analysis, morphological chart, and weighted objectives.

2.3.2.1 Checklist

Checklist is a formalization of a list of items that need to be remembered, completed, or achieved. It externalizes the thoughts into items of a list that can be checked-off as they are completed. It can be conducted either individually or within a group. Each group member may contribute to the preparation process of the checklist. Besides, members can divide the tasks within the checklist among themselves. This method can be conducted at the beginning of the design process in order to explore or analyze the design problem, it can be conducted within the idea generation phase in order to generate various design alternatives that were indicated in the checklist, or it can be conducted within the evaluation phase to assess whether the generated ideas have met the design requirements (Cross, 2008; Gonçalves et al., 2014).

2.3.2.2 Objectives Tree Method

As mentioned earlier, design problems are ill-defined problems and they are vague, complex, unstable and inconsistent (Baxter, 1995; Cross 2008; Lawson, 2005; Ulrich & Eppinger, 2012). In this respect, the designer needs to clarify the design problem and transform it into a clear statement of objectives. For this purpose, the objectives tree method was developed.

Some design objectives are available in the design brief. However, others should be obtained through asking to the client or through a brainstorming session. As the objectives are expanded, it will be seen that some objectives present greater importance than the others. Through making a ranking order, it will be possible to place the objectives into a tree diagram. At the end, it will be possible to understand the design problem deeply through clarified design objectives, sub-objectives, and the connections between them (Cross, 2008). An example of an objective tree that presents the objectives of a new transport system (Cross, 1008) is given in Figure 13.

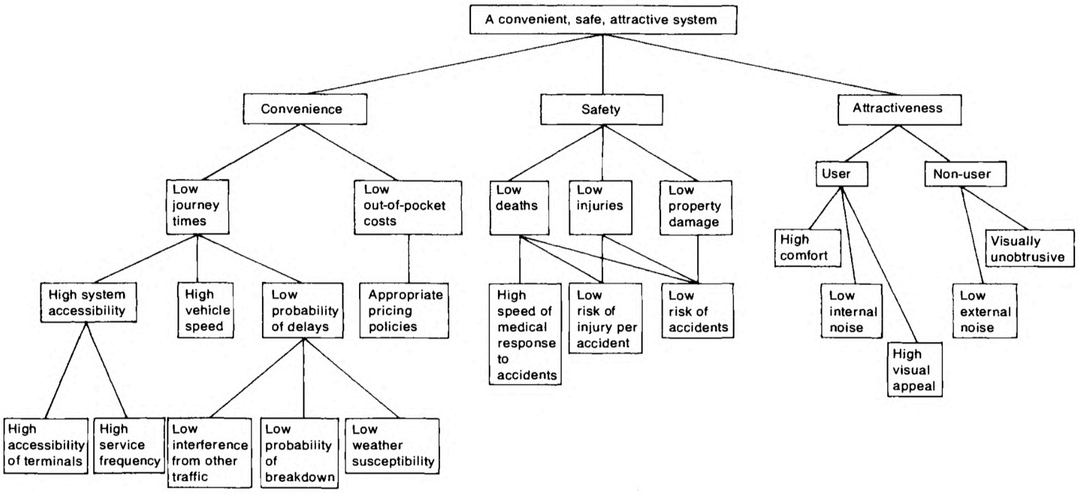


Figure 13. An example of an objectives tree (Cross, 2008, p. 69)

2.3.2.3 Function Analysis Method

The function analysis method serves for the establishment of the functions that a product must do. First, it needs the determination of an overall function for the product. Then, the overall function is broken down into a set of sub-functions. These sub-functions are expressed with a statement comprising a verb and a noun or adjective, such as separate waste, control wirelessly, and increase volume (Cross, 2008; Gonçalves et al., 2014). The function analysis method should be conducted beforehand the idea generation phase and the process becomes more beneficial if it is supported with the morphological chart method afterwards.

2.3.2.4 Morphological Chart Method

The morphological chart method was developed by Fritz Zwicky (Ritchey, 2005). The aim of this method is to generate various sub-solutions for a design problem by considering its sub-functions, and at the end to make a combination of the generated sub-solutions for an overall solution (Börekçi, 2018; Cross, 2008; Wright, 1995). The method can be conducted either individually or as a group.

The morphological chart method offers the usage of a matrix that is composed of various columns and rows. At the beginning, the designer is asked to determine the sub-functions of the product and write them down into the cells of the first column. Next, considering these sub-functions, it is expected to offer ideas for sub-solutions and write them down or sketch them into the cells of the rows. Finally, it is expected to select and combine sub-solutions that are offered for different sub-functions in order to achieve an overall solution (Börekçi, 2018; Cross, 2008; Wright, 1995). An example of a filled-in morphological chart that investigates solutions for a potato harvesting machine (Cross, 2008) is given in Figure 14.

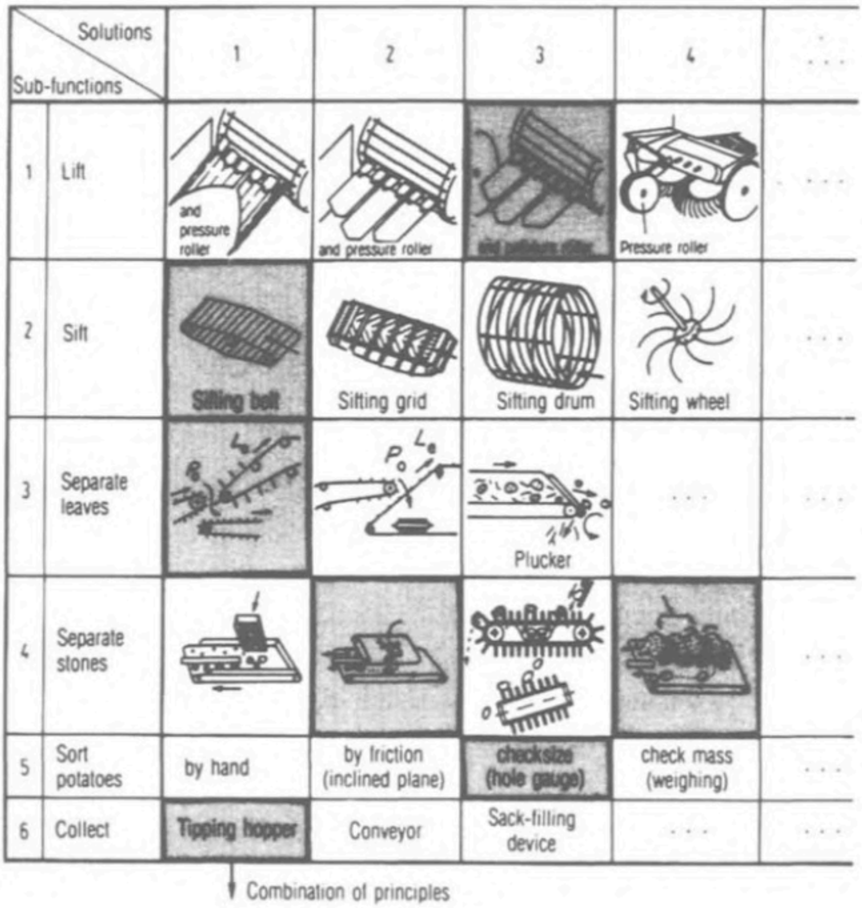


Figure 14. An example of a morphological chart (Cross, 2008, p. 128)

2.3.2.5 Weighted Objectives Method

The weighted objectives method serves for the evaluation of different design solutions and determination of the best alternative. For this purpose, at first, the design objectives are clarified. If they are already determined at the beginning of the design process, they should be reevaluated again. Later, the objectives are rank ordered, and a relative weighting is assigned to each objective. Then, each design alternative is evaluated considering the objectives and is given a quality score. Finally, each quality score is multiplied with the weight score of the objective and an overall score for each design alternative is calculated. In this way, it is possible to see the score of each design alternative and decide on the best alternative. The end result will be a table that includes the objectives and various associated scores (Cross, 2008). An example of a weighted objectives table that evaluates a joint design is given in Figure 15.

Design criteria	Weight	Design 1		Design 2		Design 3	
	W*	S	U	S	U	S	U
1 Cost							
Materials	6	8.5	0.51	5.5	0.33	7	0.42
Seals	2	8	0.16	8	0.16	8	0.16
Bearings	4	9	0.36	5	0.2	8	0.28
Washers	1	7.5	0.07	7.5	0.07	7.5	0.07
Squeeze packing	2	9	0.18	9	0.18	9	0.18
Bolts	1	9	0.09	9	0.09	8	0.08
Labour	6	8	0.48	5	0.3	7.5	0.45
Tools and equipment	6	8	0.48	5	0.3	7.5	0.45
Indirect cost	20	8.5	1.7	7	1.4	7.5	1.5
Marketing	2	7	0.14	8	0.16	9	0.18
2 Performance							
Sealing	9	8	0.72	8	0.72	8	0.72
Smoothness	9	5	0.45	9	0.81	8.5	0.76
Alignment	6	5	0.3	7	0.42	8	0.48
Growth formation	2	8	0.16	8	0.16	8	0.16
Maintenance	4	8	0.32	8	0.32	8	0.32
3 Manufacturing							
Ease	5	8.5	0.42	7	0.35	7.5	0.37
Time	5	9	0.45	4.5	0.22	7.5	0.37
Assembly	5	9	0.45	6.5	0.32	8	0.4
4 Strength	5	8	0.4	9.5	0.47	9.5	0.47
The overall utility			7.84		6.98		7.82

*W = percentage weight of each criterion (from 100)
S = score of quality of each design (from 10)
U = utility (weighted score) of design = W × S

Figure 15. An example of a weighted objectives table (Cross, 2008, p. 155)

2.4 Design Tools

As mentioned earlier, design methods consist of various procedures, techniques, aids, and tools. Among these variations, tools are the essential mediums that enhance the efficiency of a design method. Besides, design tools have the potential to become a design method on their own (Haritaipan, 2019; Roy & Warren, 2019; Wölfel & Merritt, 2013; Yoon, Desmet, & Pohlmeyer, 2016).

There are various design tools such as card decks, boards, posters, and worksheets (Haritaipan, 2019). Among these tools, cards are the most popular ones. According to a study conducted by Haritaipan (2019) 89% of the 112 design tools that were investigated were card-based design tools. Cards are preferred as a design tool since they are tangible, simple and easy to manipulate without the need of a moderator, and they facilitate creativity, communication, information and methods (Beck, Obrist, Bernhaupt, & Tscheligi, 2008; Roy & Warren, 2019; Wöfel & Merritt, 2013; Yoon et al., 2016). Carneiro et al. (2012), the developers of i/o Cards, discuss the strengths of card-based design tools as them being supportive for inspiration, communication, and organization of ideas. Besides, Ola Möller (cited in Roy & Warren, 2019), the developer of the MethodKit cards, explains the strengths of card-based design tools as them providing summarized information and a connection between unstructured tools such as Post-its and structured information such as manuals.

The creation of card-based design tools dates back to 1952 through the development of *The House of Cards* by Charles and Ray Eames. The card deck involves 54 cards on which various objects are depicted. These were the favorite objects of the Eames' that aim to stimulate and improve creative thinking (Roy & Warren, 2019). Following *The House of Cards,* a limited number of card-based design tools were developed between the 1960s and 2000s. However, after 2000, a tremendous increase in the development of card-based design tools occurred. Many companies, designers, and academicians developed various card-based design tools, and many researchers conducted studies for the classification of these tools in order to guide designers in deciding on which to use (Haritaipan, 2019; Roy & Warren, 2019).

Miemis (2012) developed a classification for 21 card-based design tools. She categorized them considering whether they are related to design principles, user experience, communication, visioning, or ideation. Furthermore, Roy and Warren (2019) classified 155 card-based design tools, considering whether they stimulate creative thinking through prompts, give information, suggest design methods, provide concepts for context related design problems, or provide checklists. Lastly, Haritaipan (2019) classified 112 design tools (89% of them were card-based design tools) into two categories: tools that provide inspiration and expand solution space, and tools that call for action. In the light of these classification attempts, it was determined to present some of the leading design tools under two main and six sub-categories. The design tools will be presented considering whether they are *idea triggering design tools* that involve *random triggers*, *context related triggers*, or *instructions*; or *guiding design tools* that either involve *tactics*, *checklists*, or *information.*

2.4.1 Idea Triggering Design Tools

Idea triggering design tools aims to trigger solutions previously unthought of through some prompts or instructions in order to aid the generation of novel ideas and enlargement of the design solution space. The design tools in this category divide into three sub-categories: random triggers, context related triggers and instructors.

2.4.1.1 Random Triggers

The design tools under this category provide random triggers in the form of words, questions, and associations that are written or illustrated on cards in order to break the usual thinking pattern of the designer. Since these tools provide random triggers, they have the potential to be utilized in any design problem (Haritaipan, 2019; Roy & Warren, 2019).

Some of the most widely known examples of design tools in this category are Creative Whack Pack, Thinkpak: A brainstorming card deck, and Designercise.

Creative Whack Pack

Creative Whack Pack is a card-based design tool that is consists of 64 cards. It was developed by Roger von Oech in 1989. The cards consist of a heading that makes a suggestion, an illustration related to that suggestion, a text that gives details about the suggestion, and a question that triggers the designer to question his/her ideas (Figure 16) (Christian et al., 2012; Roy & Warren, 2019; Smith, 1998).

Figure 16. Cards from the Creative Whack Pack design tool (retrieved from https://za.pinterest.com/lennybach/creative-whack-pack/)

Thinkpak: A Brainstorming Card Deck

Thinkpak: A Brainstorming Card Deck consists of 56 cards that aim to enhance creativity, idea generation and evaluation. It was developed by Michael Michalko in 1994 through getting inspiration from the SCAMPER design method. By using SCAMPER words such as substitute, combine, adapt, magnify and eliminate, the cards ask designers some questions regarding their design (Figure 17) (Lucero & Arrasvuori, 2010; Roy & Warren, 2019).

Figure 17. Cards from the Thinkpak: A Brainstorming Card Deck (retrieved from http://thriftynickelusa.com/Training-116555/Management-&-Leadership-Business-&-Investing/)

Designercise

Designercise is a Kickstarter project that was developed by Leyla Acaroğlu in 2015. It is a card-based design tool that consists of random prompts in various categories such as scenario, question, object, emotion, innovation, problem, and think of one (Figure 18). Through picking various cards, Designercise aims to bring disruptions into the thinking process in order to foster creativity and divergent thinking (Haritaipan, 2019).

Figure 18. Designercise cards (retrieved from https://www.kickstarter.com/projects/489540660/designercise-a-creative-thinking-game-and-ideation)

2.4.1.2 Context Related Triggers

The design tools under this category provide triggers that are related to specific fields. They aim to trigger ideas and change the perspective of the designers within specific contexts. Therefore, compared with the random trigger tools, the use of context related trigger tools is more limited (Haritaipan, 2019; Roy & Warren, 2019).

Some of the most widely known examples of design tools in this category are IoT Service Kit and PLEX Cards.

IoT Service Kit

Iot Service Kit is a board game that was developed by Paul Houghton and Ricardo Brito, designers of the Futurice Company. The kit is composed of maps, tokens and cards, and aims to foster creativity by generating interactive scenarios within the context of internet-of-things (IoT) (Figure 19). Through the usage of maps, tokens and cards of the IoT Service Kit, designers have the opportunity to assess needs, explore users, and generate solutions (Haritaipan, 2019).

Figure 19. IoT Service Kit (retrieved from https://iotservicekit.com)

PLEX Cards

PLEX cards were developed by Andres Lucero and Juha Arrasvuori in 2010. They are composed of 22 cards that aim to give inspiration while designing for playfulness. The name PLEX evolves out of the words *playful experience.* The cards contain 22 different prompts and their descriptions (Figure 20) (Lucero & Arrasvuori, 2010).

Figure 20. Example of a Plex Card (Lucero & Arrasvuori, 2010, p.33)

2.4.1.3 Instructors

The design tools under this category demand designers to execute some actions in order to foster creativity and generate new ideas. The objectives of these tools are to change the perspective of the designer on the design problem (Haritaipan, 2019; Roy & Warren, 2019).

Some of the most widely known examples of design tools in this category are Oblique Strategies and Design Heuristics.

Oblique Strategies

Oblique Strategies was developed by Brian Eno and Peter Schmidt in 1975. Oblique Strategies consists of 55 cards that involve phrases on them, demanding the designer to perform some actions (Figure 21). Some of the phrases are "*Turn it upside down", "Ask your body",* and *"Use an old idea".* The cards aim to enhance divergent thinking and stimulate new ideas (Haritaipan, 2019; Roy & Warren, 2019; Wölfel & Merritt, 2013).

Figure 21. Cards of the Oblique Strategies (retrieved from https://www.amazon.com/Oblique-strategies-hundred-worthwhile-dilemmas/dp/B0000EEZG9)

Design Heuristics

Design Heuristics was developed by James L. Christian, Shanna R. Daly, Seda Yilmaz, Colleen Seifert and Richard Gonzalez in 2010. Through observing expert designers and analyzing award-winning products, they determined 77 heuristics and transformed them into a card-based design tool. They position design heuristics in between SCAMPER and TRIZ: without being as general as SCAMPER and as specific as TRIZ. There are 77 different instructions on the cards that ask the designer to execute some actions in order to generate novel ideas and enlarge the solution space. On the front side of the cards, there is a phrase that expresses the instruction, an illustration that represents that instruction and a description of that instruction. On the back side of the cards there are some product examples that have utilized this instruction (Figure 22) (Christian et al., 2012; Roy & Warren, 2019; Yilmaz & Seifert, 2011)

Figure 22. A card from the Design Heuristics card set. Left: front side, Right: back side (Christian et al., 2012, p. 464).

2.4.2 Guiding Design Tools

Guiding design tools aim to show directions to designers within the design process by offering methods, providing checklists, or giving information.

2.4.2.1 Tactics

The design tools under this category provide designers with some tactics that are helpful within the design process from the research phase to the evaluation and selection phases. These tools might be generally applicable, as well as context related (Haritaipan, 2019; Roy & Warren, 2019).

Some of the most widely known examples of design tools under this category are Meta Cards and IDEO method cards.

Meta Cards

Meta Cards were developed in 1972 together with the aim of offering tactics to designers in identifying design problems, expanding the solution space, and providing new insights. There are 20 cards on which various tactics and descriptions are available together with relevant illustrations for different phases of the design process (Figure 23) (Roy & Warren, 2019).

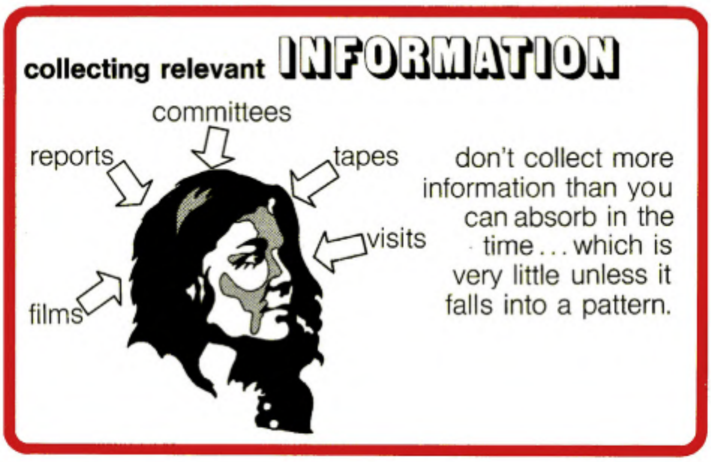


Figure 23. An example of a Meta Card (Roy & Warren, 2019, p. 128)

IDEO Method Cards

IDEO Method Cards are composed of 51 cards that aim to inform designers about different tactics and methods related with human-centered design. Each card presents a different method together with a text that mentions about how and when to use the method (Figure 24). Through presenting various methods, IDEO Method Cards provide ways for designer to empathize with the user in order to foster creativity (Lucero & Arrasvuori, 2010; Roy & Warren, 2019; Wölfel & Merritt, 2013).

Figure 24. Cards from the IDEO Method Cards set (retrieved from https://www.ideo.com/post/method-cards)

2.4.2.2 Checklists

The design tools under this category provide designers with some checklists that are useful in the design process to consider relevant key issues (Haritaipan, 2019; Roy & Warren, 2019). The most widely known example of design tool in this category is MethodKit.

MethodKit

MethodKit, developed by Ola Möller in 2012, is a card-based design tool that provides designers with a checklist by asking questions related to the issues of the industrial design such as functionality, ergonomics, aesthetics, and materials (Figure 25). Starting with a kit mainly for industrial design, new kits have been developed for different topics such as, persona development, lesson planning, workshop planning, app development, kitchen design, and wedding kit, reaching a number of 45 kits (Haritaipan, 2019; Roy & Warren, 2019; Wölfel & Merritt, 2013).

Figure 25. MethodKit (retrieved from https://methodkit.com/shop/methodkit-for-product-development/)

2.4.2.3 Information

The design tools under this category provide designers information related to specific contexts. They aim to advise the designer on various concepts by giving a summarized information (Haritaipan, 2019; Roy & Warren, 2019).

Some of the most widely known examples of design tools in this category are i/o Cards, iD Cards, and Energy Trumps.

i/o Cards

i/o Cards consist of 31 cards that give information on the process of interactive prototyping by presenting information related with the components of an interactive prototyping process such as sensors (humidity, temperature, touch, accelerometer) and actuators (DC motor, RC servo, LED, stepper motor) (Figure 26) (Carneiro et al., 2012).

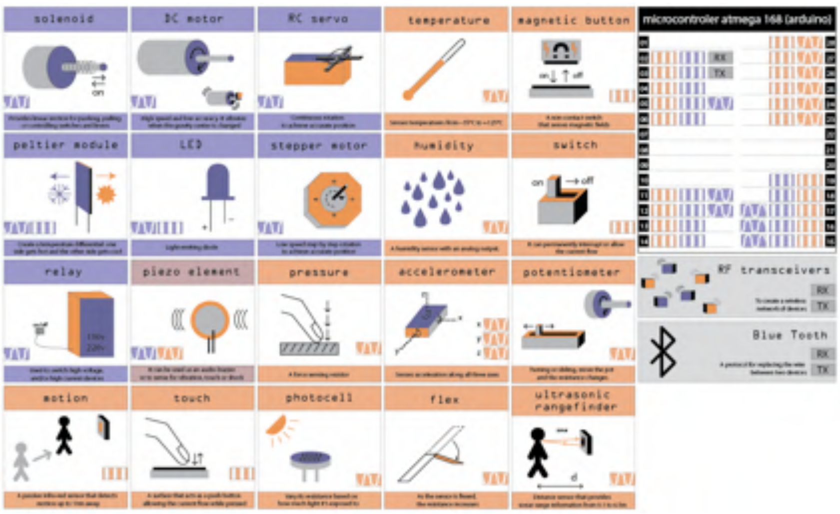


Figure 26. i/o Cards (Carneiro et al., 2012, p. 216)

iD Cards

iD Cards, developed by Mark Evans and Eujin Pei in 2014, introduce a taxonomy of 32 different types of design representations that are used by designers in different phases of the design process (Figure 27). They were developed to inform designers and engineers on the four type of representations (sketches, drawings, models and prototypes) that they use in order to enhance communication between them (Roy & Warren, 2019).

Figure 27. iD Cards in the form of a folable leaflet (retrieved from http://www.eujinpei.com/academic%20projects.html)

Energy Trumps

Energy Trumps is a card-based design tool that consists of 45 cards on which properties of 45 different materials are presented (Figure 28). They present a fast and tangible way of informing the designer about materials and their properties (Haritaipan, 2019).

Figure 28. Cards of the Energy Trump (retrieved from https://agencyofdesign.co.uk/energytrumps/)

2.5 Discussion

This chapter presented the nature, nurture, methods and tools of design. As it was mentioned, design is an activity, a result and a process. Together with the industrial era, design has become a professional activity therefore it needs a formal instruction and an academic study that aims to bring students various abilities such as, dealing with uncertain design problems and bringing novel solutions to them, making drawings, modeling and using visual media to communicate and adopting different strategies in reply to ill-defined problems. In response to help designers and design students in aiding the design process and creative thinking, various design methods and tools have been offered in order to increase the novelty and variety of the generated ideas and enhance the design solution space (Aurum & Gardiner, 2003; Cross, 2008; Gonçalves et al., 2014; Haritaipan, 2019; Roy & Warren, 2019; Wallace, 2011).

2.5.1 Evaluation and Comparison of Design Methods and Tools

As mentioned in this chapter, design methods can be classified as creative methods and rational methods. Both of them aim to enhance creativity and guide designers to reach better solutions. The design methods and tools will be evaluated and compared item by item in the rest of this section.

- While designers can be more independent in the process of creative methods compared with the rational methods, they should adopt a systematic approach in rational methods.
- Brainstorming, its variations such as NGT, Brainwriting, 6-3-5, C-Sketch and Gallery and Synectics require a group of people for the implementation, other kinds of the creative methods such as TRIZ, SCAMPER and Mind Mapping and the whole range of rational methods do not require other people for the implementation.
- While brainstorming and its variations require a moderator to manage the session, other methods do not require it.

- 6-3-5, C-Sketch and the Morphological Chart method are the only ones that utilizes a matrix during the implementation among the presented ones. Other methods just require a paper and a pencil.
- The whole range of creative methods, together with the Morphological Chart method can be evaluated as the methods for generating new ideas. Other methods offer instructions and checklist to keep the design process under control.
- Idea triggering design tools presented in this chapter are the combination of creative and rational methods as they aim to generate new ideas by adopting a systematic approach.
- Guiding design tools represented in this chapter show similarities with the rational methods as they offer a way of working and give information.

2.5.2 Criticisms of the Available Design Methods and Tools

There are some criticisms regarding the available design methods and design tools in the literature, as they have not been tested well enough. While Haritaipan (2019) argues that most of the available tools have never been tested experimentally, Roy and Warren (2019) argue that the available methods and tools evaluated by getting feedback from the users on whether they benefitted from it or not rather than evaluating design outcomes experimentally. However, due to the complexity and ill-structured nature of design problems and the design activity, it is hard to express learning outcomes in words (Dorst & Reymen, 2004). Therefore, the usability, applicability, and effectiveness of a method or tool should be experimentally tested by evaluating the design outcomes (Corremans, 2011). Furthermore, Kris (2000) and Haritaipan (2019) criticize existing tools as they provide triggers that already exist such as objects, living creatures, and emotions, or provide instructions that can be applied easily by the designer without the utilization of the design tool. However, they argue that, based on cognitive studies, creative thinking should be supported with illogical thinking such as dreams and fantasy.

Furthermore, it should be taken into consideration that, although mastering design methods and design tools positively affects the design process, it does not guarantee the achievement of a successful design outcome (Corremans, 2011). Sometimes creative ideas occur spontaneously through an *Ah-ha!* moment that often occurs when it is not expected. Various scientists, designers, and artists have experienced this moment while they are in the bath or the bed. It has been reported that they were conceived in dreams, such as the chemist Kekule discovering the hexagonal structure of the benzene molecule; Mendeleev discovering the periodic table; Elias Howe inventing the sewing machine needle; J. B. Parkinson inventing the computer controlled gun; and the poet Samuel Taylor Coleridge writing his poem, *Kubla Khan* (Barrett, 1993).

Cross (2008) and Baxter (1995) regard this experience as the moment of illumination. However, they claim that, this moment of illumination does not occur by chance; rather, it needs a preparation phase in which an application of an effort is performed against the problem, and an incubation phase in which the problem is left for settling in mind. Their arguments present similarities with the phases of the creative process offered by Kneller (cited in Lawson, 2005). He identified the creative process into five phases: first insight, preparation, incubation, illumination, and verification (Figure 29). Within the phase of first insight, the design problem is recognized, and designer decides on to devote himself/herself to solve it. The next phase, preparation, involves a conscious effort to gain a background knowledge and to generate solution alternatives regarding the design problem. Within the incubation phase, the design problem is left to rest and there is no conscious effort. The illumination phase is the one that presents an *Ah-ha!* moment. And finally, within the verification phase, the idea that comes to mind within the illumination phase is evaluated and further developed.

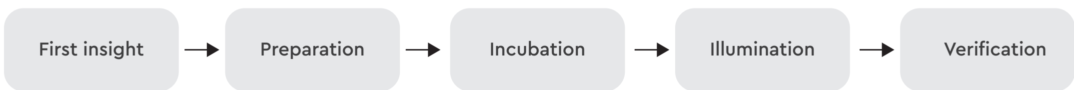


Figure 29. Phases of the creative process

The illumination phase can be linked with the *creative leap* that is regarded as the main characteristic of the creative design process. The creative leap presents similar characteristics with the illumination phase as it is defined as the sudden emergence of a previously unthought solution (Archer, 1965). However, Cross (1997) argues that, rather than a *creative leaping*, a *creative bridging* is the concept that enables the illumination and the *Ah-ha!* moment. He argues that, in order to build such a bridge, a successful relationship should be established between the problem and solution.

Among the phases of the creative process identified by Kneller, the preparation phase is important in terms of building a background knowledge and generating solution alternatives regarding the design problem. In this respect, design methods and design tools might be helpful in terms of building a creative bridge and enhance the alternative design ideas among which an illumination might occur. As it is the case of any creative process, a creative outcome is 1% inspiration and 99% perspiration (Cross, 2008).

CHAPTER 3

DESIGN FICTION

Design fiction is a relatively new concept for the design literature. The term was first used in 2005 by the science fiction writer Bruce Sterling in his book titled “Shaping Things”. During an interview in 2012, he described design fiction as “the deliberate use of diegetic prototypes to suspend disbelief about change” (Bosch, 2012, para. 3) which means, using fictional depictions to tell a story about that fictional world (Celi & Formia, 2015; Tanenbaum, 2014). Bleecker (2010), who is another pioneer of the design fiction studies, defined design fiction as a new kind of world, where the contours, limitations, and artifacts are imagined in order to create new possibilities. Furthermore, according to Candy and Dunagan (2017), design fiction emerged from the intersection of speculative storytelling and design. Besides, it is a mixture of science fiction, science fact, and design practices that provoke imagination within the interaction design, graphic design, and product design professions.

Since design fiction is a new concept for the design world, there are not many studies in which design fiction is used as an approach or a research method; therefore, there is some uncertainty in terms of the approaches that it can bring to design literature. Even the usage of the word *fiction* is debated; while Dunne and Raby (2013) use the word in conjunction with technology, Auger (2013) appraises the word in terms of unreality, and Lindley, Sharma, and Potts (2014) use the word as a medium that designers are using. Although researches evaluate the word from different perspectives, all of these interpretations may coexist and work together (Lindley, 2015).

3.1 Value of Design Fiction within the Design Context

Within the design process, designers are not entirely free: they should consider some design constraints such as production, cost, ergonomics, function, and distribution. These constraints make the process complex, limit innovation and cause producing products that are just smaller, faster, thinner, brighter than their previous versions (Bleecker, 2010; Bloch, 1995; Crilly et al., 2009; Lawson, 2005). In this respect, design fiction may become a valuable contribution for the design process. The characteristic of design fiction that facilitates the creation of a fictional, unreal and conceptual world where there are no industrial production or marketplace constraints might enable the designer to explore new ideas and possibilities (Dunne & Raby, 2013). According to Bleecker (2010), through the elimination of design constraints and the transformation of the contemporary design world into fiction rather than fact, design fiction offers new methods and experiences in which designers could rethink and reimagine for new possibilities.

There are also some counterviews to the context of design fiction. Some researchers argue that the fictional objects cannot be mass-produced and are not commercial; therefore, they are unreal. Besides, some other researchers argue that, design is already a future oriented activity that aims to create new outcomes; therefore, design fiction is just a new label for what design has already been dealing with (Franke, 2010).

People may think that the fictional objects or products of the fictional worlds are quite far from our contemporary time and world. However, design fiction is not just about imagining futures, but is also about evaluating and rethinking contemporary issues (Auger, 2013). It is not about designing realistic products for the global marketplace; rather, it is about creating provocation, inquisition, exploration, innovation, and idea generation (Bleecker, 2009). According to Dunne and Raby (2013), design approaches like design fiction are needed for the design context, since they enhance the creativity and imagination of the profession and open up new horizons for rethinking our everyday life.

Apart from practice-related issues of design fiction mentioned above that either focus on possible futures or alternative presents, design fiction is also a way to produce scientific knowledge in design research (Knutz et al., 2014; Lindley, 2015; Markussen & Knutz, 2013). Within design research, design fiction could be used as a method to criticize the contemporary as well as predict the future (Lindley, 2015). Its feature that eliminates the constraints of the commercial sector would be beneficial for design research and the design activity in terms of enhancing imagination and possibilities, and rethinking contemporary technology, manufacturing, materials, and everyday life (Dunne & Raby, 2013).

3.2 Other Fictional / Speculative Approaches

Just like Bleecker (2009) defined design fiction as the cousin of science fiction, there are other cousins of design fiction as well, such as, speculative design, critical design, and value fiction. Despite having some subtle differences due to their contextual usage, they were established on common grounds which are searching for alternative ways to everyday life and using products, models and prototypes to create provocation, exploration and innovation (Auger, 2013; Disalvo, 2012).

3.2.1 Speculative Design

According to Dunne and Raby (2013), speculative design is the closest design approach to design fiction. Speculative design is a practice that uses objects and representations in order to build up imaginary worlds that are predictions of alternative presents and possible futures (Disalvo, 2012).

While some researchers argue that design fiction and speculative design have a hierarchical relationship as design fiction being a sub-branch of speculative design (Lindley et al., 2014), others see them as distinct practices that have no hierarchical relationship (Dunne & Raby, 2013). Besides, some other researchers interpret speculative design as a research activity that produces insights instead of products, and design fiction as a research method that gives inspiration (Grand & Wiedmer, 2010; Markussen & Knutz, 2013).

To sum up, speculative design is a design activity that focuses on producing insights about alternative presents and future possibilities rather than a research method that serves for the production of a future object or product (Disalvo, 2012; Grand & Wiedmer, 2010; Lukens & Disalvo, 2011; Markussen & Knutz, 2013).

Throughout design history, many designers have been using speculative design as an approach to make predictions about the future. A TV helmet designed by Walter Pichler in 1967 to turn living rooms into portable ones was an example of this approach (Dunne & Raby, 2013) (Figure 30).

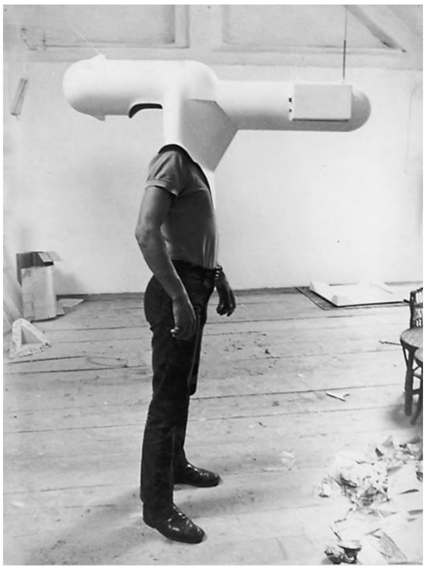


Figure 30. TV helmet designed by Walter Pichler in 1967 (Dunne and Raby, 2013, p.7)

In 1939, Normal Bel Geddes tried to depict the near future of America in his famous Futurama exhibit within the New York World's Fair. He designed large-scaled city models to present the possibilities of the next twenty years. Apart from the Futurama exhibit, he also designed things that are relatively closer to fiction. His Airliner No:4, which was designed in 1929, was an amphibian plane that could take off and land to water and earth, and it was two times bigger in size than a Boeing 747 (Dunne &

Raby, 2013) (Figure 31). These examples present insights about the alternative ways of contemporary designs and activities, and possible future scenarios.

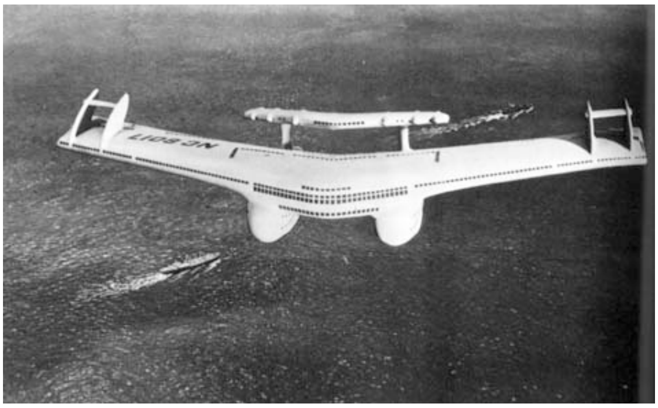


Figure 31. Airliner No:4 designed by Norman Bel Geddes in 1929 (Dunne and Raby, 2012, p. 165)

3.2.2 Critical Design

The main aim of critical design is to criticize the current situation of the design outputs and provoke the creation of different alternatives. It is an attitude and position rather than a method (Bowen, 2007; Dunne & Raby, 2007). Unlike speculative design, which focuses on insights about alternative presents and future possibilities, critical design focuses on physical materials to provoke criticism (Lindley & Coulton, 2014). According to Dunne and Raby (2001), provoking thinking by using critical design is as important as the design itself that finds solutions to the needs of people.

Critical design takes its roots from critical theory (Bardzell, Bardzell, Forlizzi, Zimmerman, & Antanitis, 2012). The specifications of critical theory are described by Calhoun (1995) as follows:

- *The way things are* is not the only alternative; rather, it reflects hidden factors.
- The acceptance of these factors without criticizing them causes problems.
- These factors should be recognized and critically analyzed.

• Other possibilities should be explored
• Through this way, an improvement in *the way things are* can be achieved.

Many designers and researchers utilized critical design approaches in their design practices. For example, Anthony Dunne and Fiona Raby tried to abolish the stereotypical design of robots through their project ‘Technological Dream Series: No. 1, Robots’ by designing robots that are compatible with the contemporary domestic environment (Auger, 2013) (Figure 32). Unlike the futuristic design of robots, which are seen in science fiction movies, the robots designed by Dunne and Raby are so domestic that they look like the furniture of the contemporary house environment.

Figure 32. Robot 3 by Dunne and Raby, Technological Dream Series: No. 1 (Auger, 2013, p. 5)

In another design project titled “Nucleus Motorcycle”, Branko Lukic tried to break down the blind acceptance of the stereotyped forms of the past, such as the symbolism of the streamline in vehicle design. He designed a motorcycle that looks different from the stereotyped motorcycle designs, through forgetting everything about physics, manufacturing, engineering, design, and motorcycles (Lukic, 2010) (Figure 33). These examples create a provocation for making criticisms about the current objects and products, and those that are produced as a result of a critical design process.

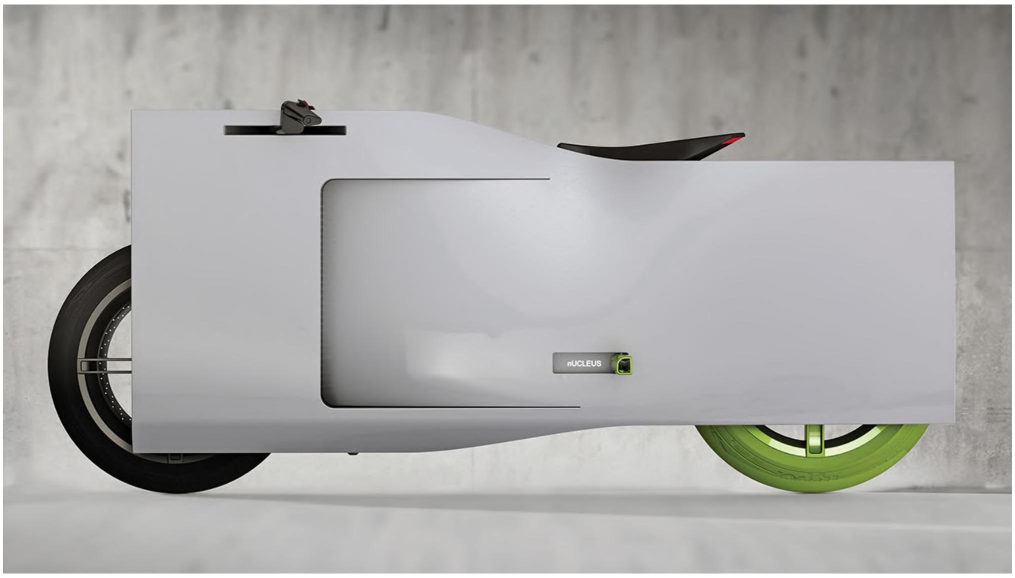


Figure 33. Nucleus Motorcycle by Branko Lukic (Lukic, 2010, p. 164)

3.2.3 Value Fiction

In the value fiction, the fictional side of the concept is the cultural settings rather than technology or products. It is the opposite of science fiction, where the technology and products are futuristic while cultural activities are traditional. Value fiction is a way of imagining different usage scenarios of existing technologies and products within fictional cultural activities (Franke, 2010; Gaver & Martin, 2000).

Robot 3, designed by Anthony Dunne and Fiona Raby (Figure 29), is also an example of value fiction. A cultural activity is being used to operate a robot as the user should hold the robot and stare at its eyes in order to operate it.

Another example of value fiction is the ‘Afterlife Battery’ by Jimmy Loizeau: A battery, which is engraved like a gravestone, is charged by using the stomach contents of a deceased person. The designer proposed to use the battery in all kinds of existing devices such as flash lamps (Knutz, Lenskjold, & Markussen, 2016) (Figure 34). The idea behind these projects are to promote discussion and debate between people about everyday life by creating alternative humoristic, surprising artifacts (Dunne & Raby, 2001).

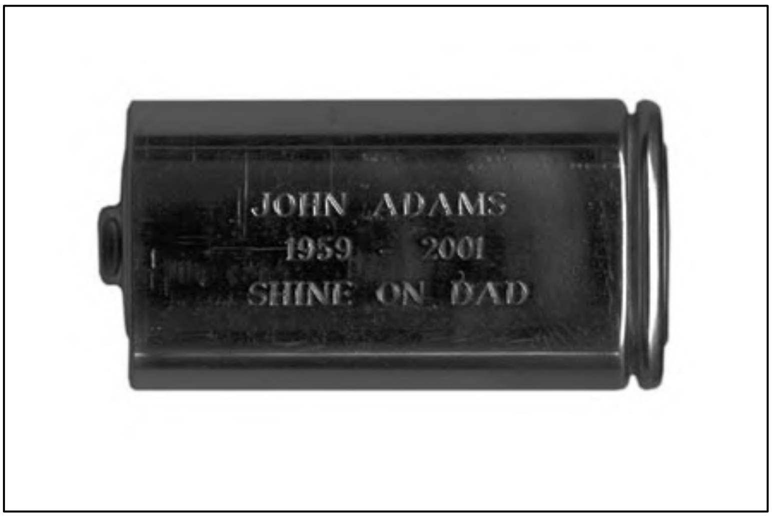


Figure 34. Afterlife Battery by Jimmy Loizeau (Auger, 2013, p. 6)

3.3 Studies within the Concept of Design Fiction

The literature of design fiction mainly comprises of articles that define the concept of design fiction and explain its role within design context by using some representations of fictional objects and products (Auger, 2013; Bleecker, 2010; Franke, 2010; Grand & Wiedmer, 2010; Knutz et al., 2014) Furthermore, some articles clarify the characteristics of design fiction and make a discussion about the usage of design fiction as a method in design research (Blythe & Wright, 2006). There are also some projects that utilize design fiction as a tool (Candy & Dunagan, 2017; Celi & Formia, 2015; Kelliher & Byrne, 2015). However, despite the arguments of some researchers indicating design fiction as a way to produce scientific knowledge in design research (Knutz et al., 2014; Lindley, 2015; Markussen & Knutz, 2013), very few studies that utilize design fiction as a method for design research were encountered.

Blythe and Wright (2006) use fiction as a resource in user centered design. They emphasize the importance of scenario and persona in the design process and criticize the approach of designers who see the persona as a static list that consists of information such as age, gender and occupation, rather than the characteristics, thoughts, experiences and feelings of the user. As a result, they introduce a method called *pastiche scenarios* that can be used to better understand the user. Regarding this method, the designer represents the usage and interaction of a product by putting themselves into the shoes of fictional characters from movies and novels such as Bridget Jones or Agatha Christie's Miss Marple.

In some other projects, utopias and dystopias are used through a fictional approach in order to imagine and materialize possible futures. Markussen and Knutz (2013) conducted a workshop that has a dystopian case: the civil war in Denmark. In this workshop, design students were asked to use Kaspar Colling Nielsen's unpublished novel "The Civil War in Denmark" as a resource and as a starting point to the design process. First, students were asked to read a piece of the text, and then after thinking an unforgettable memory or situation in their life, they were asked to place the memory into the text. Following the literary process, students were instructed to imagine objects and interactions that belong to that imaginary world and draw storyboards. One of the design outputs was called "build your own island": an imaginary world where skyscrapers are placed underneath the islands, and people have magical powers such as bubbling technique that can protect them from bomb attacks (Figure 35).

Figure 35. Build your own island (Markussen & Knutz, 2013, p. 237)

When the studies within the context of design fiction are investigated, they present some common characteristics such as *what-if* scenarios and experiments.

What-if Scenarios

All design fiction studies, whether a practical project or research method, have a common imaginary *what-if* scenario (Knutz et al., 2014). These scenarios allow for the birth of the fictional worlds, where possible futures or alternative presents are created. What-if scenarios give rise to the birth of science fiction movies as well: what if we can transfer our consciousness into another body of a creature that lives in another environment (Avatar, 2009), what if everything we see, touch, smell, hear and taste is information (Matrix, 1999), what if robots conquer the world (The Terminator, 1984), what if the world becomes so polluted that people have to travel to another planet (Wall-E, 2008).

Experiments

Another common point of design fiction studies is experiments. What-if scenarios create the suitable environment for making experiments to explore alternative presents or possible futures within design practice and design research (Knutz et al., 2014). Experiments are in the heart of many science-based disciplines. People might think that there is no role of fiction in scientific experiments since the term *fiction* is related with something that is unreal or untrue. However, the concept of *wormhole*, suggested by Albert Einstein, was first a what-if scenario that questioned what if time and space can be folded, and is now a highly accepted concept in the world of science (Knutz et al., 2014).

While the goal of making experiments in natural and applied sciences is to test the validity of a hypothesis (Koskinen, Zimmerman, Binder, Redström, & Wensveen, 2011), the goal of making experiments in art, design and architecture is to produce and develop new things. Furthermore, in design research, experiments also help to clarify some research questions (Niedderer & Roworth-Stokes, 2007). For example, within the "Audio Tooth Implant" experiment (Figure 36), Auger and Loizeau aimed to explore the combination of human body and technology, and to clarify the research question: what are the outcomes of making mobile technologies smaller (Knutz et al., 2016).

Figure 36. Audio Tooth Implant (Auger, 2013, p. 11)

3.4 Discussion

In the previous sections, it was declared that design fiction enables the creation of new fictional worlds. These fictional worlds may either be extraordinary, or involve features of the world we live in. The features that may go unnoticed in the real world, can be realized and reconsidered in the fictional world. In this sense, the fictional worlds can be used as laboratories where alternative value systems are explored in a manner that would not be possible in the conditions of the world we live in (Franke, 2010). Furthermore, the conditions of the fictional worlds might enable the designer to think differently by sticking to the rules of a fictional scenario within the design process (Tanenbaum, 2014). There are also some criteria for the creation of fictional scenarios. The scenario should be positioned in a place where it creates a balance between the familiar and the unfamiliar. If the scenario is too familiar or too realistic such that it already exists in the actual world, it will not create new perspectives, provocation, or challenges. In the opposite situation, if the scenario is too unfamiliar or utopian, then it will cause a lack of connection and engagement with the audience. Therefore, the fictional scenario should establish a bridge between the actual world of the audience and the fictional concern of the study (Auger, 2013; Grand & Wiedmer, 2010).

Grand and Wiedmer (2010) have declared six criteria for design fiction studies.

- Design fiction studies need tools, methods and practices in order to create fictional worlds.
- These tools, methods and practices should enable the materialization of the fictional worlds in terms of artifacts, interactions and images.
- A method toolbox should be developed by considering different approaches and perspectives.
- The tools, methods and practices should enable the representation, visualization and documentation of the experimentation process.
- The experimentation should involve a seeking of answers for a series of questions and a testing of series of hypotheses.
- These new techniques are expected to modify design research practices over time.

Markussen and Knutz (2013) have declared further five criteria for design fiction studies.

- A design fiction study should have a what-if scenario.
- It should have a manifestation of critique and represent how it is critical.
- It should have design aims.
- It should have a way to visualize itself.
- It should have a design strategy in terms of aesthetics.

Besides, some researchers criticize existing studies and express the needs regarding design fiction studies. According to Franke (2010) and Raford (2012), studies related to design fiction generally focus on imaginary products, such as concept transportation vehicles, alternative usage of contemporary furniture, and automatic home appliances. These objects are visually rich in terms of introducing alternative ways of living; however, they are analytically poor in terms of examining, questioning, and developing contemporary products.

According to some researchers, current studies are insufficient in providing useful methods to combine fiction with design experiments and design studies; therefore, there is a need of formal methods that provide knowledge and practicality scenarios through which researchers can understand the role of design fiction within design research, and strategies that can be utilized within the design process (Knutz et al., 2014; Lindley & Coulton, 2014; Markussen & Knutz, 2013).

CHAPTER 4

METHODOLOGY

In order to deeply understand the problem and meet the needs and aims that were mentioned in the introduction, the research carried out for this thesis consists of a mixed methods research that includes both the collection, analysis, and integration of qualitative and quantitative data (Creswell & Plano Clark, 2007; Hesse-Biber, 2010).

Within this research, qualitative methods, such as observation, peer debriefing, interviewing, and quantitative content analysis and a quantitative method, quasi-experimental research were used concertedly in order to better understand the problem and present more credible and robust results. This chapter clarifies the research methodology together with the data collection and analyses techniques of the conducted studies.

4.1 Advantages of Conducting Mixed Methods Research

Qualitative data includes open-ended information generally gathered from interviews, observations, and documents. On the other hand, quantitative data consists of close-ended information gathered from experiments, performance instruments, and checklists. While the analysis of the qualitative data consists of a categorization of words or images, the analysis of the quantitative data consists of statistically analyzed numerical results (Creswell & Plano Clark, 2007; Hesse-Biber, 2010). The nature of mixed methods research allows the combination of qualitative and quantitative data. Thus, “words, pictures, and narrative can be used to add meaning to numbers” (Johnson & Onwuegbuzie, 2004, p. 21).

There are several advantages of conducting a mixed methods research over conducting either qualitative or quantitative research alone:

- Mixed methods research provides a better environment to understand the investigated problem. With the usage of qualitative and quantitative research together, the investigated problem can be understood and presented in a more robust way (Creswell & Plano Clark, 2007; Greene, Caracelli & Graham, 1989; Hesse-Biber, 2010).
- Mixed methods research compensates for the weaknesses of qualitative and quantitative research, and therefore enhances the credibility of the findings. While qualitative research is seen as deficient in terms of the subjective interpretations of the researcher, quantitative research is seen as weak in terms of understanding the narrative explanation of the context. By using both of the datasets together, the researcher has the opportunity to offset the weaknesses of either of the approaches and present more clarified results (Creswell & Plano Clark, 2007; Greene et al., 1989; Hesse-Biber, 2010).
- Mixed methods research helps the development of a research project. The findings of a study that is conducted based on either qualitative or quantitative research can aid the generation or development of a new study that follows the other research methodology (Greene et al.,1989; Hesse-Biber, 2010).
- Mixed methods studies encourage collaboration between researchers who position themselves as either a qualitative or a quantitative researcher (Creswell & Plano Clark, 2007).

4.2 Types of Mixed Methods Research Designs

There are four main types of mixed methods designs: the triangulation design, the explanatory design, the exploratory design, and the embedded design. In this section, an overview of these designs will be provided and the embedded design that is adopted within this thesis will be elaborated upon.

4.2.1 Triangulation Design

The triangulation design is the most common approach of mixed methods studies. It is used when the researcher wants to compare and contrast or to validate or expand the results of qualitative research with quantitative research, or vice versa. Within the context of triangulation design, qualitative and quantitative data collection and analysis processes are implemented concurrently, separately and with equal significance. Following the data collection and analysis procedures, the researcher merges the datasets to interpret the results (Figure 37) (Creswell, Plano Clark, Gutmann & Hanson, 2003; Creswell & Plano Clark, 2007).

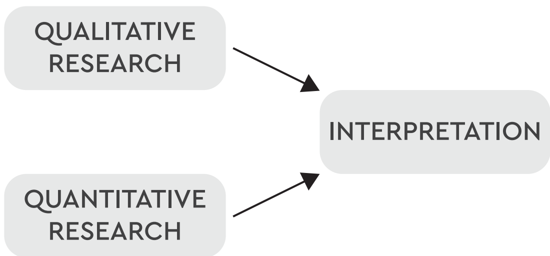


Figure 37. Triangulation design (adapted from Creswell & Plano Clark, 2007, p. 63)

4.2.2 Explanatory Design

The explanatory design approach includes two phases. First, quantitative data is collected and analyzed, then qualitative research is conducted to help explaining or building upon quantitative results. Significant, outlier, and surprising results that are obtained from a quantitative study can be explained or investigated deeply through conducting a follow-up qualitative study (Figure 38) (Creswell et al., 2003; Creswell & Plano Clark, 2007).

Figure 38. Explanatory design (adapted from Creswell & Plano Clark, 2007, p. 73)

4.2.3 Exploratory Design

Contrary to explanatory design, exploratory design starts with a qualitative research and follows with a quantitative research. The results of the qualitative research are used either to explore a phenomenon or to determine the unknown variables, measures, instruments, guiding framework or theory. Exploratory design is particularly suitable when the researcher plans to develop and evaluate a new instrument (Figure 39) (Creswell et al., 2003; Creswell & Plano Clark, 2007).

Figure 39. Exploratory design (adapted from Creswell & Plano Clark, 2007, p. 76)

4.2.4 Embedded Design

Embedded design is the research type where one data set is more dominant compared to the other data set and the less dominant one provides a supportive role for the research. This design can be used when researchers want to answer research questions that need the inclusion of either qualitative or quantitative data (Creswell et al., 2003; Creswell & Plano Clark, 2007). There are two variants of embedded design: the correlational model and the experimental model.

Embedded Design: Embedded Correlational Model

Embedded correlational model is used when the researcher needs to relate different kinds of data within a correlational study. Regarding this model, researchers conduct qualitative studies and collect predictors for the purpose of explaining quantitative data and making inferences about the relationship of different kinds of data (Figure 40) (Creswell & Plano Clark, 2007).

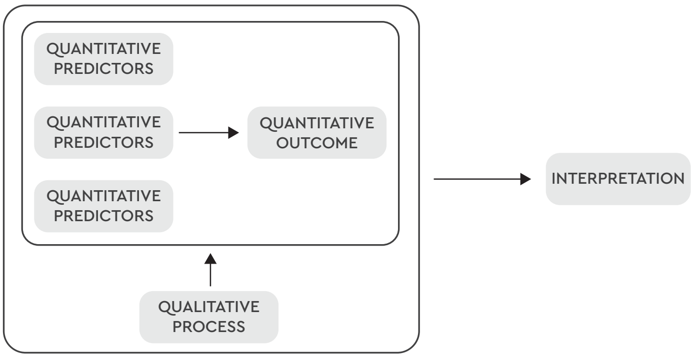


Figure 40. Embedded design: Embedded correlational model (adapted from Creswell & Plano Clark, 2007, p. 68)

Embedded Design: Embedded Experimental Model

Embedded experimental model can be defined as including qualitative data within an experimental design that deals with quantitative data. While the qualitative data can be embedded to the research during the intervention phase, it can also be embedded before or after the intervention. With the inclusion of the qualitative data during the intervention phase of an experimental research, researchers have the opportunity to qualitatively examine the intervention process together with the quantitative outcomes. Furthermore, with the inclusion of the qualitative data before or after the intervention phase of an experimental research, researchers have the opportunity to design the intervention and instruments, or decide on the participants before the intervention; or they have the opportunity to explain and evaluate the results of the intervention following the process (Figure 41) (Creswell et al., 2003; Creswell & Plano Clark, 2007).

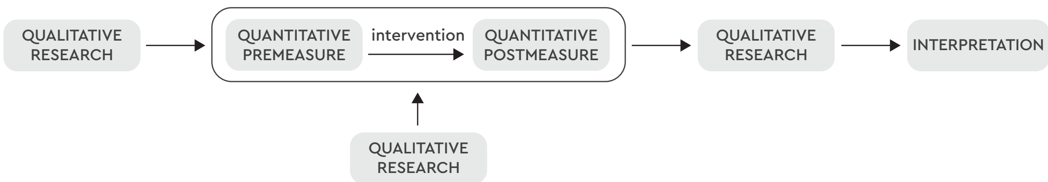


Figure 41. Embedded design: Embedded experimental model (adapted from Creswell & Plano Clark, 2007, p. 68)

Within this thesis, the embedded experimental model was adopted since the research includes an experiment and an intervention that needs to be developed through qualitative data and evaluated through both qualitative and quantitative studies.

4.3 Research Model of the Study

The embedded experimental model of the mixed methods research was adopted for the study carried out for this thesis. In this regard, first, a qualitative research consisting of observation, peer debriefing and discussion were conducted in order to determine the current situation and needs of idea generation and to develop the design tool. Then, another qualitative study consisting of a quantitative visual content analysis was conducted to determine the participants for the experiment based on the novelty and variety of their ideas. The experiment process consisted of a quantitative research measuring the pretest and posttest performance results of the participants who utilized Fictionation design tool and who did not. The experiment process also had a qualitative study consisting of an observation for the purpose of evaluating the process. Finally, following the experiment a qualitative study consisting of interviews was conducted with the participants (Figure 42).

Figure 42. Research model of the study

4.4 Data Collection and Analysis Techniques

This research was composed of three studies: needs assessment study, development of the Fictionation tool, and implementation of the Fictionation tool (Figure 43). The data collection and analysis techniques used in these studies will be presented under the following sections of each corresponding studies. The details about how these techniques were used in the research and the details about participants, setting and procedure will be explained in the following chapters of each corresponding studies. Furthermore, the time frame of the research is presented in Figure 44.

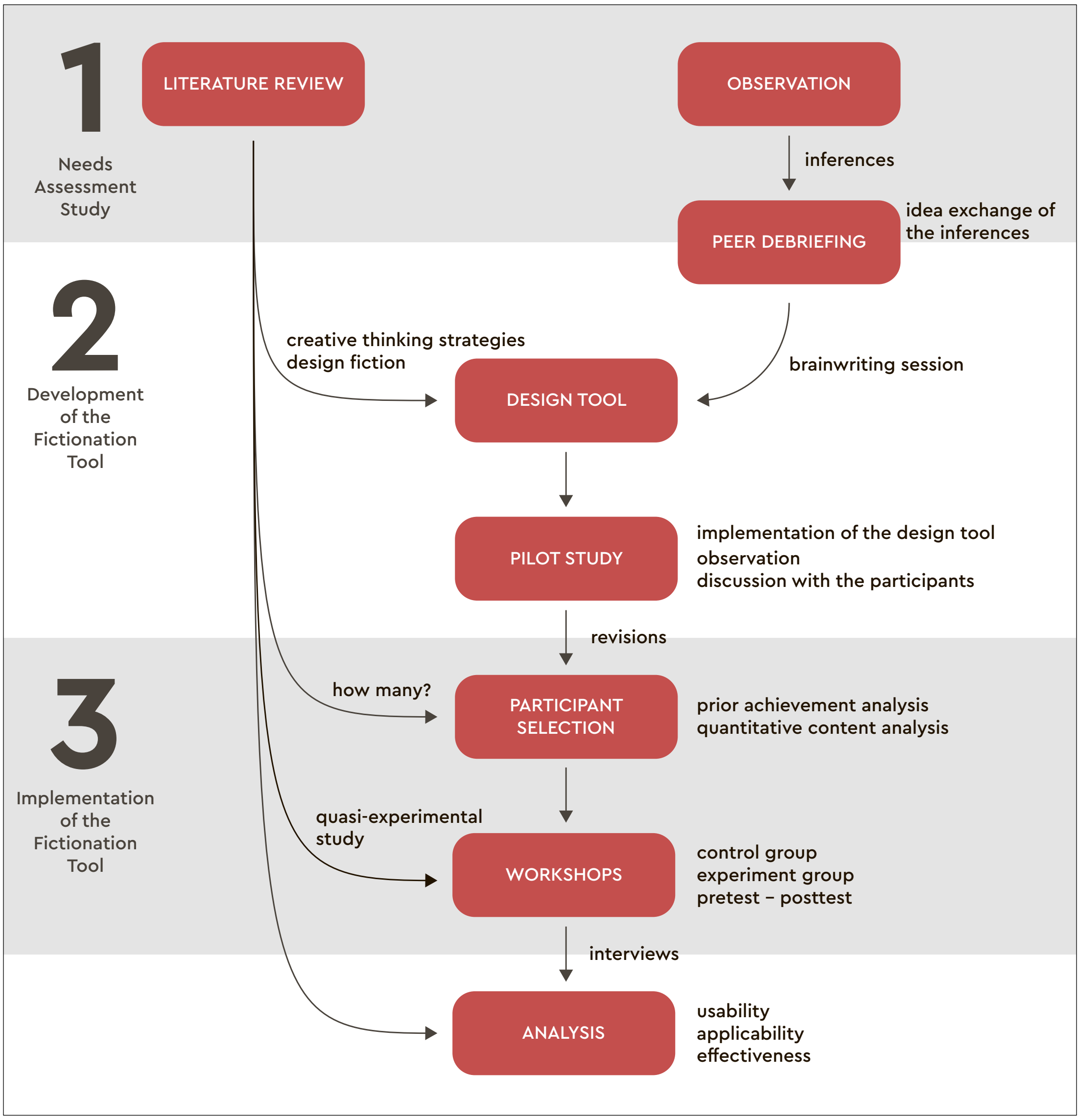


Figure 43. Research methodology: The three studies composing the research

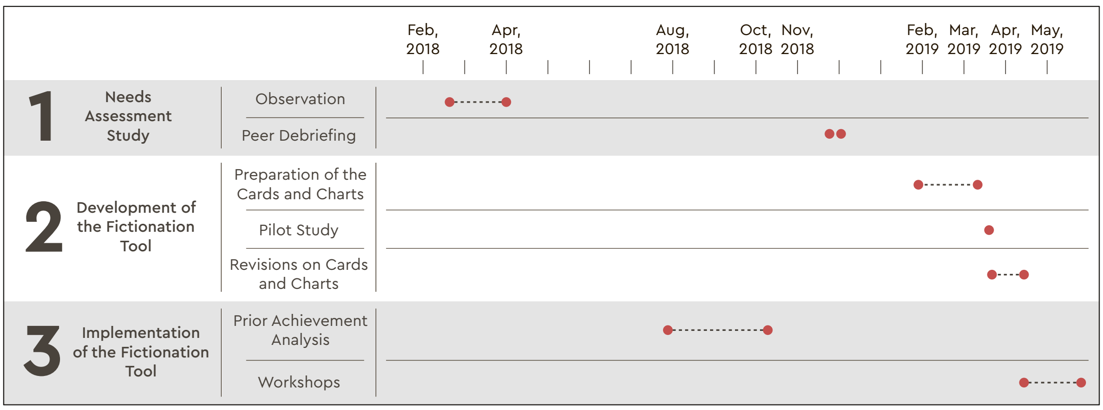


Figure 44. Time frame of the research

4.4.1 Study 1: Needs Assessment Study

As mentioned in Chapter 2, the idea generation phase of the design process is critical for the design profession and therefore design education, as it has a significant impact on the success of the final design solution. Furthermore, idea generation is an attractive topic in the design literature that many researchers have been studying in terms of its techniques, methods, cognitive processes, and creativity. To investigate the topic of idea generation deeply and to find valuable areas to work on in the context of design education, a needs assessment study among design students was conducted.

Needs assessment is a process carried out to collect information, learn the state of ability, knowledge, interest, and attitude of a group for the purpose of improving current performance or determining a deficiency (Altschuld & Eastmond, 2010).

The needs assessment study of this research was composed of observation and peer debriefing stages (Figure 45). Regarding the observation stage, a studio project was observed with the purpose of determining how students carry out their idea generation processes, the difficulties they encounter during idea generation, and how they perform. In the peer debriefing stage that followed, the idea generation processes of the students were investigated deeply within an idea exchange phase together with the author's peers and colleagues, and a brainwriting session was conducted with them.

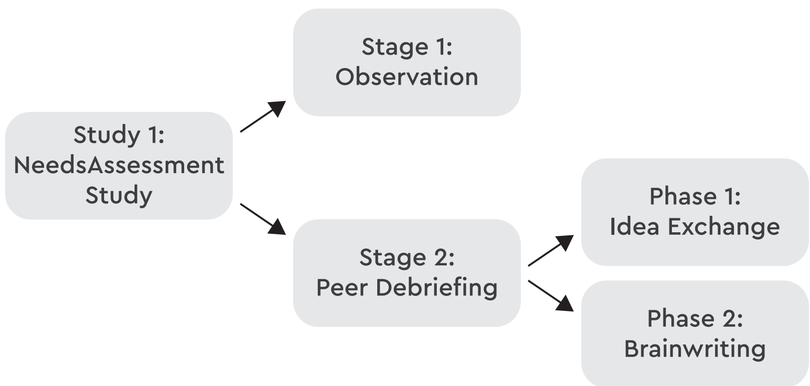


Figure 45. Stages of the Study 1

4.4.1.1 Observation

Observation is a useful data collection technique in various ways. By conducting observation, a researcher can collect data about nonverbal expressions of feelings and communication between a group of people. There is also the chance of gathering information about the topics that the participants are unable of or unwilling to share (Marshall & Rossman, 1995; Schmuck, 1997).

Furthermore, observation can be used to gain a better understanding of the context under study, to answer research questions, produce or test hypotheses and to build theory (DeWalt & DeWalt, 2002).

There are two types of observation techniques: participant and non-participant.

- In participant observation, the researcher participates in the whole of activities of the group that is being observed and acts like a member of the group without the awareness of the group that they are being observed.
- On the other hand, in non-participant observation, the researcher is not involved in the activities and observes the group passively (Perumal, 2014).

Within this study, a non-participant observation was conducted to observe the process of a 3rd year undergraduate design studio project at METU Department of Industrial Design (see Appendix A and B respectively for the brief and timetable of the project). The purpose was to gain information about the process while students were working alone or with peers. Therefore, in order not to affect the natural working environment of the students, the researcher did not participate in the activities of the group and observed them passively.

The aim of using observation in this study was to determine how students carry out their idea generation process, whether they have problems in the process, and how they perform in this process.

4.4.1.1.1 Data Collection Technique

The observer (the author of this thesis) was a teaching assistant in another course at the same department. Therefore, even though the students personally knew the observer, they were unaware that they were being observed. The observer did not directly get involved in the studio activities, but mainly observed the process passively, took photographs and took notes on a notebook during the observation process (Figure 46).

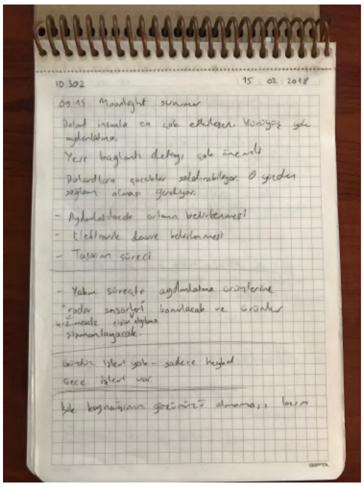


Figure 46. Observation notes of the researcher

While taking notes, the date and time of the incidents were noted. The notes also contained information about the setting of the environment, processes of the project, and important quotes made by both instructors and students.

4.4.1.1.2 Data Analysis Technique

Regarding the data analysis first, the notes were read entirely, then using Microsoft Excel, they were divided into categories regarding the information they presented. The categories were notes about setting, process, quotes of the students on either a situation analysis, problem, or need, and quotes of the instructors on the criticisms of the works of the students.

The notes about the setting and the process were evaluated to determine how students carried out their idea generation process. The notes on the quotes of the students were evaluated to determine the problems that the students had in the process, and the notes on the criticisms of the instructors were evaluated to determine how students performed in their process.

4.4.1.2 Peer Debriefing

According to DeWalt and DeWalt (2002), the inferences and findings of an observation are more valid with the usage of other techniques. To discuss the inferences gained from the observation, and to gather opinions and gain in depth insights about idea generation, a peer debriefing session was conducted.

Peer debriefing, also named as analytic triangulation, is the technique that the researcher and a disinterested peer or peers (peers who are not part of the study but have knowledge about the topic) gather to discuss the findings and progress of an investigation. These discussions can be either about initial analysis, or the next steps of the study (Hail, Hurst & Camp, 2011; McMillan & Schumacher, 1997).

Conducting peer debriefing enhances the credibility and trustworthiness of a qualitative study as the peer contributes to the explication, interpretation, and confirmation processes of the findings. Therefore, peer debriefing can be evaluated as complementary to the other strategies of qualitative research, including member checking, prolonged engagement, triangulation, negative case analysis, and persistent observation (Janesick, 2004; Spall, 1998; Spillett, 2003).

The level of trust and the background knowledge of the researchers about the phenomena that is being studied are the key factors when determining peer debriefers. Therefore, peer debriefers generally are chosen from among classmates, professional colleagues, and coresearchers (Spall, 1998).

Within this study, the researcher shared with the peer debriefers his inferences gained from the observation of the studio project and obtained their opinions and experiences regarding the idea generation process. Following the idea exchange, a brainwriting session was conducted to deeply investigate the idea generation process.

4.4.1.2.1 Data Collection Technique

Within the idea exchange phase of the peer debriefing sessions, the opinions of the participants were tape recorded and transcribed later on. The collected data was a 160 minutes long recording.

Within the brainwriting phase of the peer debriefing sessions, the participants were asked to write down the issues that needed to be considered during the idea generation process on post-it papers (Figure 47).

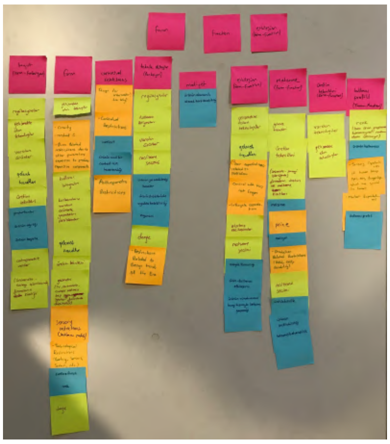


Figure 47. Issues considered by students during the idea generation process, as compiled from the first peer debriefing session.

Following the peer debriefing sessions, similar considerations were gathered under the same heading by the researcher and the participants were asked to grade the obtained considerations between 0 to 10 considering their importance for the idea generation process, through an online form. At the end, the collected data of the peer debriefing session were the total of 118 considerations written on the post-it papers and a score table of the considerations that were obtained and graded by the participants of the peer debriefing sessions.

4.4.1.2.2 Data Analysis Technique

The tape recordings of the peer debriefing sessions were transcribed into a Microsoft Excel sheet (Figure 48). The opinions of the participants were analyzed by using content analysis method (Bogdan & Biklen, 2007; Krippendorff, 2004). The opinions were coded by considering whether they were related to the general issue of idea generation, a problem of the idea generation or a need of the idea generation.

	A	B
1	Raw Data	Theme
2	Yes, I aggre that the idea generation exercises are crutial in generating various design alternatives. Especially for design students. Because they are in need of a guidance by us.	general issue of idea generation
3	Presenting many and various alternative idea generation methods will enhance the process and result in better design solutions	general issue of idea generation
4	The timing of these exercises are important. They should be conducted after the students had an overall background on the design problem	general issue of idea generation
5	The exercises should take place after the students had some ideas in hand. At first, they should try to generate ideas by themselves. Then they should be introduced with methods	general issue of idea generation
6	I aggree that students have a fixation problem	problem
7	When we look at their idea sketches, we see similar ideas	problem
8	I think they inspired mostly from the existing products. Because they all look like the ones in the market.	general issue of idea generation
9	It is true. Most of the time I heard the same complaint from students. They say hocam, this solution look beautiful but can it be produced? Or would it be economical?	problem
10	I think it is the most important part of the design process	general issue of idea generation

Figure 48. Transcription of the peer debriefing session

4.4.2 Study 2: Development of the Fictionation Tool

Following the needs assessment study, the second study of the research was the development of the design tool (Fictionation). In the first study, the problems that students face during idea generation and their needs in terms of support and guidance in this process were identified. In light of the literature review, design fiction was determined as having the potential to eliminate the problems and fulfil the needs. Furthermore, the literature review regarding creative thinking led to the decision of developing the Fictionation tool as a card-based design tool since it is simple, tangible and easy to use (Haritaipan, 2019; Roy & Warren, 2019; Wöfel & Merritt, 2013). Besides, the brainwriting sessions conducted within the peer debriefing sessions laid the foundations of the texts situated on the cards. This study was composed of two stages: design and production of the cards and charts, and pilot study (Figure 49) First, the cards and charts of the Fictionation tool were prepared.

Then a pilot study was conducted to evaluate its procedure and mediums. A discussion session was conducted with the participants right after the pilot study. Considering the opinions and suggestions of the participants, the tool was developed further and took its final form that will be mentioned in Chapter 6.

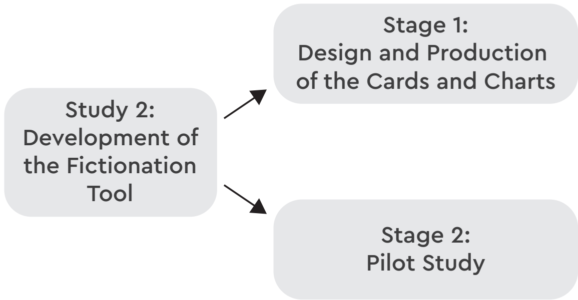


Figure 49. Stages of the Study 2

4.4.2.1 Design and Production of the Cards and Charts

This chapter focuses on the data collection and analysis techniques. The development process of the cards and charts did not contain any data collection and analysis techniques. However, this section briefly explains the process followed in designing the cards and charts. The detailed information about this process and the outcomes will be mentioned in the following chapter.

The card deck was selected as the medium for the design tool, since it is simple, tangible, does not need too much effort to use, and students can benefit from it on their own without the need of a moderator (Haritaipan, 2019; Roy & Warren, 2019; Wöfel & Merritt, 2013).

Through researches on the usability of the cards and available card-based tools, the required criteria such as, content, dimensions, typefaces, colors and material were determined, and the details will be mentioned in the following chapter.

The cards and charts were designed by using the Adobe Illustrator software (Figure 50). Later on, the front and back sides of the cards were printed on plastic coated paper separately. They were cut considering their borderlines by the author. Then, the front and back sides of the cards were glued and a card deck that has cards with visuals on both sides were obtained. Furthermore, a box was designed and produced to keep the card deck together. Besides, charts were prepared and printed on standard paper.

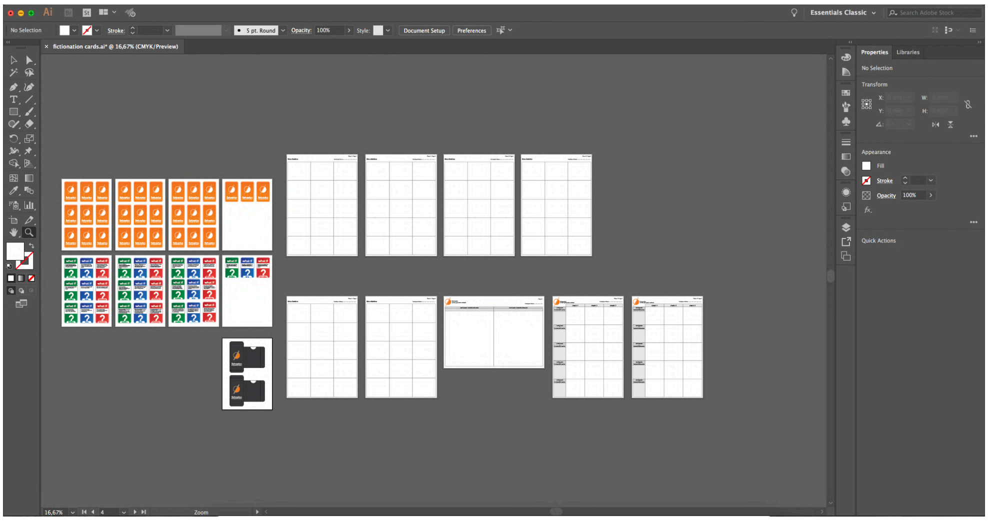


Figure 50. Preparation of cards and charts by using Adobe Illustrator

4.4.2.2 Pilot Study

Conducting a pilot study enables the opportunity to see the deficiencies of the research project in terms of research protocols, methods, or instruments. The pilot study can either be a small scaled version of the main study, or it can be the testing of an instrument that will be used in the main study (Baker, 1994; Polit, Beck & Hungler, 2001).

Regarding this study, the pilot study was conducted to test the procedure and mediums of the Fictionation tool and improve them to be used in the main study. The Fictionation tool was implemented as part of the idea generation phase of a project carried out within the Interactive Prototyping undergraduate elective course given in the 2018-2019 Spring Semester at METU Department of Industrial Design.

4.4.2.2.1 Data Collection Technique

The Data Regarding the Procedure and Mediums of the Tool

Throughout the pilot study, the researcher observed the students and took notes on a notebook about the process, time spent for the phases of the procedure followed for the implementation of the tool, encountered problems, and quotes of the participants. Right after the implementation of the tool, a discussion session was conducted with the participants for the purpose of receiving their feedback on the usability and applicability of the Fictionation tool.

Conducting a discussion session with all of the participants provided some advantages in comparison with making one-to-one interviews: it enabled to get feedback from the students right after the implementation of the tool while their experiences were still fresh, and it enabled to obtain shared opinions and experiences rather than individual thoughts, and to gain new ideas and perspectives due to the interactive environment in which each participant could hear the comments of others and state theirs (Kamberelis & Dimitriadis, 2013; Krueger & Casey, 2000).

Within the discussion session, students were asked a series of questions through which they could criticize the Fictionation tool and contribute to its improvement (see Appendix C). Most of the students expressed their opinions with regard to these questions. Due to the noisy environment, it was not possible to tape record the opinions of the participants. Therefore, the researcher took notes on a notebook and wrote exactly what the participants have declared.

The Data Regarding the Students' Output on the Charts

Students were delivered card decks and charts during the pilot study. There were different kinds of charts on which students could brainstorm and make sketches of their final design solutions. At the end of the idea generation phase in which the Fictionation tool was used, students produced a considerable number of sketches. However, these sketches were not evaluated within the pilot study since the pilot study was not about the evaluation of the outcomes but concerned with the evaluation of the procedure and mediums of the tool. Even so, the details regarding the students' output on the charts will be mentioned in Chapter 6.

4.4.2.2.2 Data Analysis Technique

The aim of conducting this pilot study was to test the procedure and mediums of the Fictionation tool and get feedback from the participants in order to improve the tool to use it in the main study. In this sense, the notes that were taken during the pilot study and within the discussion session were not transcribed for analysis. They were examined by the researcher as suggestions and the Fictionation tool was improved further accordingly.

4.4.3 Study 3: Implementation of the Fictionation Tool

The third and final study of the research is the implementation of the Fictionation tool. For this purpose, this study was conducted in two stages: a prior achievement analysis to determine the participants, and the implementation of the tool within a series of workshops (Figure 51). Considering the literature, the procedure of these workshops followed the strategies of a quasi-experimental study. There were a control and an experiment group. The literature was reviewed to determine the sampling size and find ways to assign participants to the groups. Consequently, it was determined that a matching sampling is suitable for these kind of experiments (Campbell & Stanley, 1963; Stuart & Rubin, 2008) and a prior achievement analysis should be conducted to establish the equivalence between the control and experiment groups (Campbell & Stanley, 1963; Monroe & Engelhart, 1930; Ross & Morrison, 2003).

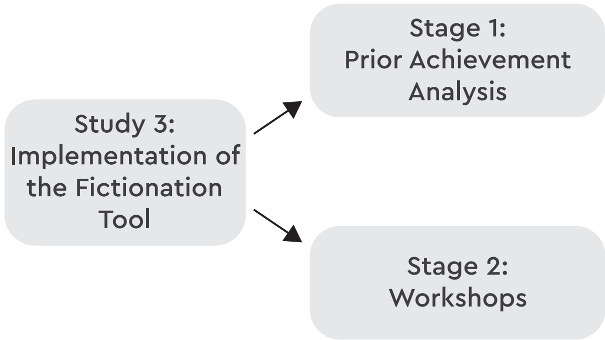


Figure 51. Stages of the Study 3

The main aim of the Fictionation tool was to expand the design solution space by increasing the variety and novelty of the generated ideas. Therefore, to compare the results between the control and experiment groups and to make a meaningful deduction, the variety and novelty abilities of these two groups should be equivalent. The prior achievement analysis aimed to ensure this equivalence. A new assessment technique that adopts quantitative content analysis strategies was used to calculate the novelty and variety scores of the students who were observed within the first study of this research. These scores assisted to assign participants among control and experiments groups to establish equivalence. After the participants of each group were determined, the Fictionation tool was implemented through a series of workshops, followed by interviews with the participants of the experiment group. The usability, applicability, and effectiveness of the Fictionation tool were analyzed by using the developed assessment technique that were also used within the prior achievement analysis and also based on the findings from the interviews.

4.4.3.1 Design of the Experiment

An experimentation is implemented to test a hypothesis. Despite the usage of experiments dating back to the 17th century, it was in the beginning of the 20th century that experimental design became systematized and it was first used in educational and psychological research (Cook & Campbell,1979; Cronbach, 1957).

There are some technical terms for an experimental study: *independent* and *dependent variable*, and *treatment*. The independent variable is the change that the researcher adds to or removes from a situation. It is the variable that the researcher is investigating. On the other hand, the dependent variable is the change that is the result of the independent variable. Besides, the treatment is the addition or extraction of a stimulus to measure the effect of a change (Ross & Morrison, 2003).

There are two types of experimental designs: *true experiments* and *quasi-experiments*. Both types include an experiment (treatment) group and a control (no-treatment) group. The difference between them is the sampling technique. While true experiments require randomly assigned participants, quasi-experiments require pre-assigned participants (Stuart & Rubin, 2008). In this study, a quasi-experimental design was adopted due to the size of the sample group that was not convenient for randomization.

The conducted experiment within this study was composed of a control group, an experiment group and a treatment, which was the Fictionation tool. To examine the effects of the proposed tool, a pretest-posttest experimental design was adopted (Table 2). In this table, ‘O’s represent observation or testing, and ‘X’ represents the treatment.

Table 2. Pretest-Posttest Experimental Design (Campbell & Stanley, 1963, p. 13)

Pretest	**Treatment**	**Posttest**
O1	X	O2
O3		O4

The experiment was separated into two sessions to measure both pretest (session 1) and posttest (session 1 + session 2) scores of novelty and variety. While the control group generated ideas by their own means during sessions 1 and 2, the experiment group generated ideas by their own means in session 1 but utilized the Fictionation tool in session 2 (Figure 52).

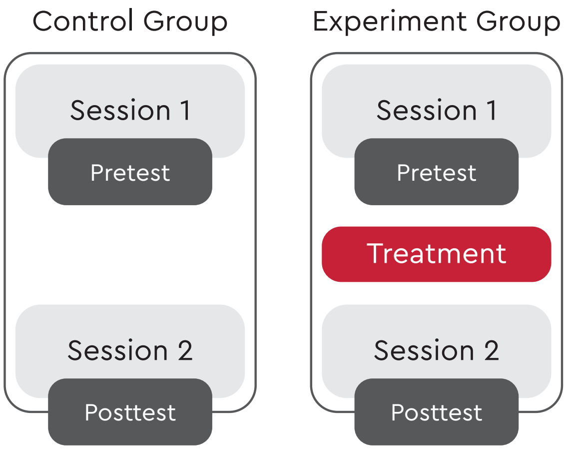


Figure 52. The design of the experiment

According to Tovey et al. (2003) and Goldschmidt (1994), idea generation through making sketches leads to new ideas. In this context, separating the experiment into two sessions and comparing the pretest and posttest results for both groups allowed to examine whether generating new ideas enabled variety and novelty in ideas during the process, or whether it was the Fictionation tool that enabled this situation. It was expected that the difference between the posttest and pretest results of the control group would show the effect of the situation in which generating ideas leads to new ideas. Besides, the difference between the posttest and pretest results of the experiment group would show both the effect of generating ideas leads to new ideas and the effect of the treatment (the Fictionation tool) (Figure 53). Through the comparison of the differences between both groups, the effect of the treatment would be obtained.

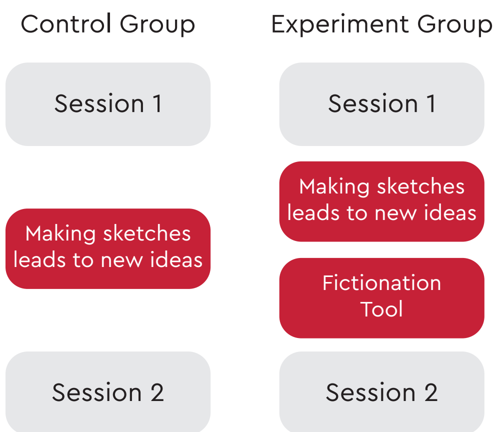


Figure 53. The effect of the treatments

4.4.3.2 The Sampling of the Study

The sampling methods vary between true and quasi-experiments: *randomization* and *matching*. True experiments consist of subjects that are randomly assigned to the treatment and control groups, and quasi-experiments consist of subjects that are pre-assigned to groups such as classes in schools or assigned by the researcher. Since the subjects of the true experiments are randomly assigned to groups, it is not necessary to pretest them. However, in quasi-experiments, to be able to make meaningful deductions, a pretesting or prior achievement analysis should be made to establish the group equivalence and use matching sampling (Campbell & Stanley, 1963; Monroe & Engelhart, 1930; Ross & Morrison, 2003; Stuart & Rubin, 2008).

The sample group of this study is the 3rd year students who were observed within the first study of the research (by the time of the implementation of the Fictionation tool, they were 4th year students), and the group was not big enough in number enough to be convenient for randomization. As mentioned before, the main aim of the Fictionation tool was to increase novelty and variety. If the sampling method was randomization, there could have been more students in the treatment group that had the potential to propose more novel and various ideas before the implementation of the tool. In this situation, it would not be possible to argue that the tool enhances novelty and variety, since the students of the treatment group already had the ability to offer more novel and various ideas compared to those in the control group. Therefore, to see the effect of the proposed tool, the abilities of producing novel and various ideas of the treatment and control groups had to be similar. In that sense, quasi-experiment was deemed suitable for the study. In this regard, a prior achievement analysis that included a quantitative content analysis study was made, and a matching sampling was used to establish group equivalence. In this context, a new assessment technique was used to investigate the idea generation sketches of the sample group and calculating their novelty and variety scores for the purpose of assigning them among control and experiment groups. The details of this assessment technique will be mentioned in the Section 4.4.3.4.1.

There is a common understanding in the literature that the sample size of an experimental study is related with the size of the data, and the number of the participants is enough when there is a significant difference between the results of the control and experiment groups. However, there are different suggestions in the literature. While some researchers offer that, the sample size of an experimental study should not be smaller than 24 (12 participants for control, 12 for experiment group) (Drew, Hardman, & Hosp, 2008), some offer that it should not be smaller than 30 (15 participants for control, 15 for experiment group) (Cohen, Manion, & Morrison, 2011). Since the size of the data would be big enough to present a difference between two groups, 24 participants were deemed sufficient for the study. However, it was decided that if the results were not clear enough to make a significant deduction, the number of the participants could be increased.

4.4.3.3 Data Collection Technique

The data was collected from participants through a series of workshops and interviews.

At first, it was thought to use think-aloud protocols as the data collection technique. It is a useful technique to analyze design activity. It requires participants to tell what they are thinking and doing during the implementation (Ericsson and Simon, 1984). However, literature reviews revealed that the technique can be disadvantageous in terms of causing a side effect of incomplete activities or inaccurate process due to the simultaneous verbalization and acting (Cross, Christiaans, & Dorst, 1996). Therefore, instead of using think-aloud protocols as the data collection technique, it was decided to leave the participants on their own while they were making sketches in order to create a familiar environment for them, and to conduct interviews right after the workshops as their memories were still fresh.

The obtained data from the workshops was a visual data that includes the idea sketches of the students. At the end of the workshops a total of 96 charts containing 768 idea sketches were collected and analyzed as data of the workshops. The obtained data from the interviews was a verbal data that includes the opinions of the students. Right after the workshops, interviews were conducted with the participants of the experiment group (those who implemented the Fictionation tool) in order to obtain their opinions about the Fictionation tool, and to assess its usability and applicability for the idea generation process. There was a total of 12 interviews that lasted between 17 to 28 minutes and had an average of 22 minutes. The interviews were tape recorded and transcribed later on. A series of questions were asked to the participants and they can be seen in Appendix D. At the end, a total of 263 minutes recording was obtained within the interviews.

4.4.3.4 Data Analysis Technique

As mentioned in the previous section, the collected data from the workshops includes a visual data that contains the idea sketches of the students and a verbal data that contains the opinions of the students as a response to the utilization of the Fictionation tool.

4.4.3.4.1 Data Analysis of the Visual Data (Idea Sketches)

For the purpose of quantitatively analyzing visual data, this thesis offers a new assessment technique that adopts quantitative content analysis strategies. Quantitative content analysis is an empirical and unbiased method for evaluating and analyzing auditory, textual, or visual contents. Through this technique auditory, textual, or visual contents can be transformed into codes and thus, they can be statistically analyzed (Margolis & Pauwels, 2012; Van Leeuwen & Jewitt, 2001).

The technique also includes the usage of FBS ontology (Gero & Kannengiesser, 2014; Sarkar & Chakrabarti, 2006) and the genealogy tree technique (Shah et al., 2003), and also a developed version of the measurement technique developed by Shah et al. (2003) and Nelson et al. (2009) to measure novelty and variety. This assessment technique was both used for calculating the novelty and variety scores of the students within the prior achievement analysis that was conducted to determine for the participants for the workshops and for calculating the novelty and variety scores of the students within the Fictionation workshops.

The Function, Behavior and Structure (FBS) Ontology

In order to analyze the visuals, they have to be broken down into their components (Bell, 2001; Krippendorff, 2004). For this purpose, this thesis offers the usage of the FBS ontology. This is a product categorization system that is used to break a product or artefact into its characteristic features or components. While the letter F represents *function*, the letter B represents *behavior*, and the letter S represents *structure*. Function is the description of what the product does. Behavior can be defined as the product's attributes to fulfill the function, and the structure can be described as the components or elements that the product is composed of (Gero & Kannengiesser, 2014; Sarkar & Chakrabarti, 2006).

The results of this encoding process should be reliable and consistent, therefore, to increase the inter-rater reliability, the encoding process was separately conducted by three different coders, who were industrial design educators who have four to six years of experience. At the end of the encoding process, three solution clouds containing various functions, behaviors and structures were obtained. Then the coders came together to obtain one merged solution cloud.

The Genealogy Tree

Following the encoding process, the obtained codes were categorized by considering the genealogy tree technique. This is an analysis technique used to see the origins of ideas. Regarding this technique, the product is divided into sub-categories in the shape of a tree diagram that consists of different levels. At the highest level, ideas are diversified by their physical principles. At the second level, working principles are the criteria through which ideas are differentiated. The third and fourth levels consist of ideas that are different from each other based on their embodiment and details respectively (Figure 54) (Shah et al., 2003).

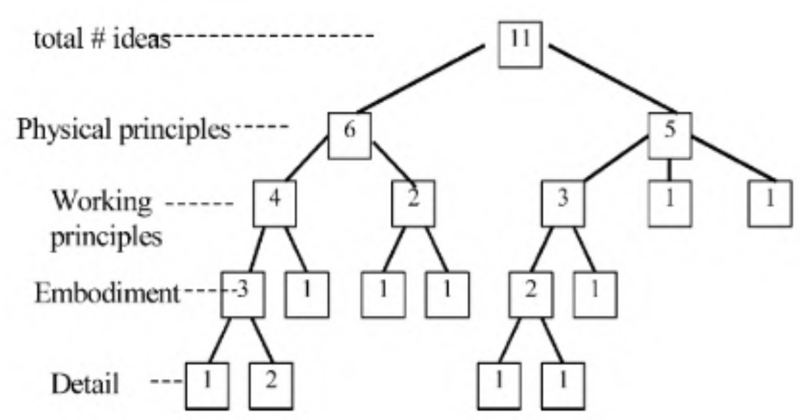


Figure 54. The genealogy tree model (Shah et al., 2003, p. 126)

The three coders worked together using the genealogy tree technique and placed all the items in the solution cloud in the shape of a tree diagram. After the tree diagram was prepared, the three coders started to place the sketches under relevant categories. After a certain point where it was believed a general consensus in the distribution of idea was reached, the researcher continued to the placement process alone and completed the tree diagram. Then the researcher used a developed version of the measurement technique developed by Shah et al. (2003) and Nelson et al. (2009) to calculate novelty and variety scores.

Calculation of the Novelty Scores

For the purpose of calculating novelty, a formula that was used in the studies of Shah et al. (2000); Shah et al. (2003), and Moon and Han (2016) were used. The formula basically calculates how novel an idea is compared to the other related ideas. Where T is the total number of ideas that fulfill the same function, S is the number of current solutions for that function, and the novelty score is calculated as $N = (T-S) \times 10 / T$. The novelty scores of each idea category were calculated using this formula; then results were used in the calculation of the novelty scores of each student. The novelty score of a student is the average of the novelty scores of his/her ideas that are produced under different categories.

For example, as represented in Figure 55 right, assuming that a student offered a total of 15 ideas that consist of three different categories as a response to a design problem, to calculate the novelty score of that student, first, the novelty scores of the categories (Figure 55, left) should be calculated.

The novelty score of the category for which the student offered 6 ideas is calculated as (230-30) * 10 / 230 = 8,695. The novelty score of the category for which the student offered 5 ideas is calculated as (230-40) x 10 / 230 = 8,26. Finally, the novelty score of the category for which the student offered 5 ideas is calculated as (230-50) x 10 / 230 = 7,826. In the light of these scores, the novelty score of the student can be calculated as [(6x8,695) + (4x8,26) + (5x7,826)] / 15 = 8,289.

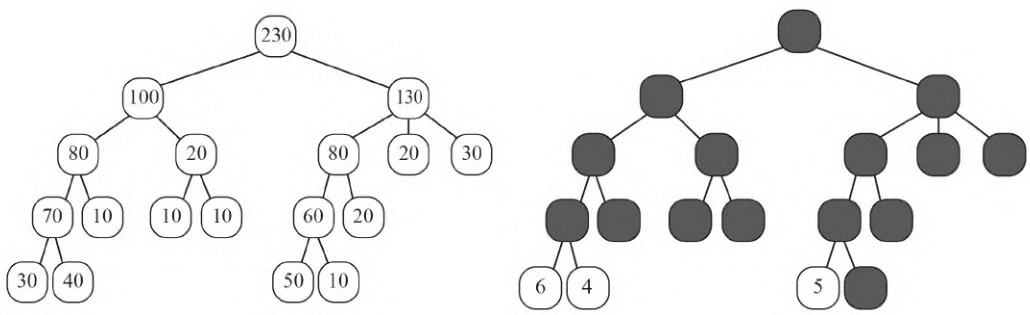


Figure 55. Left: Total genealogy tree of the design problem. Right: Ideas of the student within the total genealogy tree

Calculation of the Variety Scores

For the purpose of calculating variety scores for an idea set, many researchers are using a metric developed by Shah et al. (2003). This metric requires a genealogy tree that contains solution approaches to a design problem and offers a score between 0 and 10. Differentiation of the ideas at higher levels of the genealogy tree creates a greater variety, therefore the values of each level decrease as **10, 6, 3** and **1** respectively (Figure 56).

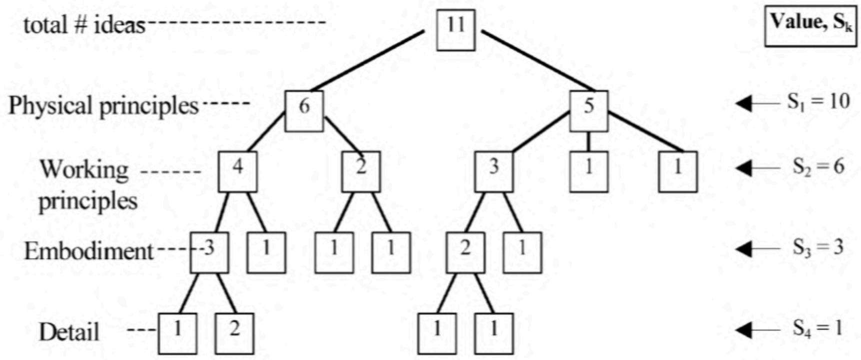


Figure 56. Values of each level (Shah et al., 2003, p. 126)

These values were determined by Shah et al. (2003) for the calculation of the score. However, these values are not strictly determined, and they can be changed considering the number of levels in the genealogy tree. The score is calculated by firstly multiplying the number of branches at each hierarchical level to their corresponding level values, then adding each sum and dividing the sum to the total number of ideas. For example, regarding the genealogy tree in Figure 56 the variety score is calculated as [(2 x **10**) + (5 x **6**) + (6 x **3**) + (4 x **1**)] / 11 = 6,545.

However, there are two flaws in this equation. In some situations, genealogy trees that comprise higher variety, receive lower scores and some solutions receive a variety score bigger than 10, despite the fact that they should get scores between 0 and 10. In Figure 57, the genealogy B consists of three different ideas at the highest level and receives a variety score of 10. However, despite having less differentiated ideas in the highest level, the genealogy A gets a score of 10.66, which is higher than 10, and therefore higher than the score for genealogy B.

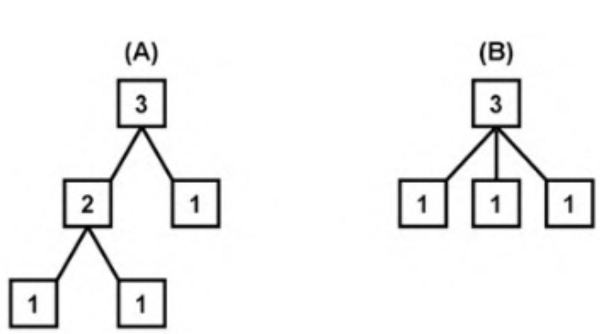


Figure 57. Higher actual variety in genealogy B got a lower variety score compared to genealogy A (Nelson et al., 2009, p. 740)

Nelson et al. (2009) offered a solution to overcome this flaw. Instead of counting the branches at a hierarchical level, they offer to count the differentiations between branches which is one less than the number of branches. If there is only one branch at a hierarchical level, then the differentiation will be zero. Furthermore, the total number of ideas will be one less to preserve the score between 0 and 10. When this equation is implemented to the genealogy trees in Figure 57, the genealogy A gets a score of [(1 x **10**) + (1 x **6**)] / 2 = 8 and genealogy tree gets a score of (2 x **10**) / 2 = 10 which presents better results than the equation of Shah et al. (2003).

Variety is about the exploration of the solution space and the number of the offered ideas does not mean anything in this exploration. Regarding this exploration, it is important to offer ideas that are different from each other. However, Shah et al. (2003) and Nelson et al. (2009) offered to divide the variety score into the total number of ideas at the end of their formula. This equation was found problematic. For example, while student A in Figure 58 just offered two ideas under different categories, it is obvious that student B made a deeper exploration by offering ideas in different categories and therefore should get a higher variety score compared to student A. However, when the formula of Shah et al. (2003) was applied to those students, student A would get a variety score of (2x10) / 2 = 10 and student B would get a variety score of [(2x10) + (5x6) + (6x3) + (4x1)] / 11 = 6,545. Besides, when the formula of Nelson et al. (2009) was applied to those students, student A would get a variety score of (1x10) / 1 = 10 and student B would get a variety score of [(1x10) + (4x6) + (5x3) + (3x1)] / 10 = 5,2.

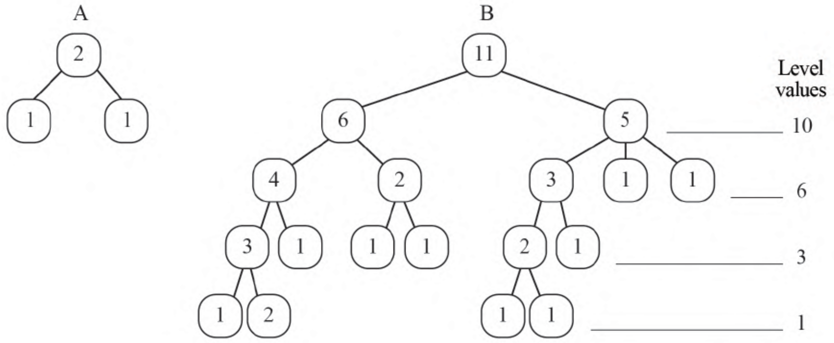


Figure 58. Flaw in the variety formula

It is obvious that, there is a flaw in the formulas of Shah et al. (2003) and Nelson et al. (2009) regarding the calculation of variety score. Therefore, a new metric that measures the ratio of the solution space exploration done by a specific student to all students is offered within this thesis. In this metric, the total genealogy tree was accepted as the solution space for that problem and each student's variety score was calculated by comparing their genealogy tree to the total genealogy tree. The variety score was not divided into the total number of ideas at the end of the equation as it is done in the studies of Shah et al. (2003) and Nelson et al. (2009). Instead, the variety score of a student was compared with the total variety score of the solution space. Furthermore, the technique of counting the differentiations between branches offered by Nelson et al. (2009) was adopted within the calculation of the variety score. In order to preserve the scores between 0 and 10, the formula of [(variety score of the student x 10) / variety score of the solution cloud] was offered. When the offered formula was applied to the ideas of student A and B that were represented in Figure 58, the genealogy tree A would get a variety score of (1x10) = 10 and the genealogy tree B would get a variety score of [(1x10) + (4x6) + (5x3) + (3x1)] = 52. The ideas of other students, together with these two would constitute a bigger solution space and a bigger genealogy tree. Assuming that the variety score of that genealogy tree is 80, the variety score of student A can be calculated as (10x10) / 80 = 1,25 and the variety score of student B can be calculated as (52x10) / 80 = 6,5. When the results were compared with the ones of Shah et al. (2003) and Nelson et al. (2009), they presents a consistency in terms of acquiring a bigger variety score for student B.

4.4.3.4.2 Data Analysis of the Verbal Data (Interviews)

The tape recordings of the participants were transcribed into a Microsoft Excel sheet (Figure 59). The quotations of the participants were transcribed as raw data and through using content analysis method, they were analyzed in order to code them to achieve coherent and valid interpretations (Bogdan & Biklen, 2007; Krippendorff, 2004). The themes of the coding process were determined as process (workshop process), duration (time allocated for each phase), situation analysis (earlier experiences), cards (opinions related to Fictionation cards), charts (opinions related to Fictionation charts) and aim (aim of the workshop). The questions that were asked to the participants (see Appendix D) were already determined by considering these themes. Therefore, regarding the content analysis method, the themes were reached within the first round of the analysis.

	A	B	C	D
1	Participants	Raw Data	Theme	Positive / Negative
2	s3	The process was easy to understand	Process	(+)
3	s3	The limitation regarding time within Phase 2 made a haste for me but I understand that it was helpful to generate more ideas	Duration	(+)
4	s3	The process was beneficial to think without limitations	Process	(+)
5	s3	We consider limitations within our projects therefore we can not generate novel ideas	Situation Analysis	(nötr)
6	s3	The scenarios on what if cards were reasonable	Cards	(+)
7	s3	Design of the cards were successful	Cards	(+)
8	s3	The texts on the cards were understandable	Cards	(+)
9	s3	Bold text were useful. I do not need to read all the text	Cards	(+)
10	s3	I Choose the cards regarding the visualizations in my mind	Cards	(nötr)
11	s3	The aim of the method was to foster creativity	Aim	(+)
12	s3	In studio projects, instructors asks us to generate novel ideas, but we do not know how to generate them	Situation Analysis	(nötr)

Figure 59. Transcriptions of the interviews

This chapter presented the methodology of the study by defining it as a mixed method study. Furthermore, it presented the adopted research model and data collection and analysis techniques that were used within the three studies of the research. In the following three chapters, the details and results of the three studies will be given respectively.

CHAPTER 5

STUDY 1: NEEDS ASSESSMENT STUDY

As mentioned in the previous chapter, the research carried out for this thesis consists of three studies: needs assessment study, development of the Fictionation tool, and implementation of the Fictionation tool (Figure 40). Chapter 4 presented the research model and methodology. This chapter, together with the following two chapters will present the results of the studies that were conducted within this thesis.

The needs assessment study was composed of two stages: observation and peer debriefing. The observation was carried out to investigate how students carry out their idea generation process in a studio project. The peer debriefing stage also had two phases: idea exchange and brainwriting. They were conducted with colleagues to gather opinions and gain in depth insights and investigate the idea generation process within a brainwriting session.

5.1 Observation

As mentioned in the previous chapter, a non-participant observation was conducted as part of the first study of this research. The aim of the observation was to determine how students carry out their idea generation process, whether they have problems in the process, and how they perform in this process.

5.1.1 Observed Group, Setting, Project and Duration of the Observation

The Observed Group

The observation involved the conduct of a 3rd year undergraduate design studio project at METU Department of Industrial Design for a duration of seven weeks.

The project had an emphasis on idea generation and integrated the usage of many idea generation methods in the early stages; therefore, this project was chosen for observation. There were 46 students (11 males, 37 females) enrolled to the course in the semester of observation (2017-2018 Spring) and eight instructors were included in the tutorial team. Each student had accomplished their compulsory studio courses so far, and besides their studio course, they were taking other must and elective courses.

The Studio Setting

During the observation process, students were working in their natural studio setting where there was an interactive environment in which they can share intellectual and social processes, receive feedback and get help from their instructors as well as from their classmates (Figure 60) (Güngör, 2005). The studio was a big open space where each student had a desk they could work at. The desks were placed in the studio in groups so that students could interact with their peers easily and the placement of the desks enabled students to go around the studio and observe other groups, with the big spaces between them. Furthermore, there was a different kind of desk in the studio that is designated for the common use of the studio as in the cases of giving general critiques.

Figure 60. The setting of a design studio

Besides, there were boards on the walls of the studio enabling students to hang up their works on. Thus, the process of a project was within the sight of the students and instructors, and wall critiques could also be made in front of these boards.

The Project

The title of the project observed was “Sustainable Outdoor Lighting Family for METU Campus in Collaboration with Moonlight”. The project was carried out in collaboration with Moonlight, a major outdoor lighting company located in Ankara, Turkey. In this project, students were asked to develop a family of outdoor lighting units aligned with the institutional identity of the METU campus, and in accordance with sustainable design considerations. The project also had a particular focus on maintenance and repair, and design solutions inspired by nature. The outdoor lighting family was expected to consist of three types of lighting fixtures: bollards, pole/post tops, and wall and/or pillar mounted fixtures. The brief and timetable of the project can be seen in Appendix A and B respectively.

Regarding the outcomes of the project, each student conducted research and made presentations regarding their findings; they generated design ideas and acquired a considerable number of sketches and models; they modelled and visualized their ideas using software and prepared presentation boards as well as the models of their design solutions.

The Duration of the Observation

The observation was carried out in the Spring semester of the 2017-2018 academic year. The studio course took place on Mondays and Thursdays over a period of 14 weeks, which is the semester duration. The total class hours per week was 12. On Mondays, class started at 13.40 pm and finished at 17.30 pm. On Thursdays, class started at 8.40 am and finished at 17.30 pm, with a lunch break between 12.30 pm and 13.40 pm. Beside the course hours, studio was open for the usage of the students for 24 hours, and students had the opportunity to continue working after the course hours. The observation was conducted within the first project of the Spring semester that occupied seven weeks. Thus, the researcher had the opportunity to observe students for a total of 84 hours.

5.1.2 Process of the Project

The project had four phases: A research phase including literature search, market search and campus observation; an idea generation phase including the methods of inspirational gallery, biomimicry, morphological chart, the matrix, and the task exercises; a design finalization phase; and a design presentations and final evaluation phase (Figure 61).

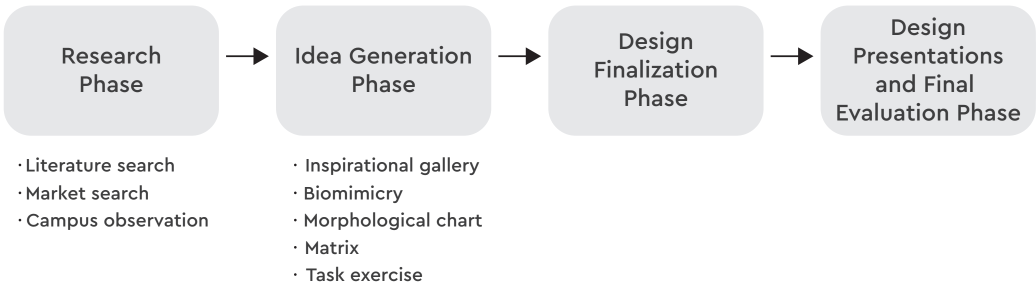


Figure 61. Phases of the lighting project

At the beginning of the project, designers from Moonlight came to the studio with some of their product examples and carried out a technical product examination session regarding technical details, material usage and production. Furthermore, they mentioned about future trends in outdoor lighting products (Figure 62).

Figure 62. Designers from Moonlight talking about products

5.1.2.1 Research Phase

Prior to the idea generation phase, students were asked to make a literature and market search, a field observation in teams, and present their findings and insights in class. There were ten teams constituted for the research phase: six of them had five students and four of them had four students. The literature and market search were expected to include a review and analysis of the following topics related to the project context:

- Moonlight company,
- Other local and international lighting companies,
- Types of lighting products,
- Product examples,
- Led lighting technology,
- Components of lighting products,
- Materials related with lighting products,
- Biomimicry,
- Sustainability,
- Smart technologies.

The field observation was expected to cover interviews with campus users and maintenance staff as well as observation on the usage of outdoor lighting units in the METU campus. The topics to be covered included the following:

- Interviews with the METU shareholders such as students, tutors, maintenance staff, taxi drivers, on their opinions on outdoor lighting within the campus,
- Main areas and main paths within the campus,
- Existing outdoor lighting products within the campus; documentation and observation of performance,
- Encountered problems of the outdoor lighting products within the campus,
- Usage of outdoor lighting in campus in different times of the day.

5.1.2.2 Idea Generation Phase

During the idea generation phase, students utilized different idea generation methods.
The first of these was the "design inspired by nature" (inspiration gallery and biomimicry sketch analysis) method. Following the research phase, students were asked to observe, explore and documents six different natural systems or organisms such as animals, plants, trees and seeds within METU campus and bring samples and printouts of taken photographs to class for the purpose of making an inspiration gallery (Figure 63).

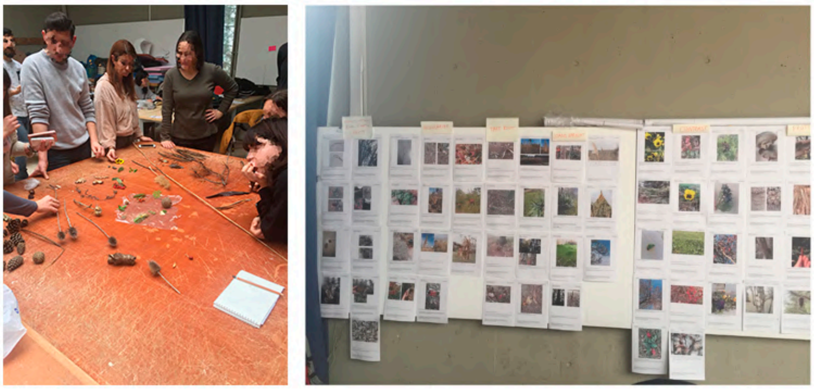


Figure 63. Inspirational gallery

Students were asked to select and compile six natural organisms, behaviors and/or systems from the inspirational gallery. For each source of inspiration, students were expected to prepare a detailed hand sketch analysis describing and visualizing its unique features and components in terms of the biomimicry strategies (Figure 64) and the implications of the features in terms of form, color, pattern, feedback, scale, etc. (Figure 65). Biomimicry is an approach that takes nature and its systems and organisms as a source of inspiration to emulate and produce design solutions to solve design problems (Benyus, 1997; Yen & Weissburg, 2007). In this project, students explored strategies and principles of nature in terms of various strategies, such as attach-detach, assemble, modularize, hold-grip, direct, and harmonize, to generate diverse ideas.

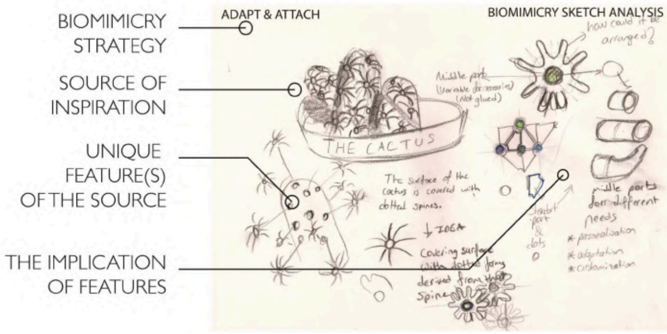


Figure 64. Unique features and components (image taken from the biomimicry sketch analysis brief handed out to students)

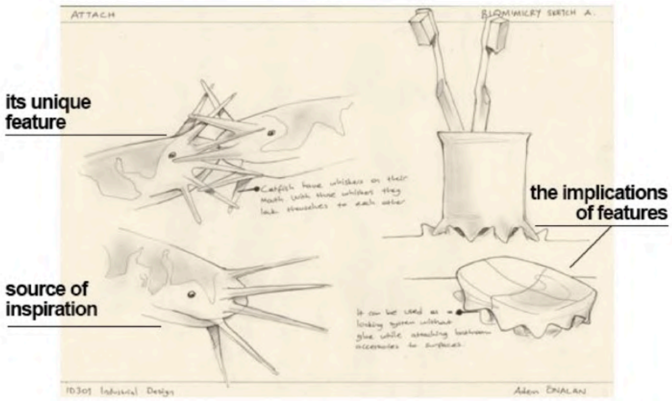


Figure 65. Implications of the features (image taken from the biomimicry sketch analysis brief handed out to students)

Following the biomimicry sketch analysis step, the morphological chart method was conducted. Morphological chart is a table used for exploring various form alternatives for the components of a product (Gonçalves et al., 2014; Cross, 2008). This is done by first decomposing the product and identifying its sub-functions. The general agreement in the literature is to determine at least 8, and at most 12 sub-functions (Börekçi, 2018). Then, these sub-functions are listed on the first column of the matrix. For each row representing a sub-function, six alternative component ideas are sketched; these are called sub-solutions. When the chart is completed, there are many ideas of partial products or components. The aim of this method was to provide a pool of solutions for the following exercises. Once the chart was filled, students were asked to make six mock-ups of the sub-solutions that they had sketched (Figure 66).

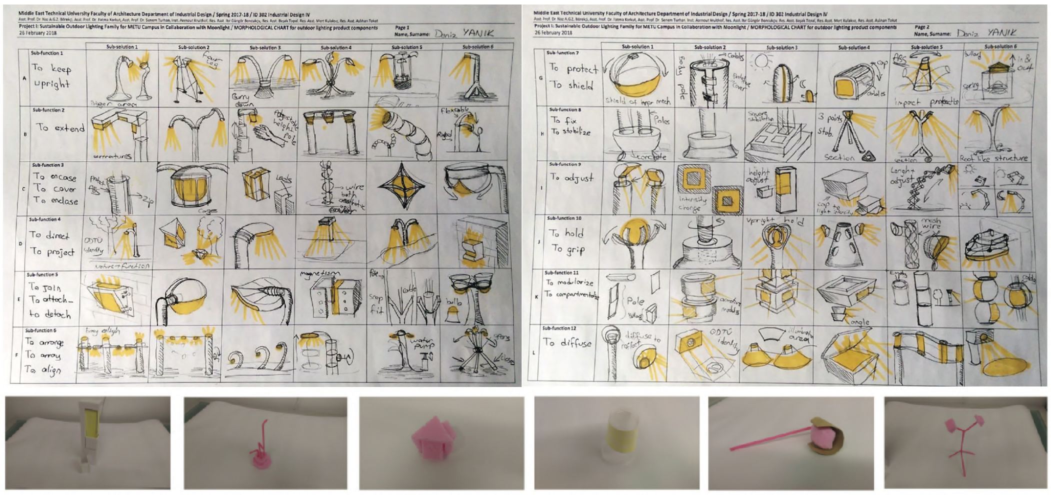


Figure 66. Morphological chart and mockups of a student

Following the morphological chart method, students performed a new idea generation exercise called the Matrix (Korkut and Doğan, 2010). The Matrix consisted of the project dimensions placed on the top of each column, and the project themes placed on the left of each row. The design task was to sketch a minimum of 9 ideas in each intersecting cell of the matrix table inspired by the themes and the dimensions provided to students. The project themes were campus team in charge, magical creatures of the campus and service satellite in orbit. The project dimensions were rugged, interactive, disguised and/or exposed, and evolving (Table 3).

Table 3. Project themes and dimensions of the Matrix exercise

Project Themes/Project Dimensions	Rugged	Interactive	Disguised and /or exposed	Evolving
Campus Team in Charge				
Magical Creatures of the Campus				
Service Satellite in Orbit				

Having completed the Matrix exercise, students had 9 ideas. The next idea generation exercise was the Task exercise. This time, first students were asked to select two ideas from the outcomes of the Matrix exercise and develop them. Then, they were asked to carry out three of the following four tasks to transform each idea: “make it a product which allows upgrading aesthetically”, “make it a locally inspired product family”, “make it vandal-proof”, and “add a secondary function as an additional or an integrated element”. Finally, they were expected to review their sheets for each idea and prepare two A3 sheets to present in studio and get feedback (Figure 67).

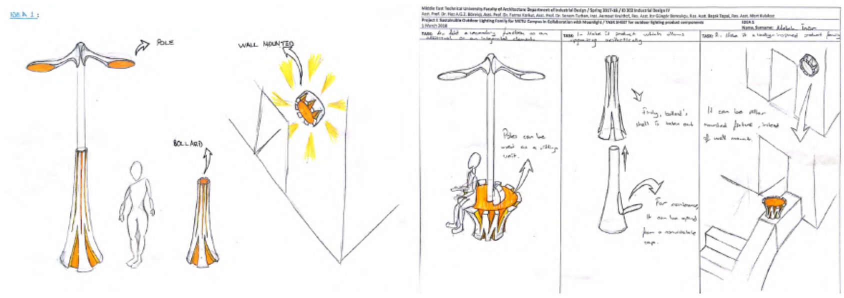


Figure 67. The Task exercise sketches of a student

5.1.2.3 Design Finalization Phase

After all the idea generation exercises were finished, students carried on getting feedbacks from the instructors based on their sketches and mock-ups. Considering these feedbacks, they made refinements on their design solutions and finalized their products.

5.1.2.4 Design Presentations and Final Evaluation Phase

For the final week of the project, students prepared their 2D and 3D presentations to present their products to the jury. The 2D presentation boards included a concept board and a technical drawing board. The 3D presentations included the full-scale models of two members of the lighting family (bollard, pole/post top and wall/pillar mount), and a scaled model of the other member (Figure 68). The final evaluation jury took place with the participation of the studio instructors, external department instructors and representatives from the collaborating firm.

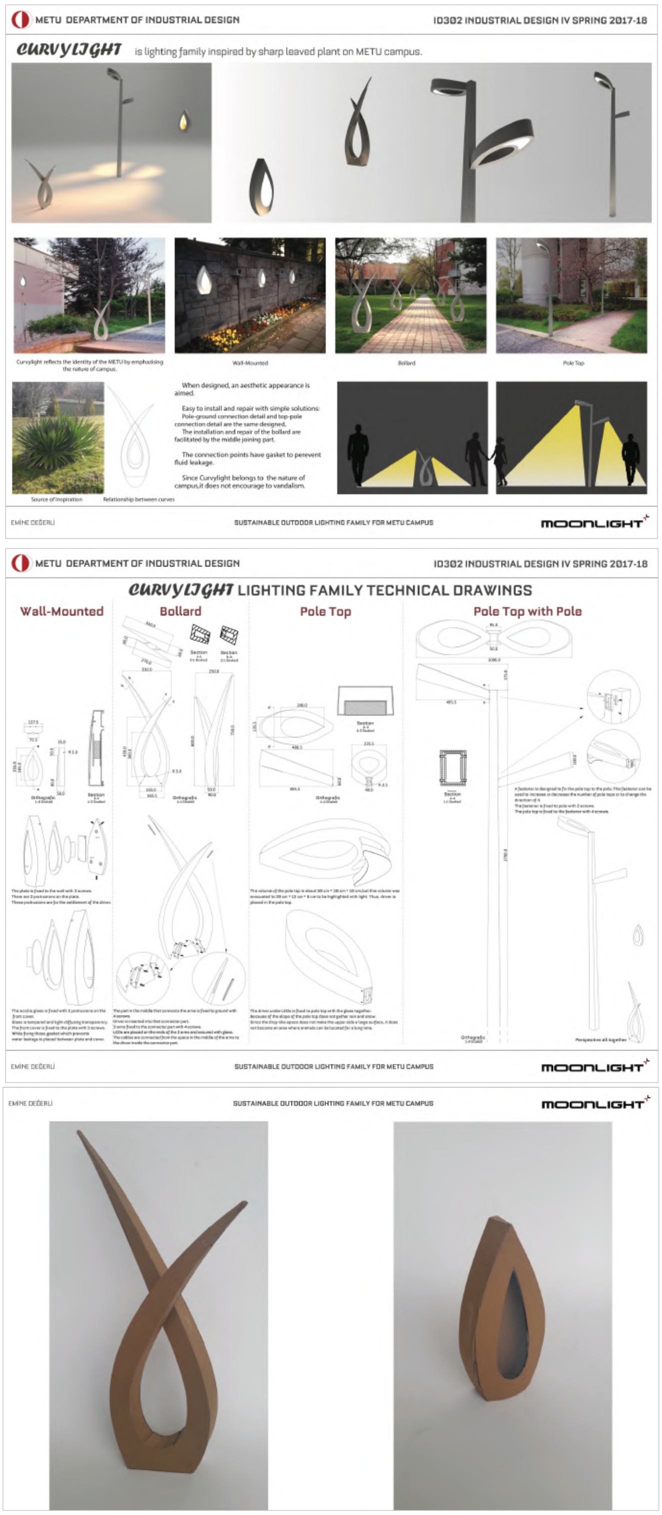


Figure 68. Presentation board and models of a project. Top left: Concept board. Top right: Technical drawing board. Bottom: Full-scale paper-based models of the bollard and wall-mounted fixture.

5.1.3 Inferences from the Observation

It was observed during the seven-week observation process that, the research phase brought students a background knowledge about the lighting products. This background knowledge was also a preliminary preparation for the idea generation process. During idea generation, the biomimicry exercise provided the students a different perspective in terms of searching for sources of inspiration in the natural environment. The next idea generation exercise, the morphological chart method, provided the students a pool of ideas in a short period of time. These two exercises supported students in generating ideas in a divergent manner. The Matrix exercise, which was the third idea generation exercise, supported students in generating ideas in a convergent manner through different inspirational themes. This time, instead of generating new alternative solutions, students investigated their pool of ideas and by getting inspiration from the delivered themes, they chose the ideas that they wanted to work on and developed them. Lastly, through the Task exercise, students further developed some of the generated ideas of the Matrix exercise.

The importance of idea generation exercises became visible towards the end of the project and especially in the final jury. There were many examples of students who were inspired from the idea generation exercises and who reflected the ideas that they generated in these exercises onto their final products. For example, Figure 69 presents one of the sketches generated by a student as a result of the Matrix exercise. It is obvious that the generated idea that offers ejecting some parts of the product, inspired the student while developing his/her final design solution. Furthermore, Figure 70 shows that, the student almost reflected the same idea that was generated in the idea generation phase onto the final design solution. These examples show the critical importance of the idea generation exercises for the final design solution.

Figure 69. Idea generation sketches and final design solution of a student. Left: An idea generated during the Matrix exercise, Right: The final design solution

Figure 70. Idea generation sketches and final design solution of a student. Left: An idea generated during the Matrix exercise, Right: The final design solution

Another critical point was that, half of the class had experienced the Morphological Chart method in the previous semester, and it was observed that they had more control over the exercise compared to those that did not have experience in it. Those who had experienced the exercise started the task instantly; however, those who had not experienced the exercise needed to ask their friends and instructors about the procedure. Therefore, it can be argued that, conducting these kinds of idea generation exercises repeatedly and in different contexts would enable students to master these issues. According to Gick and Holyoak (1983), students become less context-dependent and more flexible when they have the opportunity to apply their knowledge and skills in multiple contexts.

Furthermore, it was observed that many of the proposed ideas by the students were similar to the examples that they had presented in the literature and market search. Therefore, it can be inferred that, students might have had a fixation problem restraining them from generating alternative and novel ideas to the ideas available in the market that they saw during research. Findings from the literature were also in parallel with these inferences. Many researchers indicated that designers, especially novice designers struggle to produce diverse and novel ideas and generally their efforts end up with fixation (Aspelund, 2015; Bruseberg & McDonagh-Philp, 2002; Christian et al., 2012; Linsey et al., 2010; Sio et al., 2015; Vasconcelos & Crilly, 2016).

Apart from these, while the students were chatting, it was heard from many of them that even though they wanted to produce different and innovative ideas for form and function in the idea generation process, the issues such as production techniques, cost, and material possibilities created a limitation for them. Some of the statements were as follows: “it is a beautiful form but it cannot be produced”, “even though the form of the product that I draw is beautiful and I want to reflect this to my final design solution, the issues like production techniques and material possibilities is an handicap for us”, “it is beautiful but it will be costly”. It was also indicated that, this situation was caused neither by the requirements of instructors nor the project, it was a limitation that students put upon themselves as they could not proceed without thinking about the feasibility of the final product. However, the idea generation process should be one during which students can think freely and produce in a divergent manner. The ideas that they have abandoned for the indicated reasons, might be hampering some successful final design solutions.

To sum up, the main inferences from the observation process was that,

- Idea generation exercises are a critical part of the design process and students should be introduced with many of them.
- Students might be having a fixation problem in which they have difficulties in generating novel ideas.
- Students might not be able to think freely and generate ideas in a divergent manner in the idea generation process because of their concerns about the further steps of the design process, such as production, cost and material constraints.

5.2 Peer Debriefing

As mentioned in Chapter 4, to discuss the inferences gained from the observation, and to gather opinions and gain in depth insights about idea generation, a peer debriefing session was conducted as the second stage of the needs assessment study. The session composed of two phases: idea exchange and brainwriting.

5.2.1 Peer Debriefers of the Session

Eight peer debriefers (five males and three females) participated in the session. The peer debriefers were research assistants in the same department as the researcher. They had 2 to 7 years of experience as tutors of the undergraduate design studio courses ranging from 1st year to 4th year (Table 4). They were experienced in the topic of idea generation, both as industrial designers and as industrial design educators, and they had fresh memories from their studentship experiences. Therefore, they had the opportunity to talk about both their experiences as designers, the experiences that they had as educators with students, and the experiences that they faced during their studentship.

Table 4. The Peer Debriefers of the Sessions

Sessions	Peer Debriefer #	Years since graduation	Studio course experience	Participated studio courses
Session 1 (75 minutes)	Peer Debriefer 1	7 years	6 years	1st, 3rd and 4th years
	Peer Debriefer 2	9 years	7 years	4th years
	Peer Debriefer 3	8 years	4 years	3rd and 4th years
	Peer Debriefer 4	10 years	4 years	2nd and 4th years
Session 2 (85 minutes)	Peer Debriefer 5	7 years	3 years	2nd and 4th years
	Peer Debriefer 6	6 years	2 years	2nd years
	Peer Debriefer 7	7 years	3 years	1st and 3rd years
	Peer Debriefer 8	7 years	3 years	3rd years

5.2.2 Procedure of the Sessions

The busy schedule of the participants required that the peer debriefing was held in two sessions. The sessions were conducted in two separate groups that accommodated four participants each and lasted around 75 and 85 minutes. Each session was managed by the researcher as the moderator, and the sessions took place around a big desk in a quiet room in the Faculty. The sessions were conducted in two phases: idea exchange and brainwriting.

5.2.2.1 Idea Exchange

At the beginning of each session, the researcher shared his inferences gained from the observation of the studio project and obtained the opinions and experiences of the peer debriefers regarding the idea generation process. All of the peer debriefers indicated the importance of the idea generation process for obtaining a successful end result. They mentioned that, during the idea generation process, various alternatives for the form, function and interaction of the product are generated. It was also declared that, the more the ideas generated in the idea generation process have variety and novelty, the more successful the final product is.

Regarding the inferences of the observation process, peer debriefers agreed that there is a problem in generating various and novel ideas during the idea generation process.

Considering their experiences as industrial designers, design studio instructors and former undergraduate students, they mentioned that, they and students, who they have observed as instructors, restrict their creative thinking process with the further considerations of the design process such as material, production techniques and cost.

Furthermore, it was mentioned that the tendency for restriction changes considering the project brief. If the project brief demands students to produce futuristic products, then the students do not limit themselves by considering the subsequent issues of the design process since they are not asked to design for today's world and are free to imagine future possibilities. On the other hand, if the project brief demands solutions to the problems of the contemporary world, which is generally the case, then students cannot think freely because of their considerations of the subsequent issues of the design process. Based on the judgments of the peer debriefers, the inferences of the observation process could be qualified as valid.

5.2.2.2 Brainwriting

Following idea exchange, a brainwriting session was conducted to deeply investigate the idea generation process. Regarding this stage of the session, each participant was given post-its and asked to write down the issues that needed to be considered during the idea generation process, both based on their personal experiences and on their insights related to students, gained during studio courses. Then, all the post-its were compiled, and a pool of considerations was obtained (Figure 71). As mentioned in the previous chapter, the peer debriefing sessions were conducted in two separate groups of four participants. While, the participants of the first peer debriefing session wrote 62 considerations, the participants of the second session wrote 56 considerations. Following the sessions, the researcher examined the post-its and eliminated the considerations that are similar to each other. Following this process, 20 considerations for Group 1 and 17 considerations for Group 2 were obtained (Table 5).

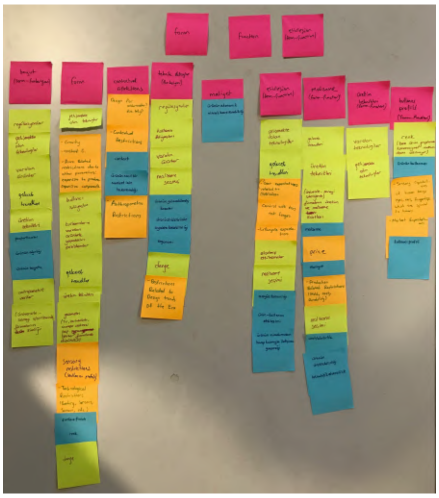


Figure 71. Issues considered by students during the idea generation process, as compiled from the first peer debriefing session.

Table 5. Considerations of the idea generation process

Considerations obtained from Group 1	Considerations obtained from Group 2
contextual restrictions	new technologies
new technologies	existing products
existing products	productions techniques
future trends	cost
production techniques	user needs
gravity	existing forms
cost	structure
user needs	ergonomics
existing forms	color
technological restrictions	user
structure	proportions
ergonomics	anthropometric measurements
color	balance
sense organ	material
user	accustomed interactions
proportions	purpose
weight	dimensions
anthropometric measurements	
surface finish	
balance	

Following the peer debriefing sessions, the considerations indicated in the two groups were combined, identical ones were merged and a total of 24 considerations were obtained and sent to the participants through an online form. Participants were asked to grade the considerations between 1 to 10 considering their importance for the idea generation process. Table 6 presents the scores and their averages obtained from the grading task. When the results were examined, it was seen that 13 considerations received higher scores compared to the others. Some of these considerations are similar to each other such as “user” and “user needs,” “existing products” and “existing forms”, and “new technologies” and “technological restrictions”. These considerations were gathered under a single heading and at the end a total of ten considerations were acquired: new technologies, existing products, production techniques, gravity, cost, sense organ, user, anthropometric measurements, accustomed interactions, and purpose.

Table 6. Scores of the considerations

Considerations	**p1**	**p2**	**p3**	**p4**	**p5**	**p6**	**p7**	**p8**	**Average**
contextual restrictions	2	2	3	3	3	3	2	2	2,5
new technologies	7	7	7	8	8	9	9	10	8,1
existing products	8	9	9	9	10	10	10	10	9,4
future trends	1	1	2	2	2	3	3	4	2,3
production techniques	7	7	8	9	9	9	10	10	8,6
gravity	7	7	8	8	9	9	10	10	8,5
cost	6	7	7	8	8	9	9	10	8,0
user needs	7	8	8	9	9	9	10	10	8,8
existing forms	9	9	9	9	10	10	10	10	9,5
technological restrictions	7	8	8	8	9	9	9	10	8,5
structure	2	2	3	3	3	3	4	4	3,0
ergonomics	3	4	5	5	5	5	6	6	4,9
color	1	1	1	1	1	1	1	2	1,1
sense organ	6	7	7	7	7	8	9	10	7,6
user	8	8	9	9	9	10	10	10	9,1
proportions	2	2	2	2	3	3	4	6	3,0
weight	1	1	1	2	2	2	2	2	1,6
anthropometric measurements	7	9	9	9	9	9	9	10	8,9
surface finish	1	1	1	1	1	2	3	3	1,6
balance	1	2	2	3	4	4	4	4	3,0
material	4	4	4	4	5	5	5	5	4,5
accustomed interactions	7	8	8	8	9	9	9	10	8,5
purpose	8	8	8	9	9	9	10	10	8,9
dimensions	1	2	2	2	2	2	3	3	2,1

As mentioned in the previous sections, the needs assessment study was composed of two stages: observation and peer debriefing. The inferences that were gained from the observation paved the way for the assessment of the problem and need regarding idea generation. Furthermore, the outcomes of the peer debriefing sessions confirmed the inferred problem and need that were gained as a result of the observation. Besides, the acquired considerations that were presented in Table 6 were used in the development process of the Fictionation tool and the details will be given in the next chapter that presents the second study of this research.

CHAPTER 6

STUDY 2: DEVELOPMENT OF THE FICTIONATION TOOL

Following the needs assessment study, the second study of the research 'Development of the Fictionation Tool' was carried out. As mentioned in Chapter 4, regarding the literature review, design fiction was determined to be used as a strategy to fulfil the needs of design students during idea generation and eliminate their problems in idea generation that were acquired following the observation and peer debriefing. The literature review regarding idea generation methods, tools and strategies led the Fictionation tool to become a card-based design tool. For this purpose, a card deck and charts were prepared.

6.1 Preliminary Version of the Fictionation Tool

6.1.1 Card Deck

While preparing the card deck, firstly a literature search regarding the guidelines for a card-based design tool was conducted. Within this research, properties such as medium, dimensions, typefaces, and material were investigated. Following the literature search, the content of the cards was constituted.

6.1.1.1 Medium of the Card Deck

Regarding medium, many of the available card-based tools consist of a combination of text and image or illustration (Haritaipan, 2019; Roy & Warren, 2019; Wölfel & Merritt, 2013). However, studies show that representation of images may negatively affect the idea generation process by creating design fixation that directs designers to generate ideas related with the represented image only (Chan, Fu, Schunn, Cagan, Wood, & Kotovsky, 2011; Chiu & Shu, 2012; Perttula & Liillanen, 2006; Sio et al., 2015). Furthermore, a study done by Goldschmidt (2011) presents that, textual stimuli is a useful tool for idea generation process. For these reasons, it was decided to use only text regarding the medium of the card deck.

According to Yoon et al. (2016), cards should represent the information at a first glance. Therefore, an easy to read sans-serif typeface (Avenir) was selected for the text and bold text was used to draw attention to the important keywords.

Many of the available card decks are designed in the dimensions of a business card (55mm x 85mm) for ease in use and they are printed on plastic-coated paper for durability. Therefore, these specifications were used while producing the card deck of the Fictionation tool.

6.1.1.2 Content of the Card Deck

The cards present some *what-if* design fiction questions that aim to trigger thinking differently and support students in overcoming restricting considerations by creating a fictional world where they can explore, produce and develop differently than in the real world.

For the purpose of determining the what-if questions, the ten considerations that were obtained as the outcomes of the brainwriting session conducted during peer debriefing were used (Table 6). Within the peer debriefing sessions, participants were also asked to categorize the considerations under different headings. The outcome was the three headings of form, function, and interaction. Form refers to the external qualities of the product, function is the description of what the product does, and interaction refers the users' and products' reactions to enable communication among themselves. To increase the number of the what-if questions and thus the diversity of the cards, these topics were integrated into the ten considerations. For example, the consideration of *new technologies* converted into *what-if* questions regarding *form, function* and *interaction*, became as follows:

- What if there were new technologies that are not present in the contemporary world, how would the *form* of the product be regarding that technology?
- What if there were new technologies that are not present in the contemporary world, how would the *function* of the product change regarding that technology?
- What if there were new technologies that are not present in the contemporary world, how would the user *interact* with the product regarding that technology?

With this approach, it was aimed to support students in handling the considerations regarding form, function and interaction, and in offering diversified solutions. All ten considerations were converted into what-if questions (Table 7) considering this approach and at the end a total of 30 idea generation cards were produced (see Appendix E). The cards related with *form* were colored blue, the cards related with *function* were colored green and the cards related with *interaction* were colored red to emphasize the difference. Furthermore, a logo was designed for the tool and printed at the back side of the cards (Figure 72). The name of the design tool was determined as "Fictionation", which is the combination of the words "fiction" and "generation".

Table 7. What-if questions generated for the ten considerations

Considerations	Form	Function	Interaction
New Technologies	What if there were new technologies that are not present in the contemporary world, how would the form of the product be regarding that technology?	What if there were new technologies that are not present in the contemporary world, how would the function of the product change regarding that technology?	What if there were new technologies that are not present in the contemporary world, how would the user interact with the product regarding that technology?
Existing Products	What if the product had an unusual form that is different than the ones in the market, how would the form of the product be?	What if the product had an unusual form that is different than the ones in the market, how would the function of the product change?	What if the product had an unusual form that is different than the ones in the market, how would the user interact with the product?
Production Techniques	What if the contemporary production techniques allowed you to realize anything, how would the product's form be?	What if the contemporary production techniques allowed you to realize anything, how would the function of the product change?	What if the contemporary production techniques allowed you to realize anything, how would the user interact with the product?

Gravity	What if there were no gravity, how would the form of the product be?	What if there were no gravity, how would the function of the product change?	What if there were no gravity, how would the user interact with the product?
Cost	What if there were no economic constraints, how would the form of the product be?	What if there were no economic constraints, how would the function of the product change?	What if there were no economic constraints, how would the user interact with the product?
Sense Organ	What if the user interacted with the product through a different sense organ, how would the form of the product be?	What if the user interacted with the product through a different sense organ, how would the function of the product change?	What if the user interacted with the product through a different sense organ, how would the user interact with the product?
User	What if the product were designed for an extraordinary user, how would the form of the product be?	What if the product were designed for an extraordinary user, how would the function of the product change?	What if the product were designed for an extraordinary user, how would the user interact with the product?
Anthropometric Measurements	What if the anthropometric measurements of the user changed, how would the form of the product be?	What if the anthropometric measurements of the user changed, how would the function of the product change?	What if the anthropometric measurements of the user changed, how would the user interact with the product?
Accustomed Interactions	What if there were a different interaction with the product than the accustomed one, how would the form of the product be?	What if there were a different interaction with the product than the accustomed one, how would the function of the product change?	What if there were a different interaction with the product than the accustomed one, how would the user interact with the product?
Purpose	What if the product were designed for an extraordinary purpose, how would the form of the product be?	What if the product were designed for an extraordinary purpose, how would the function of the product change?	What if the product were designed for an extraordinary purpose, how would the user interact with the product?

Figure 72. Fictionation cards

6.1.2 Charts

Charts were also prepared for the Fictionation tool to make sketches on. As mentioned in Chapter 4, there were a control group and an experiment group in the study, and it was performed in two sessions (Figure 73).

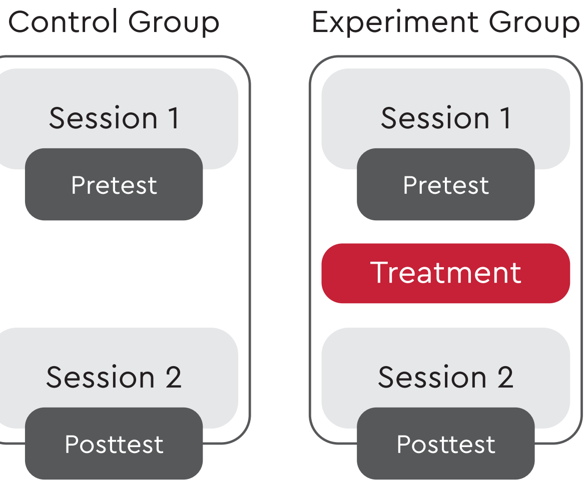


Figure 73. The design of the experiment

6.1.2.1 Charts of the Control Group

Participants of the control group would be asked to make 30 sketches in each of the two sessions, making a total of 60 sketches. Therefore, an A3 sized paper was divided into 15 cells forming a 5-row by 3-column chart. Two charts were to be used in the first session and two were to be used in the second session; The charts were successively titled as Phase 1 / Page 1, Phase 1 / Page 2, Phase 2 / Page 1, and Phase 2 / Page 2. There was also a space for the participant to write his/her name (Figure 74). This chart was named “initial ideas chart”.

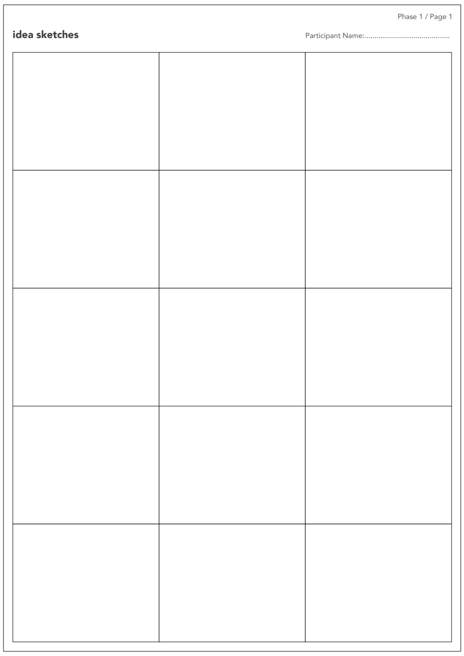


Figure 74. Initial ideas chart

6.1.2.2 Charts of the Experiment Group

The participants of the experiment group used the same charts as the control group for the first session. They were delivered two A3 size sheets with a total of 30 cells to make sketches on. Regarding the second session, participants were asked to generate new ideas by utilizing the Fictionation cards. For this purpose, a new A3 sized chart containing two cells was prepared and named “design for divergence chart”. It was expected that participants would make numerous sketches inside each cell considering the card that is being used. The chart also had an area to write the information about the Fictionation card that was being used. Furthermore, Phase 2 was written on the top right-hand side of the sheet, and the chart had a space for the participant to write his/her name (Figure 75).

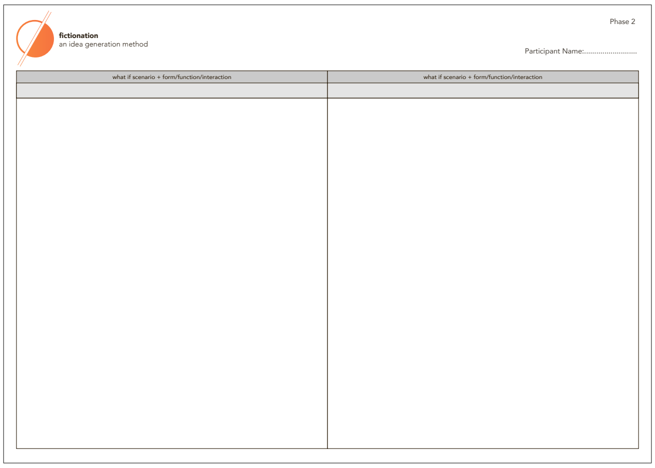


Figure 75. Design for divergence chart

Participants of the experiment group were also delivered one more chart. It was similar to the chart of the control group by having 15 cells. Furthermore, it had an area to write the information about the Fictionation card that was being used, Phase 3 was written on the top right-hand side, and a space for the participant to write his/her name (Figure 76). Participants were expected to evaluate the sketches that were done on the previous chart and develop new ones on this chart. Participants were delivered two of these charts to make 30 sketches. This chart was named "design for convergence chart".

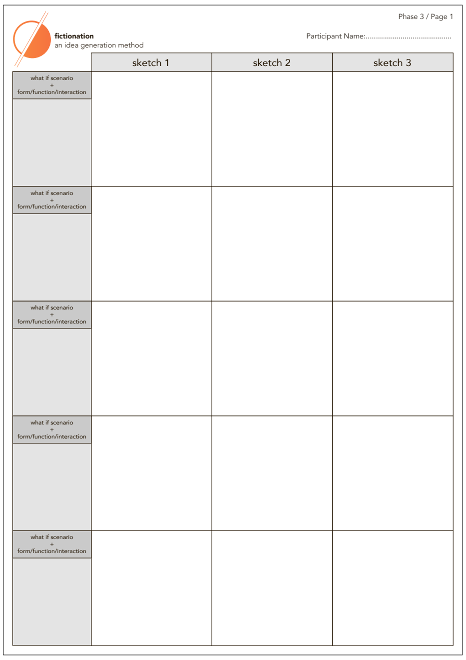


Figure 76. Design for convergence chart

6.2 Pilot Study

Following the preparation of the preliminary version of the Fictionation tool, a pilot study was conducted to test the procedure and mediums of the tool. The pilot study was implemented as part of the idea generation phase of a project carried out within the Interactive Prototyping undergraduate elective course given in the Department.

The Interactive Prototyping elective course aims to build working interactive prototypes by using techniques of programming and electronics. This was a 14-week course and had four phases: introduction to the fundamentals of prototyping, defining a problem, idea generation, and implementation. The Fictionation tool was tested on the 10th week of the course, within the course hours (three hours). By that time, students had gained information about the fundamentals of prototyping, defined their problem statements, and started generating ideas. The projects were: a toilet that forces the user to clean the bathroom environment, an exercise robot that encourages the user to exercise more, a coffee machine that has different operating modes, and a robot that entertains cats thereby helping owners to have some time for themselves.

6.2.1 Participants and Setting of the Pilot Study

The Participants

The Fictionation tool was implemented as part of the idea generation phase of a project carried out within the Interactive Prototyping undergraduate elective course given in the 2018-2019 Spring Semester at METU Department of Industrial Design. There were 14 students enrolled to the course and 13 students (two males, 11 females) who attended the pilot study. Eleven of them were 3rd year undergraduate industrial design students (the pilot study was implemented nearly one year later after the observation, therefore the 3rd year students who were the participants of the observation and those who were the participants of the pilot study were different), and two of them were postgraduate architecture students. The students were working in groups. There were four groups: one group of two, one group of three and two groups of four.

The Setting

The pilot study was conducted in the Faculty's computer lab studio, where the course took place. There were four long tables that were aligned, and there was enough space for each student to work at them. There was also a projector hung on the ceiling and a lectern in front of the screen to make presentations (Figure 77).

Figure 77. The setting of the pilot study

6.2.2 Implementation Process

The implementation process was moderated by the researcher and the two course instructors. Participants were informed about the procedure through a consent form before the implementation (see Appendix F). The pilot study was planned in four phases, as presented in Figure 78. Even though students were working in groups for their project in the course, they were asked to work individually for the pilot study. The focus of the pilot study was the procedure of the Fictionation tool in terms of its mediums, duration, workload, and content. Therefore, the quality and quantity of the generated ideas were ignored regarding the concern of the pilot study. However, students were informed to get the most out of the tool so as to develop their projects within the course. Phase 1 was added to the process for that reason towards increasing the number of the generated ideas.

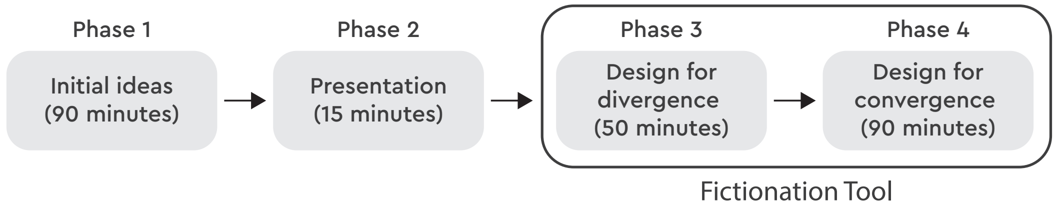


Figure 78. Process of the pilot study

Phase 1

Starting with a 90 minutes phase, students were asked to generate 30 ideas considering their project on their own. Due to the limitation of time and busy schedule of the course, the first phase of the pilot study was given as a home assignment before the course. For this purpose, students were delivered two initial ideas charts containing 15 cells each (Figure 79, Left). They were asked to bring the filled charts to class. At the end, a total of 19 charts containing 256 sketches were collected (Figure 79, Right).

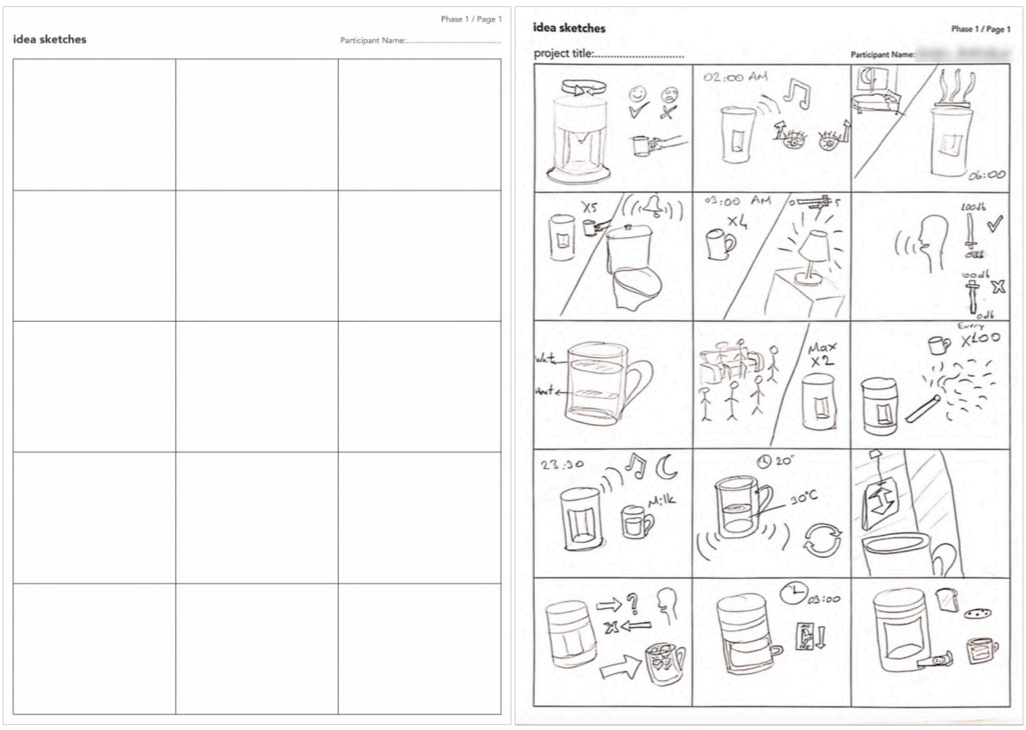


Figure 79. Phase 1 charts. Left: Initial ideas chart, Right: An example of a filled-in chart

Phase 2

Starting from Phase 2, the process was performed in the class. In the second phase, a presentation about the procedure of the Fictionation tool was made by the author to the students (see Appendix G).

Phase 3

This was followed by Phase 3, asking students to generate ideas in a divergent manner by using the Fictionation cards. The four groups of students were delivered a card deck that contains the Fictionation cards, and five design for divergence charts for each student to work on (Figure 80, Left). They were asked to pick ten out of the 30 cards that they wanted to work on. This could be a deliberate selection as well as a random one. Later, they were asked to generate ideas based on the what-if scenarios on the cards. A total of 50 minutes was given for this phase.

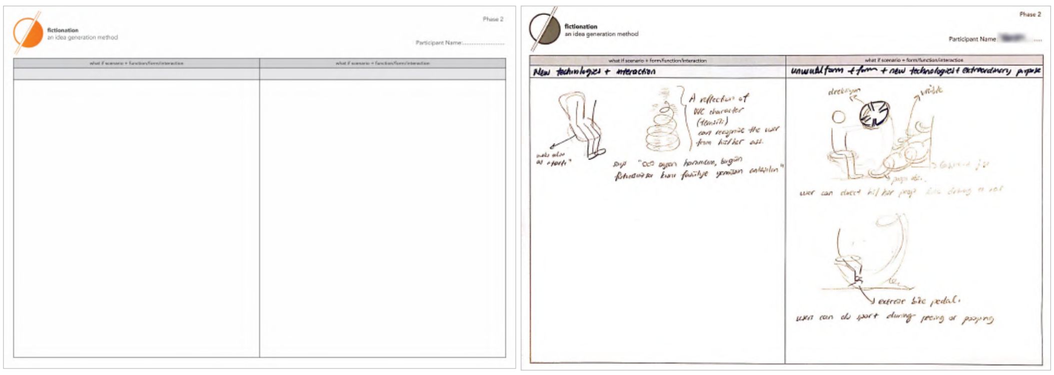


Figure 80. Phase 3 charts. Left: Design for divergence chart, Right: An example of a filled-in chart

Phase 4

In the fourth and final phase, the students were asked to evaluate the ideas that they generated in the previous phase and made 30 new sketches that offered ideas applicable in our contemporary world. They were required to think in a convergent manner and develop the design ideas. For their task, they were delivered two design for convergence charts containing 15 cells each (Figure 81, Left). At the end, a total of 18 charts containing 198 sketches were collected (Figure 81, Right).

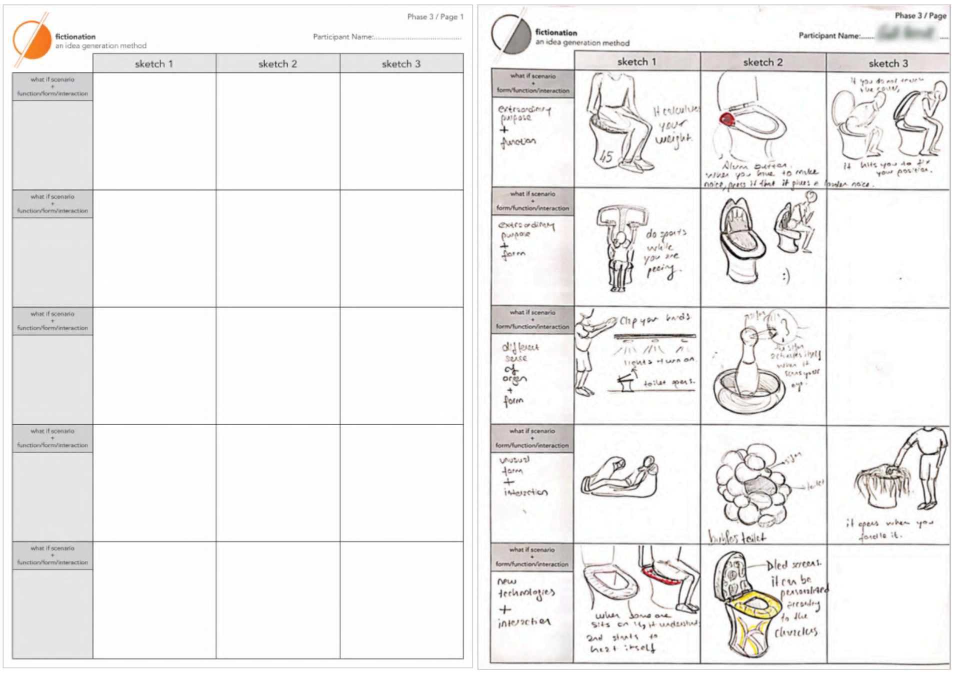


Figure 81. Phase 4 charts. Left: Design for convergence chart, Right: An example of a filled-in chart

Right after the implementation of the Fictionation tool, a discussion session was conducted with the participants for the purpose of receiving their feedback on its procedure and mediums.

6.2.3 Observations from the Implementation

During the implementation the researcher observed the students and took notes on a notebook about the process, duration of the phases, and encountered problems. Based on the observation, the following problems were determined:

- Students did not understand that they were expected to make numerous sketches based on each picked card within Phase 3, design for divergence. Most of them generated only one idea based on each picked card.
- Regarding Phase 4, design for convergence phase, it was observed that students got bored. This situation was thought to originate from the workload required for the task.

6.2.4 Discussion Session

A discussion session was conducted with the participants following the implementation of the Fictionation tool, where they were asked a series of questions regarding the tool's usability (see Appendix C). The following opinions, problems and suggestions were compiled from this session:

- The cards were guiding to think differently and generate ideas that were not thought of before.
- The texts were easy to understand.
- The sizes of the cells of the charts were sufficient to make sketches in.
- The number the picked cards could be less.
- The expected number of the ideas in such a time is excessive.
- Instead of giving a total of 50 minutes for the design for divergence phase, the procedure could allow five minutes of design divergence for each card.
- A new card that examines the "place" could be added to the card deck.
- It would be useful to implement the tool in a teamwork session.

6.2.5 Revisions Made Following the Pilot Study

Based on the observation inferences of the research gained during the pilot study and the opinions and suggestions of the participants, some revisions were made on the procedure, charts and cards of the Fictionation tool.

6.2.5.1 Revisions on the Procedure

First of all, picking eight cards instead of ten to make sketches for, was determined as sufficient to reduce the workload. Furthermore, it was determined to request two ideas per card instead of three for the design for converge chart. Therefore, picking eight cards instead of ten, the required sketches for the design for converge chart would be 16 in total (instead of 30). For the purpose of equalizing the number of the generated ideas, required sketches for the initial ideas chart was also decreased from 30 to 16.

The design for divergence phase was initially given a total of 50 minutes of duration in the pilot study where they were expected to explore all 10 cards; this was changed into allocating 5 minutes for each card of the 8 cards. With this change, it was expected that students would feel a pressure on them and make sketches without being critical, which is the desired state of mind while generating ideas in a divergent manner.

6.2.5.2 Revised Version of the Fictionation Tool

Revisions on the Charts

Due to the expected number of ideas changed for the initial ideas (Phase 1) and design for convergence phases (Phase 4), their charts were redesigned to accommodate the requested 16 ideas (Figure 82).

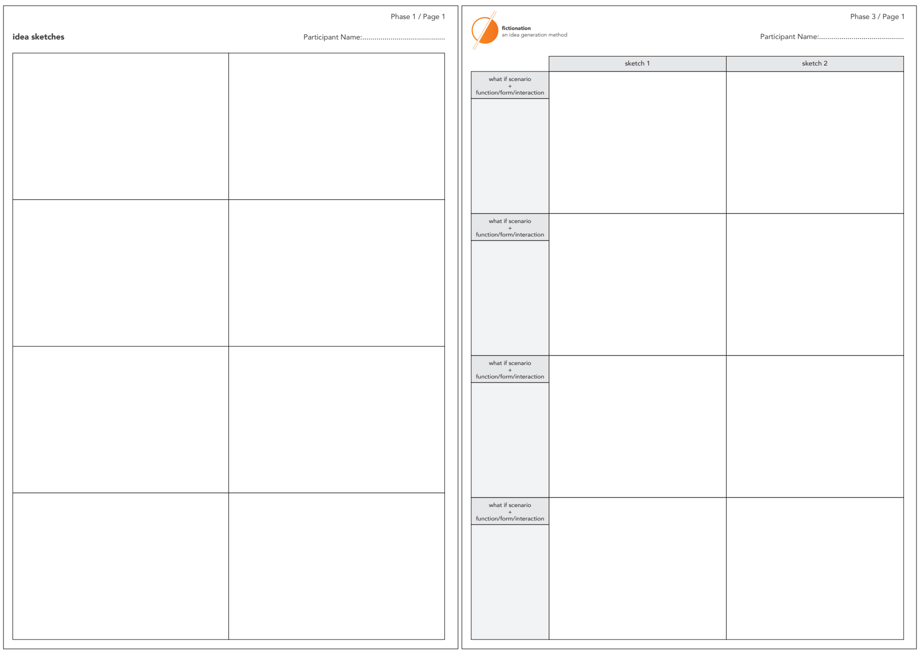


Figure 82. Revised charts. Left: initial ideas chart, Right: design for convergence chart

Furthermore, due to the problem that students could not understand that they were expected to make numerous sketches in each big single-piece cell based on the 10 picked cards within the design for divergence phase (Phase 3), the design for divergence chart was redesigned so as to contain multiple cells (Figure 83). Besides, to enable quick sketching and prevent students to spend too much time on a single sketch, the size of the cells was reduced, and the paper size was changed to A4.

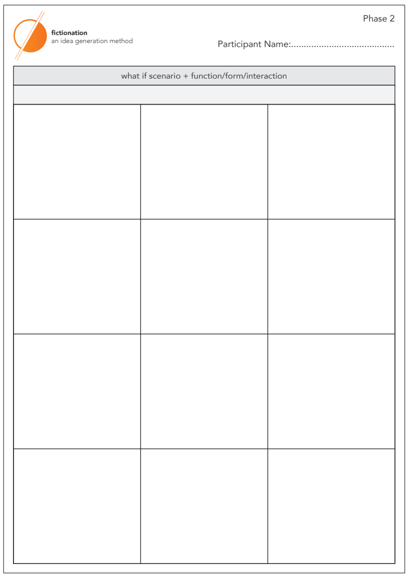


Figure 83. Revised divergence chart

Besides, in response to the suggestion of the participants of implementing the tool in a teamwork session, a new A3 size chart was designed and named as teamwork chart (Figure 84).

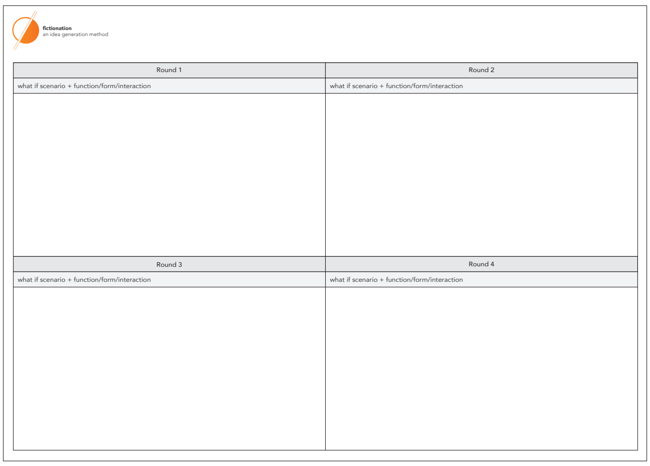


Figure 84. Teamwork chart

Revisions on the Cards

Based on the suggestions of the students of having a new card that examines the "place", three new cards containing what-if questions on form, function and interaction were added to the card deck which at the end made a total of 33 cards in the deck (see Appendix E). The new what-if questions examining the place were as follows:

- What if the product were designed for an extraordinary place, how would the form of the product be?
- What if the product were designed for an extraordinary place, how would the function of the product change?
- What if the product were designed for an extraordinary place, how would the user interact with the product?

This study enabled for the design and production of the Fictionation tool. Through considering the guidelines in the literature, the first version of the tool was prepared and through conducting a pilot study, the procedure and mediums of the Fictionation tool were revised and took its final form that would be used within the workshops that will be presented in the next chapter in detail.

CHAPTER 7

STUDY 3: IMPLEMENTATION OF THE FICTIONATION TOOL

The third and final study of the research was the implementation of the Fictionation tool. The study was conducted in two stages: a prior achievement analysis to determine the participants, and the implementation of the tool within a series of workshops.

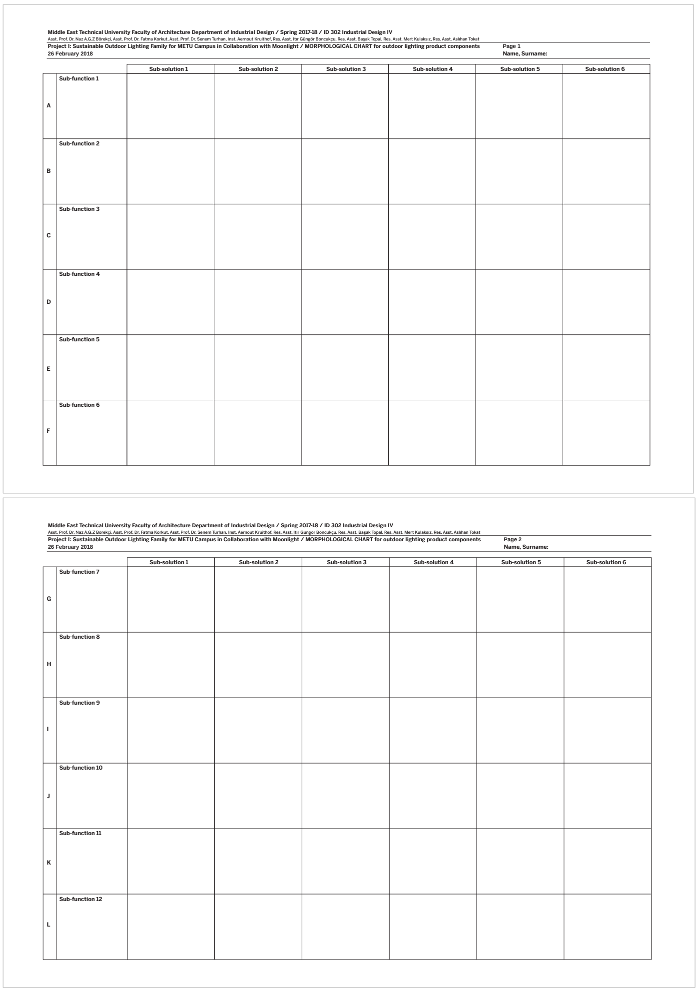
7.1 Prior Achievement Analysis

For the purpose of ensuring the equivalence of the control and experiment groups, a prior achievement analysis was needed. In this respect, the idea generation sketches of the lighting family project of the 3rd year students were examined in order to calculate their novelty and variety scores and to assign them among the control and experiment groups.

7.1.1 Research Materials of the Analysis

Referring to the observation carried out in the first study of the research, during the idea generation process of the outdoor lighting family project, students carried out different idea generation methods, namely the morphological chart, matrix and task exercises. In this stage of this study, only the outputs of the morphological chart exercise were examined because this was the first step of idea generation in which students made idea sketches for design ideas in a divergent manner. Each of them produced around 70 sketches, which is a significant number to evaluate various design alternatives and group them in such a manner that they serve to decide on the participants to take part in the workshops.

There were 46 students in the studio and 45 of them accomplished the morphological chart exercise. Students were given an A2 size paper (divided into two A3 size sheets) with a chart containing 12 rows and 7 columns (Figure 85). The first column was to list the sub-functions of the product and the other columns were for producing sub-solutions for particular sub-functions. It was expected that each sub-function would have 6 sub-solutions and each student would generate a total of 72 ideas (12 x 6) (Figure 86). At the end, there were 3185 sketches in the total of charts obtained from the 45 students. While the minimum number of the sketches drawn by a student was 57, the maximum was 72 and the average was 70,7 (Table 12).



Middle East Technical University Faculty of Architecture Department of Industrial Design / Spring 2017-18 / ID 302 Industrial Design IV
Asst. Prof. Dr. Naz A.G.Z Börekçi, Asst. Prof. Dr. Fatma Korkut, Asst. Prof. Dr. Senem Turhan, Inst. Aernout Kruithof, Res. Asst. Itır Güngör Boncukçu, Res. Asst. Başak Topal, Res. Asst. Mert Kulaksız, Res. Asst. Aslıhan Tokat
Project I: Sustainable Outdoor Lighting Family for METU Campus in Collaboration with Moonlight / MORPHOLOGICAL CHART for outdoor lighting product components — Page 1
26 February 2018 — Name, Surname:

		Sub-solution 1	Sub-solution 2	Sub-solution 3	Sub-solution 4	Sub-solution 5	Sub-solution 6
A	Sub-function 1						
B	Sub-function 2						
C	Sub-function 3						
D	Sub-function 4						
E	Sub-function 5						
F	Sub-function 6						

Middle East Technical University Faculty of Architecture Department of Industrial Design / Spring 2017-18 / ID 302 Industrial Design IV
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Project I: Sustainable Outdoor Lighting Family for METU Campus in Collaboration with Moonlight / MORPHOLOGICAL CHART for outdoor lighting product components — Page 2
26 February 2018 — Name, Surname:

		Sub-solution 1	Sub-solution 2	Sub-solution 3	Sub-solution 4	Sub-solution 5	Sub-solution 6
G	Sub-function 7						
H	Sub-function 8						
I	Sub-function 9						
J	Sub-function 10						
K	Sub-function 11						
L	Sub-function 12						

Figure 85. Left: Two morphological chart sheets distributed to students

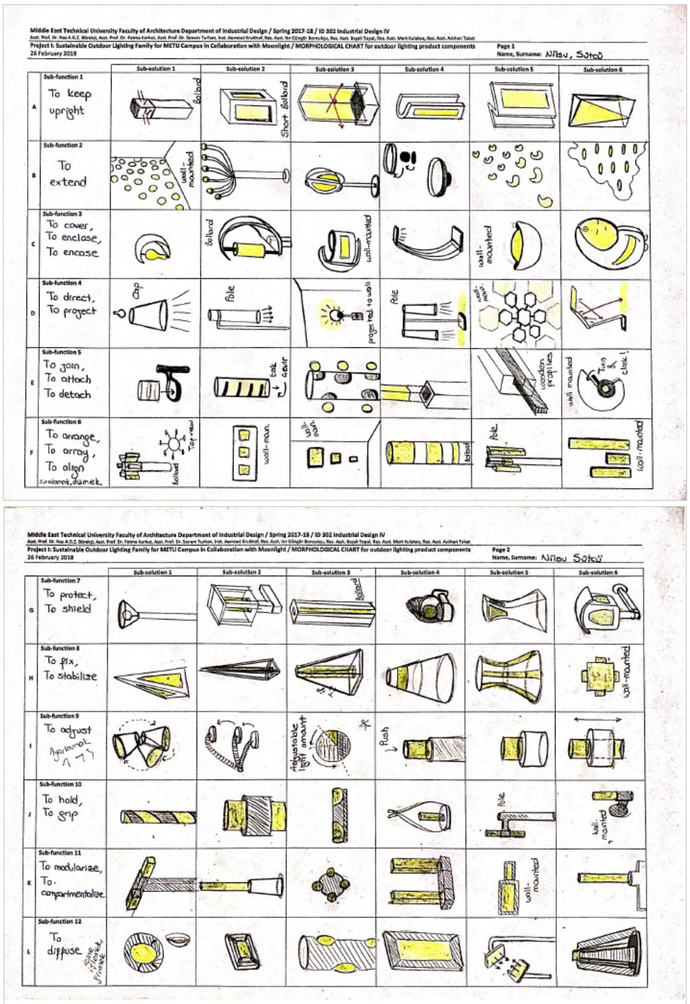

Figure 86: An example of a filled-in morphological chart

The research materials of the prior achievement analysis were the collected 3185 sketches. Regarding the examination of the sketches, various sketching styles were observed. While some of the students used diagrammatic sketches, some used representational sketches, some used symbolic sketches and some used doodling sketches.

Diagrammatic sketches are those that generally use simple geometrical shapes to visualize artificial or natural phenomena such as light and sound, product or building components, and spatial boundaries (Do, Gross, Neiman, & Zimring 2000). The students generally used diagrammatic sketches to indicate light, light direction, and position of the lighting in an environment (Figure 87, top left).

Representational sketches are those that are relatively more detailed compared to the others. These sketches are generally three-dimensional and give spatial and environmental information (Börekçi, 2016) (Figure 87, top right). Many of the sketches done by the students took part under this category.

Symbolic sketches are those that only reflects the idea in the mind without thinking about the final product (Börekçi, 2016) (Figure 87, bottom left). There were also many examples of these sketches done by the students.

Doodling sketches are quick sketches that are mostly drawn to stimulate new ideas. They are difficult to perceive since they do not give much information about the purpose, environment or spatial features (Börekçi, 2016; Schenk, 2014;) (Figure 87, bottom right).

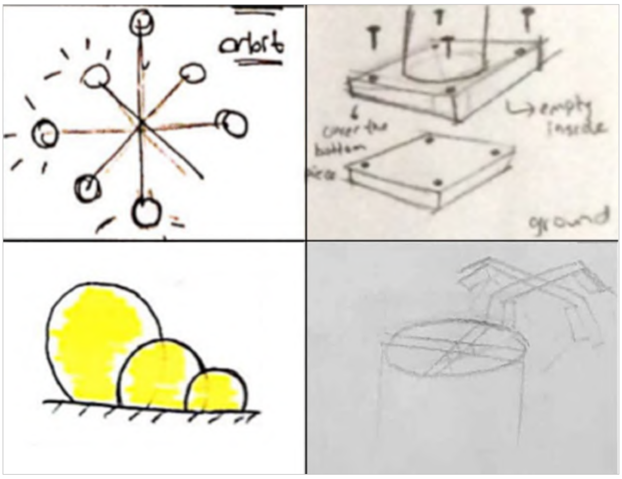

Figure 87. Sketching style examples. Top left: diagrammatic sketch. Top right: representational sketch. Bottom left: symbolic sketch. Bottom right: doodling sketch

Some of the students used annotations in their sketches. While some of them used multiple-word sentences, some of them just used single-words and some used titles in their drawings (Figure 88). For example, without the multiple-word sentences, the road and the size of the lighting unit is hard to understand regarding the sketch that is on the left; without the single-word annotations and the arrows, the sketch in the middle is understood as a fixed object instead of having bendable parts; and the title and the arrow give information about the extending movement regarding the sketch on the right. According to McGown, Green, and Rodgers (1998), sometimes, the sketches are difficult to understand by the observers, therefore adding textual descriptions may help the observer to understand the meaning of the sketches. Considering the examined sketches, those that were supported with textual descriptions were generally understood more easily.

Figure 88. Annotation style examples. Left: multiple-word sentences, Middle: single-word annotations, Right: titles.

7.1.2 Codification of the Sketches

In order to examine these sketches, the assessment technique that was offered within this thesis was used (see Section 4.4.3.4.1). For this purpose, FBS ontology and genealogy tree techniques were used to encode and categorize the sketches. Considering the FBS ontology, the 3185 sketches were examined one by one by three coders (industrial design educators, one being the author) separately. The aim was to note each function, behavior and structure alternatives for each sketch. Within this process, various alternative solutions to a problem were observed. For example, while the lighting part was on a pole in some of the sketches, it was on a base or it was attached somewhere in others. This situation enabled having a function group including sketches related to “placing the lighting” and behavior groups including sketches that “place lighting on a pole”, “place lighting on a base” or “attach lighting somewhere”. Furthermore, while the lighting was placed on a pole in some sketches, it was placed on more than one poles in others. Such situations enabled having structure groups such as “one pole”, “two poles”, or “poles that have branches”. Through the examination of the sketches with this approach, three solution clouds containing various functions, behaviors and structures were attained by the three coders.

The items in these solution clouds were the categories of each ideas represented in the sketches. While coder 1 achieved 35 categories, coder 2 achieved 36, and coder 3 achieved 34 categories. Although the categories have slightly different names, their main points are similar to each other (Table 8).

Table 8. Proposed categories of the coders within the prior achievement analysis

Coder 1	Coder 2	Coder 3
pole has a support	supportive	support
pole is sticked to the ground	sticking	digged in
pole has roots	roots	root shaped
one pole	stick shaped	a pole
pole has branches	branching	branches
two poles	two sticks	two poles
bridge shaped	bridge like	-----
three poles	three sticks	three poles
attached to somewhere	on tree	on tree
-----	on wall	on wall
-----	on ground	-----
on a base	light on base	on base
-----	stick on base	-----
flexible parts	flexible	bendable
foldable parts	foldable	foldable
moving on a rail	rail	moving parts
telescopic	telescopic	telescopic
dimming	-----	dimming
has sensors	sensors	sensors
adjusting direction of the light	light direction	direction
rotation of the light source	light rotating	rotation
rotation of the reflective part	-----	-----
have a blocker	blocker rotating	-----
adjusting light intensity	light intensity	intensity
-----	light height	height
adjusting structure	adjusting structure	structure
scissors mechanism	scissors mechanism	scissors
modular	-----	modular
magnetic parts	magnets	magnetic
joining	joining	joining
has a gap	emptiness	gap
have a direct light	direct light	direct lighting
one source	one source	one light source
two sources	two sources	two light sources
three sources	three sources	three light sources
-----	-----	more than three
reflecting a visual	reflection	reflection
lighting through reflection	-----	-----
giving light to same direction	same direction	lighting same direction
giving light to different directions	different directions	lighting different direction
-----	extra function	-----

To assess the inter-rater reliability of qualitative data, generally the formula generated by Miles and Huberman (1994) is used. It is simply the ratio between the number of agreements and the total number of agreements and disagreements. When there are three or more coders, Light (1971) suggests calculating the reliability for all coder pairs and then getting the mean of these results. When the reliability was calculated, between coders 1 and 2 there is 0.887, between coder 2 and 3 there is 0.842, and between coder 1 and 3 there is 0.884 kappa value. Besides the mean score is 0.887 (Table 9). Landis and Koch (1977) presented a guideline to interpret reliability values. While values between 0.0 and 0.20 indicates slight agreement, values between 0.20 and 0.40 indicates fair agreement, values between 0.40 and 0.60 indicates moderate agreement, values between 0.60 and 0.80 indicates substantial agreement, and values between 0.80 and 1.0 indicates perfect agreement. Therefore, the categorization of the ideas has a perfect reliability.

Table 9. Reliability of the categorization within the prior achievement analysis

Coders	Reliability Values	Interpretation
1-2	0,887	Perfect
1-3	0,884	Perfect
2-3	0,842	Perfect
Mean	0,887	Perfect

7.1.3 Categorization of the Sketches

Using the genealogy tree technique, all the items in the solution cloud were placed in the shape of a tree diagram. All three coders worked together and combined their solution clouds to get better results.

Some branches were placed in the diagram just to contain sub-branches even though they did not have any function, behavior or structure. For example, the branch of "number of poles" was placed in the diagram to contain its sub-branches that are one pole, two poles, three poles, and other (including those with different structure types).

After the tree diagram was prepared, the three coders started to place the 3185 sketches under relevant categories. During this process, some new categories were created through the agreement of each coders. After a certain point, the researcher continued with the placement process alone and completed the tree diagram. During the placement process, some of the sketches were eliminated since they did not offer much information about the function, behavior, or structure of the product: while some of the sketches were about the production of the product, some were about the alignment of the lighting units in an environment, some were about the materials, and some were showing a minor detail so the overall idea was not observable. Besides, some of the sketches were also eliminated since they were a repetition of an idea that was already offered by the same student. Furthermore, some ideas were placed under different categories since the sketch offered information on more than one category (Table 10). Figure 89 represents some examples of sketches that were placed under the categories of both "stick" and "one source". Furthermore, the *sketch a* also took part in the "support" category and the *sketch d* on the right also took part in the "height" category.

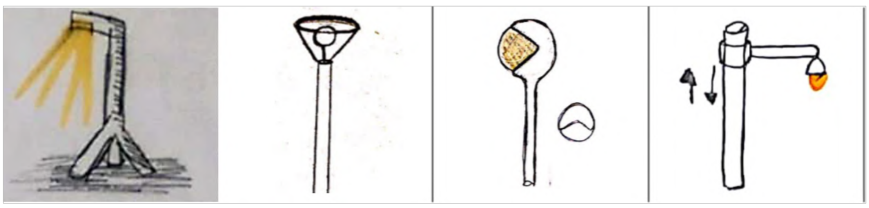

Figure 89. Sketches that are placed under more than one category (from left to right a, b, c and d)

At the end, there were a total of 2111 sketches placed in the tree diagram (Figure 90). At the highest level, the ideas were separated into four themes which were *placing*, *adjusting*, *illuminating* and *additional function*. There were 747 ideas under the theme of *placing*, 423 under *adjusting*, 918 under *illuminating* and 23 under *additional function* (Figure 91). While the theme of *placing* contains ideas that are related with the placement of the lighting unit, the theme of *adjusting* contains ideas that propose making alterations in the form or function of the product, the theme of *illuminating* represents ideas that are related with the type and means of illumination, and the theme of *additional function* involves ideas that propose an extra function to the product other than illuminating the environment.

Table 10. Sketch statistics of the prior achievement analysis

	Number of sketches	Irrelevant sketches	Repetitive ideas	Valid sketches	Sketches that were placed under various categories	Total number of ideas in the tree diagram
s1	72	14	6	52	6	58
s2	72	14	13	45	12	57
s3	72	11	6	55	17	72
s4	69	33	6	30	6	36
s5	72	11	11	50	19	69
s6	72	19	8	45	8	53
s7	71	24	9	38	15	53
s8	70	26	8	36	12	48
s9	72	28	14	30	8	38
s10	72	22	10	40	22	62
s11	72	20	12	40	18	58
s12	72	19	11	42	11	53
s13	72	26	13	33	13	46
s14	72	15	8	49	21	70
s15	72	26	12	34	13	47
s16	70	32	11	27	10	37
s17	72	24	9	39	14	53
s18	71	21	15	35	16	51
s19	70	27	12	31	11	42
s20	72	33	9	30	6	36
s21	72	14	20	38	12	50
s22	70	19	14	37	7	44
s23	72	16	12	44	17	61
s24	70	23	19	28	10	38
s25	72	24	17	31	8	39
s26	57	13	11	33	7	40
s27	72	24	14	34	14	48
s28	72	36	11	25	4	29
s29	72	35	9	28	7	35
s30	72	20	15	37	6	43
s31	72	20	13	39	2	41
s32	72	32	14	26	4	30
s33	72	16	16	40	21	61
s34	72	20	14	38	11	49
s35	58	14	9	35	10	45
s36	72	29	15	28	3	31
s37	72	39	10	23	4	27
s38	72	28	22	22	2	24
s39	67	19	12	36	8	44
s40	66	16	13	37	13	50
s41	72	23	9	40	14	54
s42	72	21	14	37	9	46
s43	72	22	17	33	8	41
s44	72	21	15	36	19	55
s45	72	20	16	36	11	47
total	3185	1009	554	1622	489	2111

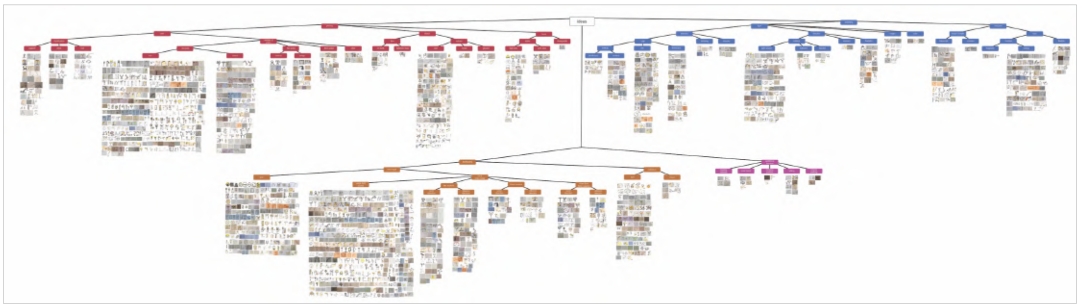

Figure 90. Tree diagram containing sketches within the prior achievement analysis

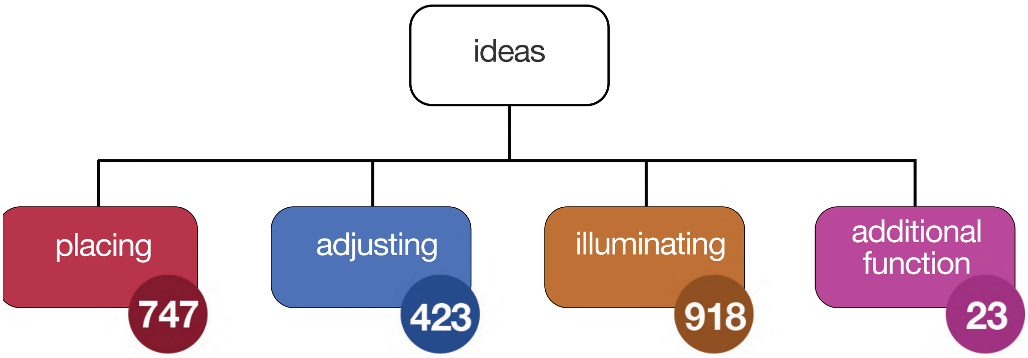

Figure 91. Highest level themes of the prior achievement analysis

7.1.3.1 Theme of *Placing*

The themes of the highest level also branch out to different idea categories. The theme of *placing* separates into three categories: *pole*, *attach*, and *base* (Figure 92). While the category of *pole* presents ideas in which the lighting unit is positioned on a pole, the category of *attach* includes ideas in which the lighting unit is attached to somewhere other than a pole, and the category of *base* includes ideas that have the lighting unit positioned on a base.

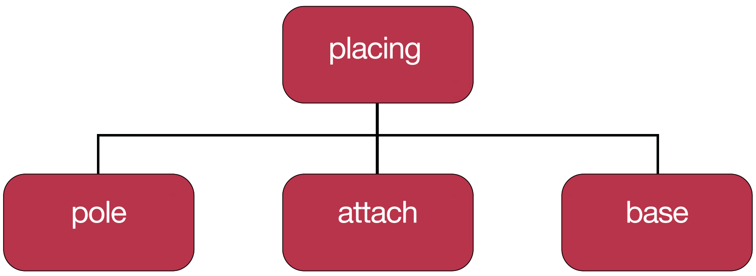

Figure 92. Branches of the theme of placing

The Category of *Pole*

The category of *pole* separates into two sub-categories: *stabilization* and *number of poles* (Figure 93).

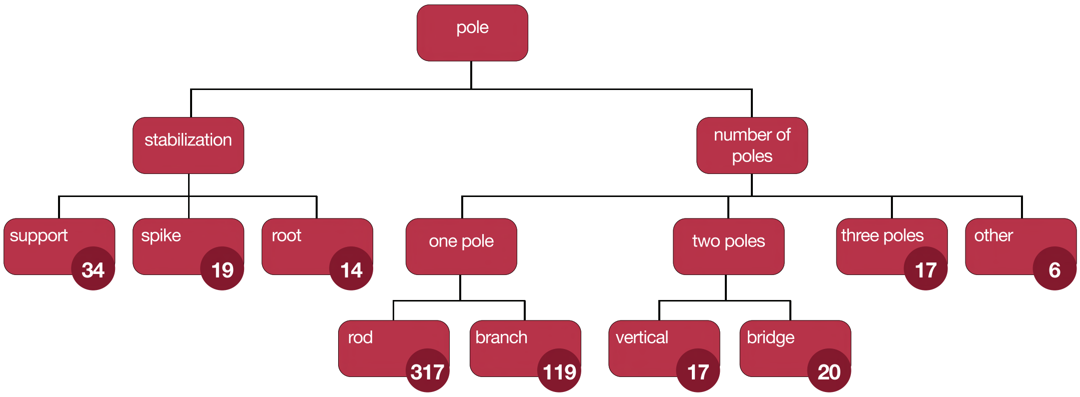

Figure 93. Branches of the category of pole

- The sub-category of *stabilization* contains ideas that offer solutions about the stabilization of the pole,
    - by having a *support* that reinforces its posture (Figure 94, 1),
    - by pushing into the ground soil with the help of a sharp bottom part (*spike*) (Figure 94, 2), or
    - by having *root* shaped structure under the ground to stabilize it (Figure 94, 3).
- The sub-category of *number of poles* contains ideas that have various number of poles attached to the lighting unit. It offers solutions for the placement of the lighting unit,
    - by having *one pole* that either
        - has a *rod-shaped* structure rising from the ground like a stick (Figure 94, 4), or
        - has a *branching* shape of structure that has two or more branches on which lighting units are placed (Figure 94, 5),
    - by having *two poles* that either
        - rise *vertically* towards the sky (Figure 94, 6) or,
        - rise towards the sky and combine like a *bridge* shaped structure (Figure 94, 7),

- by having *three poles* rising from the ground (Figure 94, 8), or
- by having *other* kinds of structures such as having four poles, or a mesh structure, or shaped like a weeble (Figure 94, 9).

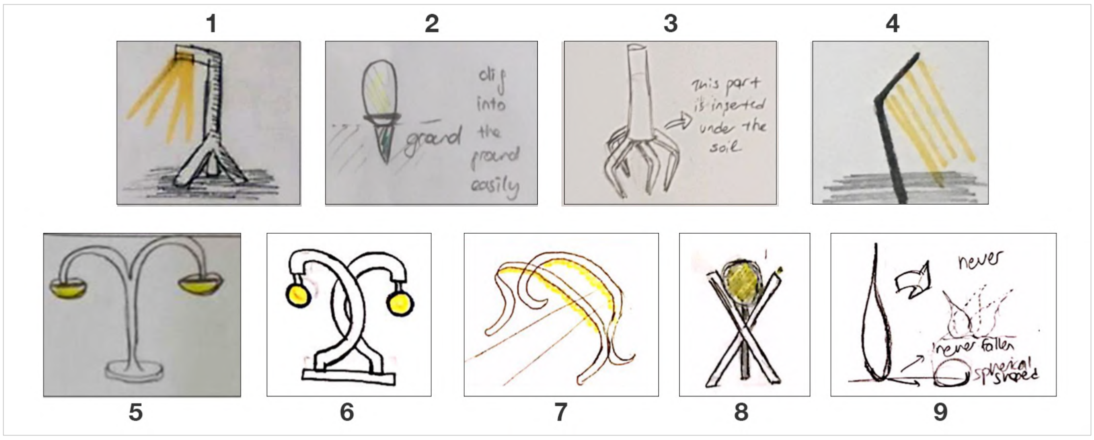

Figure 94. Sketch examples from the category of pole

The Category of *Attach*

The other category of *placing* was *attach* which also separates into two sub-categories: *tree* and *surface* (Figure 95).

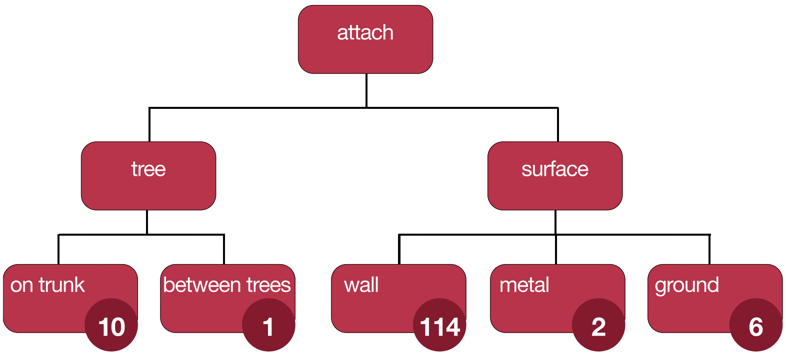

Figure 95. Branches of the category of attach

- The sub-category of *tree* contains ideas that offer solutions in which the lighting unit is attached either
  - *on the trunk* of a tree (Figure 96, 1), or
  - on a structure that is positioned *between trees* (Figure 96, 2).
- The sub-category of *surface* contains ideas that offer solutions in which the lighting unit is placed

- on a *wall* (Figure 96, 3),
- on a *metal* surface (Figure 96, 4), or
- on the *ground* (Figure 96, 5).

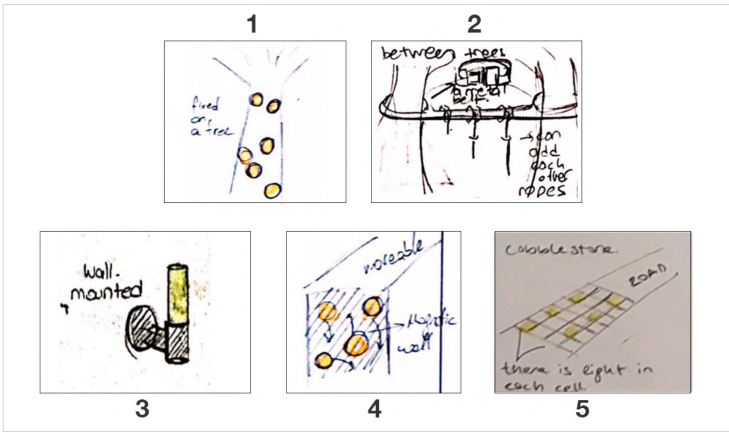

Figure 96. Sketch examples from the category of attach

The Category of *Base*

Another category of *placing* was *base,* which separates into two sub-categories: *stable* and *changeable* (Figure 97).

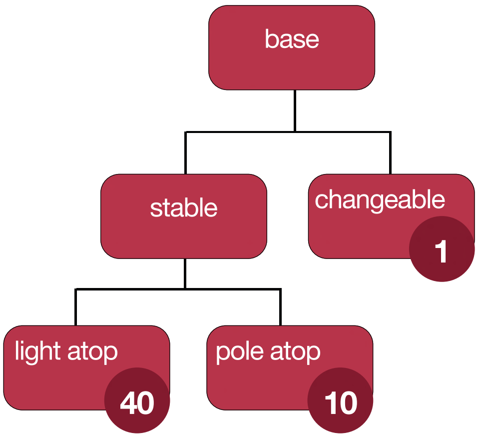

Figure 97. Branches of the category of base

- The sub-category of *stable* contains ideas with a stable base. It offers solutions either
  - with a *light atop* a stable base (Figure 98, 1), or
  - with a *pole atop* a stable base (Figure 98, 2).

- The sub-category of *changeable* includes only one idea in which the base of the product is adjustable and can have different forms (Figure 98, 3).

Figure 98. Sketch examples from the category of base

An expanded version of the sketches within the theme of *placing* can be seen in Appendix H.

7.1.3.2 Theme of *Adjusting*

Another theme of the highest level was *adjusting* that has two categories: *light* and *structure*. While the category of *light* includes ideas that offer to make alterations about the light, the category of *structure* includes ideas that offer an adjustable structure (Figure 99).

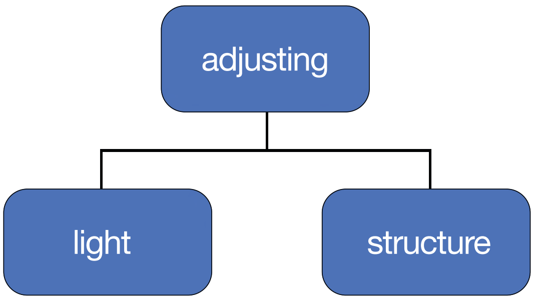

Figure 99. Branches of the theme of adjusting

The Category of *Light*

This category offers alternatives for the *intensity*, *direction*, *height* and *color* of the light (Figure 100).

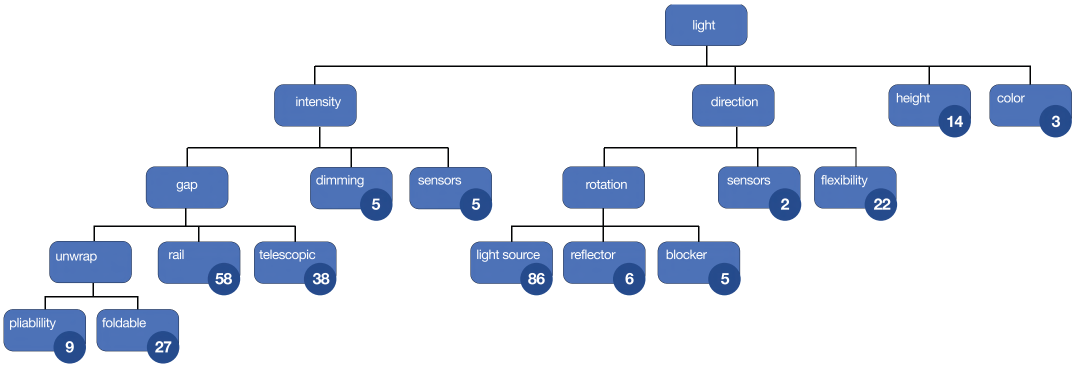

Figure 100. Branches of the category of light

- The sub-category of *intensity* contains ideas in which the intensity of the light is adjustable
  - through a *gap* on the surface of the product in order to making alterations on the areas that diffuse light,
    - by *unwrapping* the lighting unit through *pliability* (Figure 101, 1) or *foldability* (Figure 101, 2),
    - by sliding some parts of the product on a *rail* to decrease or increase the gap where the light diffuses from (Figure 101, 3), or
    - by opening up or closing a *telescopic* structure (Figure 101, 4),
  - by *dimming* the intensity of the light through some switches or mechanisms (Figure 101, 5), or
  - with *sensors* that alter the intensity of the light regarding the luminosity or the crowdedness of the environment (Figure 101, 6).

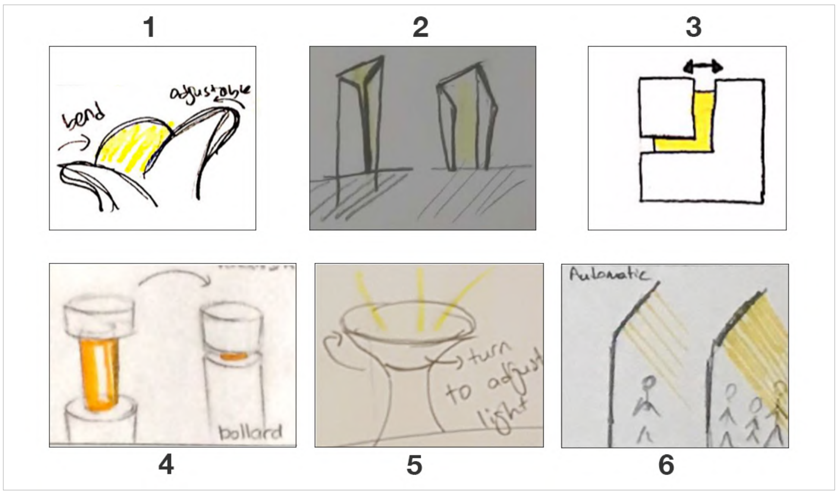

Figure 101. Sketch examples from the sub-category of intensity

- The sub-category of *direction* contains ideas that offers to adjust the direction of the light
    - o through the *rotation* of
        - the *light source* (Figure 102, 1),
        - the *reflector* (Figure 102, 2), or
        - the *blocker* (Figure 102, 3),
    - o through some *sensors* (Figure 102, 4), or
    - o through the *flexibility* of a structure (Figure 102, 5).

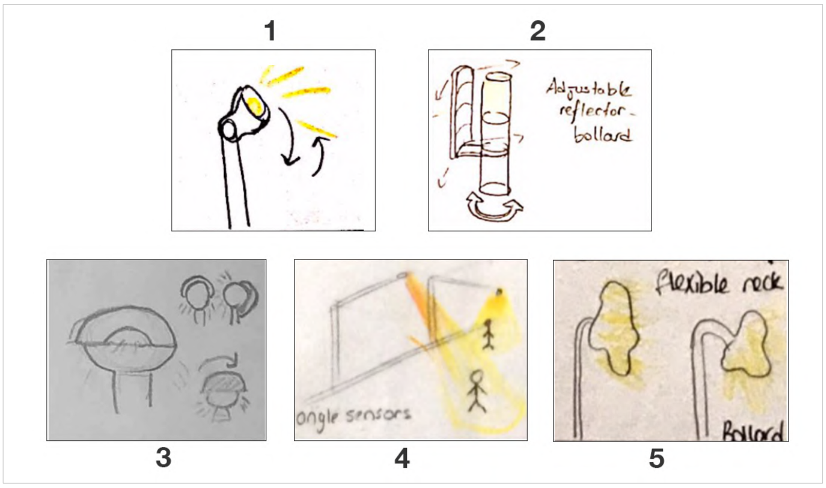

Figure 102. Sketch examples from the sub-category of direction

- The sub-category of *height* contains ideas in which the height of the lighting unit is adjustable (Figure 103, 1).
- The sub-category of *color* includes ideas in which the color of the light is adjustable through some interventions (Figure 103, 2).

Figure 103. Sketch examples from the sub-categories of *height* and *color*

The Category of *Structure*

The category of *structure* includes ideas in which the structure of the product is adjustable, and it has two sub-categories: *height/length* and *form* (Figure 104).

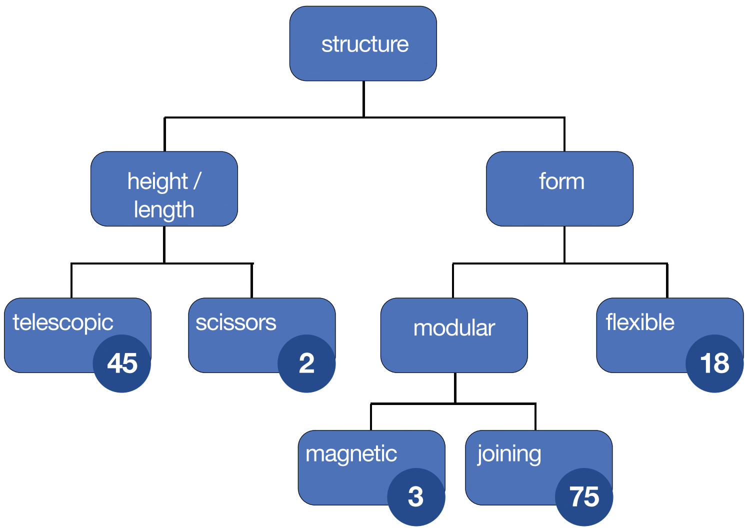

Figure 104. Branches of the category of structure

- The sub-category of *height-length* contains ideas in which the height or length of the product is adjustable through either
  - a *telescopic* structure (Figure 105, 1), or
  - a *scissors* mechanism (Figure 105,2).

- The sub-category of *form* contains ideas in which the form of the product is adjustable through
    - a *modular* structure with
        - *magnetic* joints (Figure 105, 3), or
        - a *joining* mechanism (Figure 105, 4),
    - a *flexible* structure (Figure 105, 5).

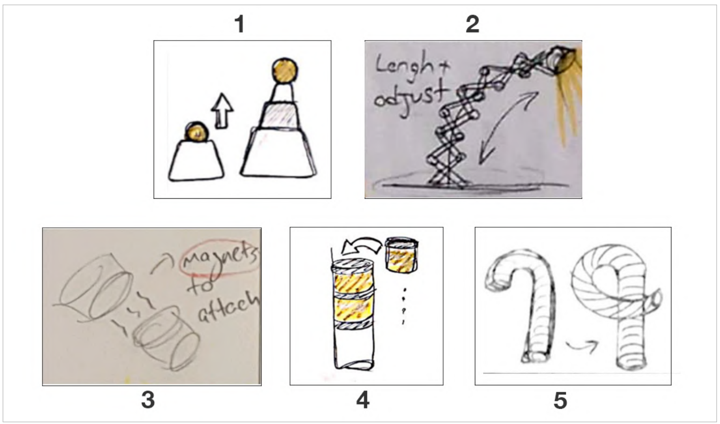

Figure 105. Examples from the category of structure

An expanded version of the sketches within the theme of *adjusting* can be seen in Appendix I.

7.1.3.3 Theme of ***Illuminating***

Another theme of the highest level was *illuminating* that has two categories: *direct light* and *reflection*. While the category of *direct light* includes ideas that illuminate the environment with direct lighting, the category of *reflection* includes ideas that illuminate the environment with a reflection (Figure 106).

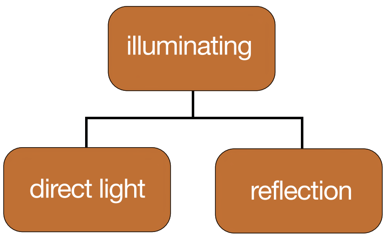

Figure 106. Branches of the theme of illuminating

The Category of Direct *Light*

This category has two sub-categories: through a *gap* and on a *pole/base* (Figure 107).

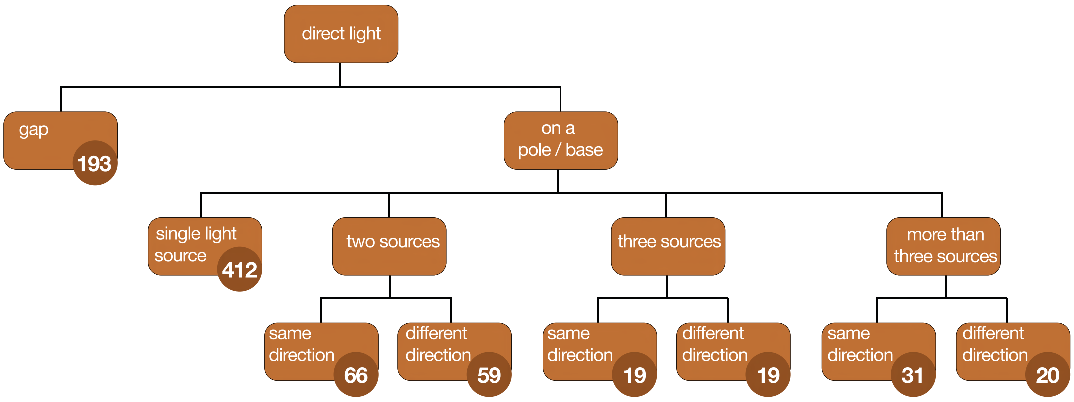

Figure 107. Branches of the category of direct light

- The sub-category of *gap* contains ideas in which the light is diffused from the empty spaces of the product (Figure 108, 1).
- The sub-category of *pole/base* contains ideas in which the light is diffused from the lighting unit
  - from a single light source positioned either on a pole or a base (Figure 106, 8),
  - from *two sources* that illuminate in either
    - the *same direction* (Figure 108, 3), or
    - *different directions* (Figure 108, 4),
  - from *three sources* that illuminate in either
    - the *same direction* (Figure 108, 5), or
    - *different directions* (Figure 108, 6),
  - from *more than three sources* that illuminate in either
    - the *same direction* (Figure 108, 7), or
    - *different directions* (Figure 108, 8),

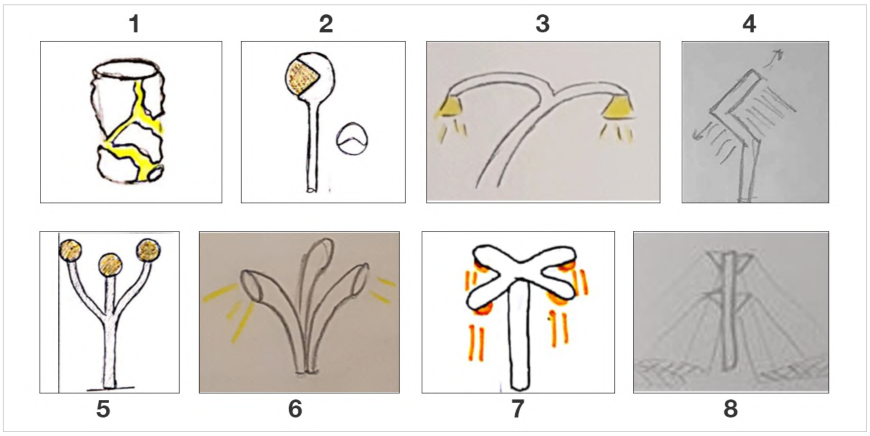

Figure 108. Examples from the category of direct light

The Category of Reflection

The category of *reflection* has two sub-categories: *light* and *visual* (Figure 109).

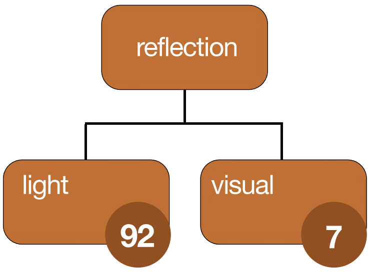

Figure 109. Branches of the category of reflection

- The sub-category of *light* contains ideas that illuminate the environment through a reflection from a surface (Figure 110, 1).
- The sub-category of *visual* contains ideas that reflect a visual onto a surface (Figure 110, 2).

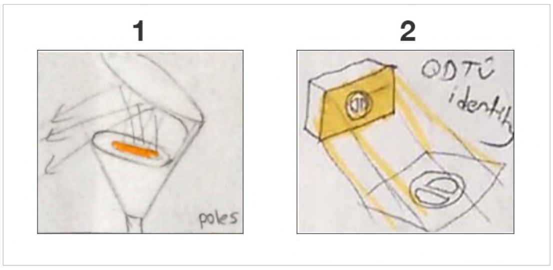

Figure 110. Examples from the category of reflection

An expanded version of the sketches within the theme of *illuminating* can be seen in Appendix J.

7.1.3.4 Theme of Additional Function

The last theme of the highest level was *additional function*. It has five categories: *feeding animals*, *solar panel*, *hanging posters*, *sitting*, and *bicycle parking* (Figure 111).

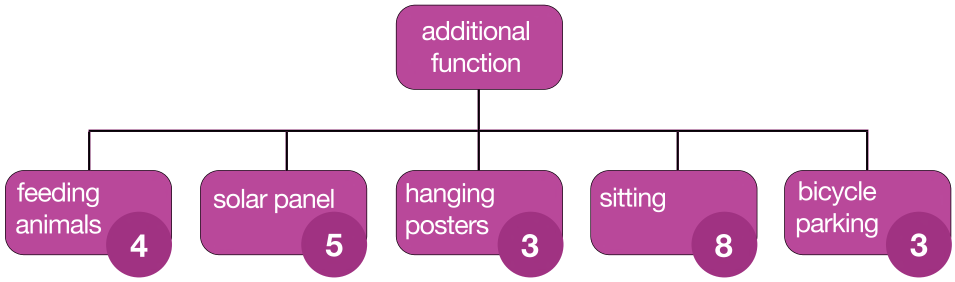

Figure 111. Branches of the theme of additional function

The Category of *Feeding Animals*

The category of *feeding animals* includes ideas in which the product has a place or function to feed the animals (Figure 112, 1).

The Category of *Solar Panel*

The category of *solar panel* includes ideas in which the product has a solar panel to produce its own energy by collecting sun rays (Figure 112, 2).

The Category of *Hanging Posters*

The category of *hanging posters* includes ideas in which the product has a specific part to enable people to hang posters (Figure 112, 3).

The Category of *Sitting*

The category of *sitting* includes ideas in which the product has a specific part to enable people to sit on (Figure 112, 4).

The Category of *Bicycle Parking*

The category of *bicycle parking* includes ideas in which the product has specific parts to allow people to park their bicycles (Figure 112, 5). An expanded version of the sketches within the theme of *additional function* can be seen in Appendix K.

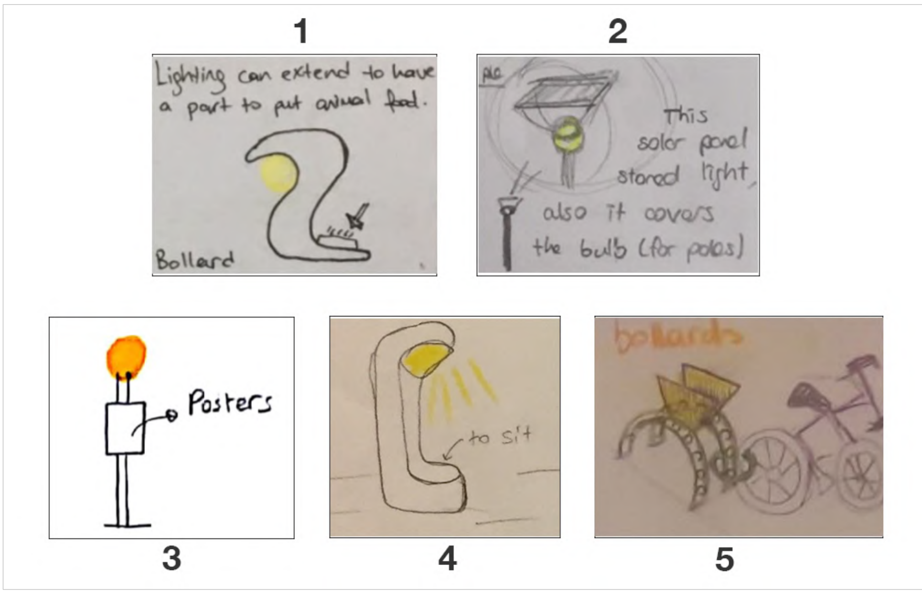

Figure 112. Examples from the theme of additional function

7.1.4 Calculation of the Scores

7.1.4.1 Novelty Scores

Following the categorization process of the ideas, the novelty scores were calculated for each idea category. For this purpose, the assessment technique that was mentioned in Section 4.4.3.4.1 was used.

The novelty score is calculated as N= (T - S) x 10 / T, where T is the total number of ideas that fulfill the same function, and S is the number of current solutions for that function. For example, there were 747 different solutions under the theme of *placing,* and 14 different solutions under the category of *root* fulfilling the function of *placing*. The novelty score of these 14 *root* ideas is calculated as (747 - 14) x 10 /

747 = 9,813. On the other hand, the novelty score of the category of *rod* consisting of 317 ideas is 5,756. Therefore, the more novel an idea is, which means it is less explored in the solution space, the higher score it gets.

Besides, since an additional function could be added into any of the 2111 ideas, the novelty scores for the ideas under the theme *additional function* were calculated by considering all of the ideas without limiting the scope to the theme. For example, the novelty score of the category of *feeding animals* were calculated as (2111 - 4) * 10 / 2111 = 9,981. The novelty score of each idea category was calculated and used in the calculation of the novelty score for the students (Table 11). Following the calculation of the novelty scores of the categories, the novelty scores of the students were calculated. The novelty score of a student is the average of the novelty scores of the ideas that are produced under different categories. For example, if the student has two ideas under the category of *root* and three ideas under the category of *rod*, the novelty score of the student will be: [(2 x 9,813) + (3 x 5,756)] / 5 = 7,378

Table 11. Novelty scores of the categories within the prior achievement analysis

Placing		**Adjusting**		**Illuminating**		**Additional function**	
support	9,545	pliability	9,787	gap	7,898	feeding animals	9,981
prick	9,745	foldable	9,362	single light source	5,512	solar panel	9,976
root	9,813	rail	8,629	two s./same direction	9,281	hanging posters	9,986
rod	5,756	intensity/telescopic	9,102	two s./diff. direction	9,357	sitting	9,962
branch	8,407	dimming	9,882	three s./same direction	9,793	bicycle parking	9,986
vertical	9,772	intensity/sensors	9,882	three s./diff. direction	9,793		
bridge	9,732	light source	7,967	more/same direction	9,662		
three poles	9,772	reflector	9,858	more/ diff. direction	9,782		
other	9,920	blocker	9,882	light	8,998		
on trunk	9,866	direction/sensors	9,953	visual	9,924		
between trees	9,987	direction/flexibility	9,480				
wall	8,474	height	9,669				
metal	9,973	color	9,929				
ground	9,920	structure/telescopic	8,936				
light atop	9,465	scissors	9,953				
pole atop	9,866	magnetic	9,929				
changeable	9,987	joining	8,227				
		structure/flexible	9,574				

7.1.4.2 Variety Scores

Following the calculation of the novelty scores of all categories, the variety scores were calculated. There were six hierarchical levels in the total genealogy tree and the values for each level were determined as **20, 15, 10, 5, 2** and **1** respectively from the top to the bottom (Figure 113).

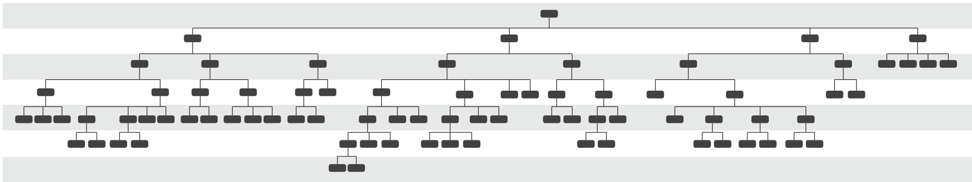

Figure 113. Values of each level of the tree diagram within the prior achievement analysis

While there were four idea categories at the top level, there were 12 at the second, 16 at the third, 28 at the fourth, 18 at the fifth and two at the sixth level. As mentioned in Section 4.4.3.4.1, counting the branches at a hierarchical level, the number of the differentiations between branches which is one less than the number of branches was counted. In this respect, the variety score of the total solution space was calculated as: (3 x **20**) + (11 x **15**) + (15 x **10**) + (27 x **5**) + (17 x **2**) + (1 x **1**) = 545.

After calculating the variety score of the total genealogy tree, the variety scores of the students were calculated. In this respect, the categories in which the student offered ideas were considered and divided into the variety score of the total genealogy tree. For example, Student 1 proposed solutions only for the red-marked categories seen in Figure 114. However, these are the final ideas and they all belong to some higher-level categories which are marked with blue. So, at the highest level, the proposals of Student 1 consist of four categories. It has seven categories in the second level, ten at level three, 12 at level four, 11 at level five and one at level six which was excluded from the equation since there was not any differentiation. Therefore, the variety score of Student 1 is calculated as: [(3 x **20**) + (6 x **15**) + (9 x **10**) + (11 x **5**) + (10 x **2**)] x 10 / 545 = 5,780.

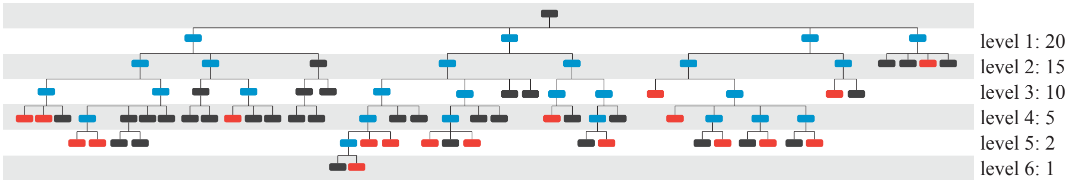

Figure 114. Variety diagram of Student 1 within the prior achievement analysis

7.1.5 Results of the Prior Achievement Analysis

The novelty and variety scores of the 45 students were calculated by using Microsoft Excel (Figure 115) and the results are represented in Table 12.

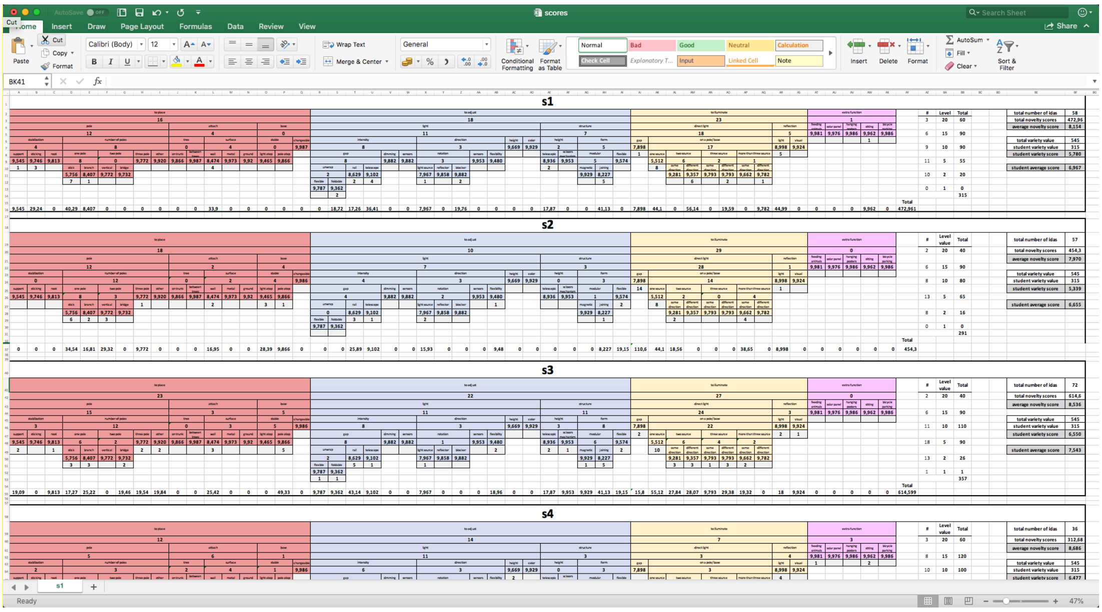

Figure 115. Screenshot of the Microsoft Excel document within the prior achievement analysis

Table 12. Novelty, variety and average scores of the students within the prior achievement analysis

Novelty		Variety		Average	
s4	8,686	s42	8,055	s42	8,157
s3	8,536	s34	6,917	s4	7,581
s36	8,527	s41	6,881	s34	7,546
s26	8,304	s3	6,550	s3	7,543
s42	8,259	s15	6,514	s41	7,464
s39	8,222	s8	6,495	s15	7,261
s31	8,217	s4	6,477	s36	7,209
s45	8,202	s40	6,239	s45	7,184
s28	8,187	s45	6,165	s40	7,172
s34	8,175	s5	6,147	s31	7,154
s1	8,154	s31	6,092	s8	7,124
s40	8,106	s6	5,982	s26	7,097
s38	8,093	s7	5,927	s1	6,967
s41	8,046	s26	5,890	s5	6,965
s25	8,045	s36	5,890	s39	6,891
s24	8,034	s1	5,780	s7	6,886
s30	8,023	s10	5,780	s6	6,854
s19	8,023	s24	5,633	s24	6,834
s15	8,008	s39	5,560	s30	6,727
s32	7,987	s33	5,541	s10	6,715
s16	7,970	s30	5,431	s2	6,655
s2	7,970	s2	5,339	s25	6,546
s7	7,846	s27	5,229	s9	6,516
s9	7,822	s9	5,211	s27	6,464
s37	7,820	s21	5,119	s33	6,394
s5	7,783	s11	5,101	s32	6,342
s8	7,752	s25	5,046	s16	6,334
s35	7,726	s43	4,899	s21	6,282
s6	7,726	s18	4,771	s28	6,249
s27	7,698	s14	4,734	s43	6,231
s22	7,681	s16	4,697	s11	6,103
s10	7,651	s32	4,697	s44	6,028
s43	7,563	s44	4,514	s19	5,929
s44	7,542	s28	4,312	s38	5,918
s21	7,445	s29	4,312	s22	5,886
s33	7,247	s12	4,257	s18	5,883
s23	7,239	s17	4,257	s14	5,797
s12	7,238	s22	4,092	s35	5,753
s11	7,104	s13	4,073	s12	5,747
s20	7,067	s19	3,835	s37	5,672
s17	7,045	s35	3,780	s17	5,651
s18	6,996	s20	3,761	s29	5,541
s13	6,930	s38	3,743	s13	5,502
s14	6,861	s23	3,560	s20	5,414
s29	6,769	s37	3,523	s23	5,400
average	7,785	average	5,262	average	6,524

For the purpose of making the novelty and variety scores more meaningful, a solution space visualization was prepared. In this visual, the numbers represent the number of sketches that took place in a category. The more sketches included in that category, the bigger the size of the corresponding node. Furthermore, the nodes were placed considering their exploration frequencies: the more a node (category) is explored or studied, the more it is close to the center of the solution space. The nodes that are close to the outer borders of the solution space represent less studied ideas which are novel. For example, the yellow node that is numbered 412, represents the category of *single light source* that contains the highest number of sketches, is the biggest and the closest node to the center. On the other hand, the red nodes that are numbered 1, represent the categories *changeable* and *between trees* that contain the lowest number of sketches and they are the smallest and farthest nodes to the center. In Figure 116, the nodes are represented with their connections to their upper hierarchical levels and Figure 117 presents nodes without connections within their levels that nest within each other, which is more suitable to show the solution space.

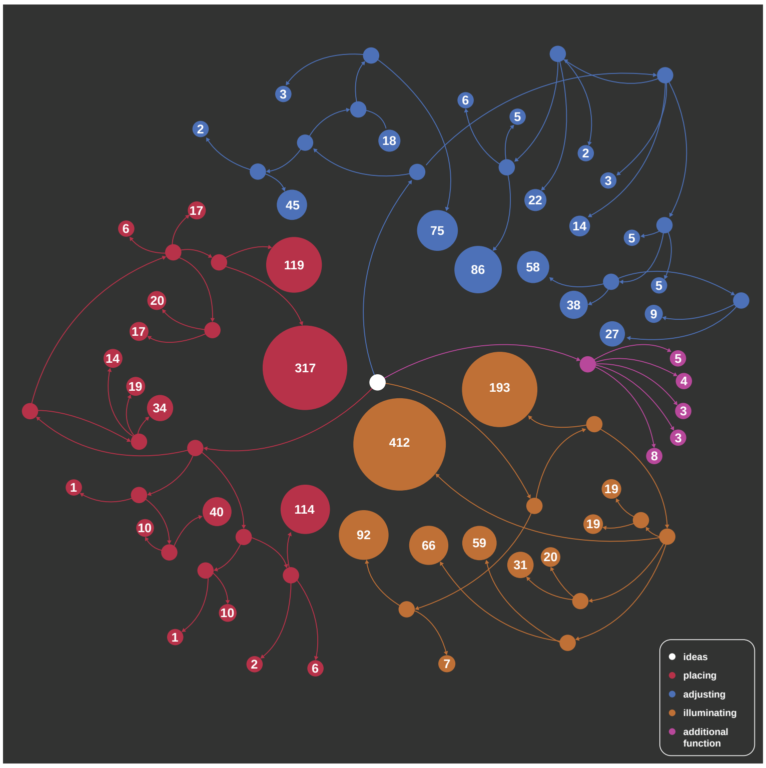

Figure 116. Representation of the solution space with the connections to upper levels

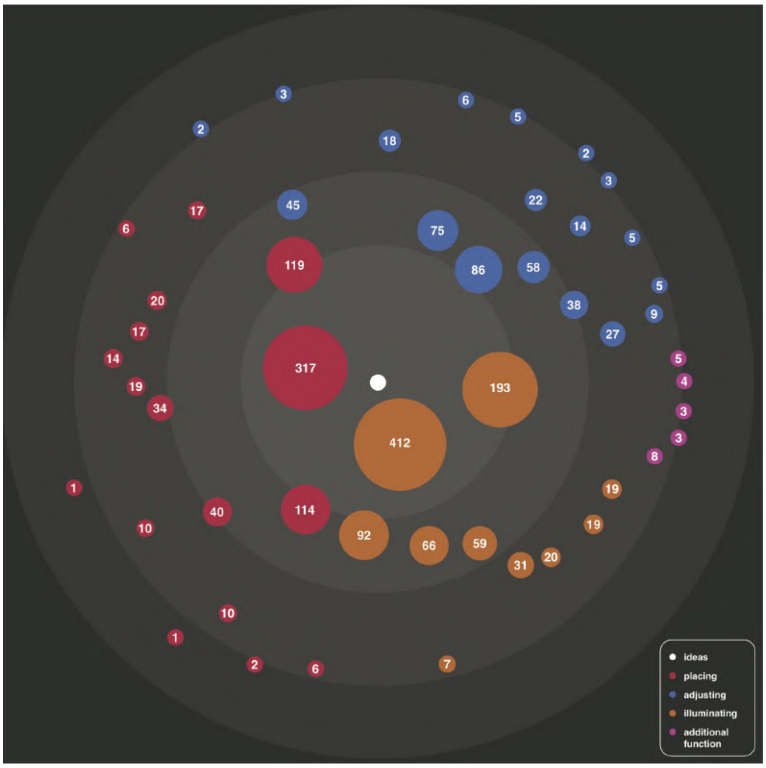

Figure 117. Representation of the solution space

Figure 118 represents the novelty score of Student 4 who is the one that got the highest novelty score. The numbers indicate the number of ideas that the student generated for a category. S/he has many ideas that are placed at the outer levels of the solution space. That is why s/he got a high novelty score. Besides, Student 3 has more ideas that are placed at the outer levels of the solution space compared to Student 4 however, s/he has many more ideas in the center of the solution space, which have low novelty scores (Figure 119). These ideas reduced the average novelty score of Student 3 and this is the reason s/he got a novelty score lower than Student 4.

Figure 118. Distribution of the ideas that Student 4 offered within the solution space who got the highest novelty score

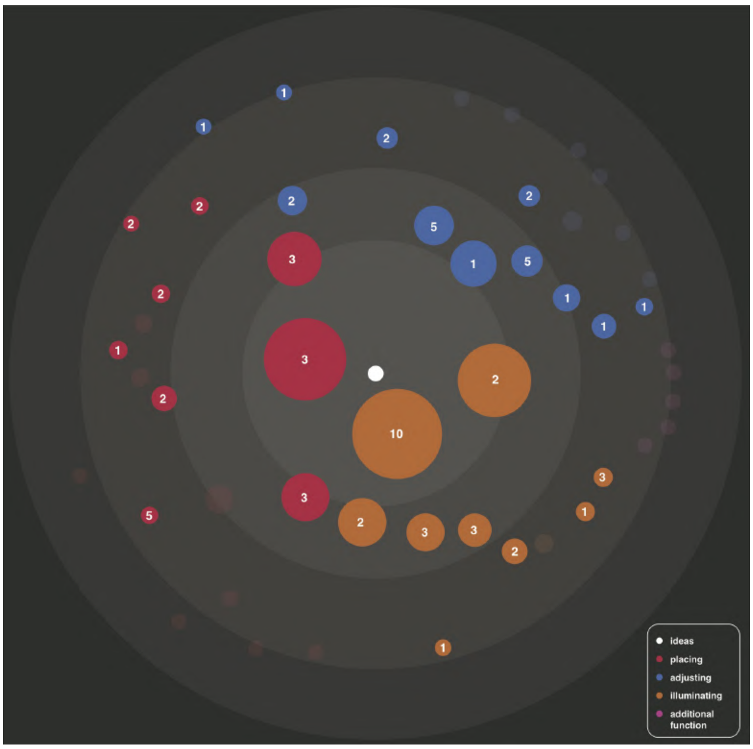

Figure 119. Distribution of the ideas that Student 3 offered within the solution space who got the second-best novelty score

On the other hand, Figure 120 represents the novelty score of Student 29 who is the one who got the lowest novelty score. His/her ideas are gathered at the inner levels of the solution space and were among ideas that were highly offered within the student group. This is the reason why s/he got a low novelty score.

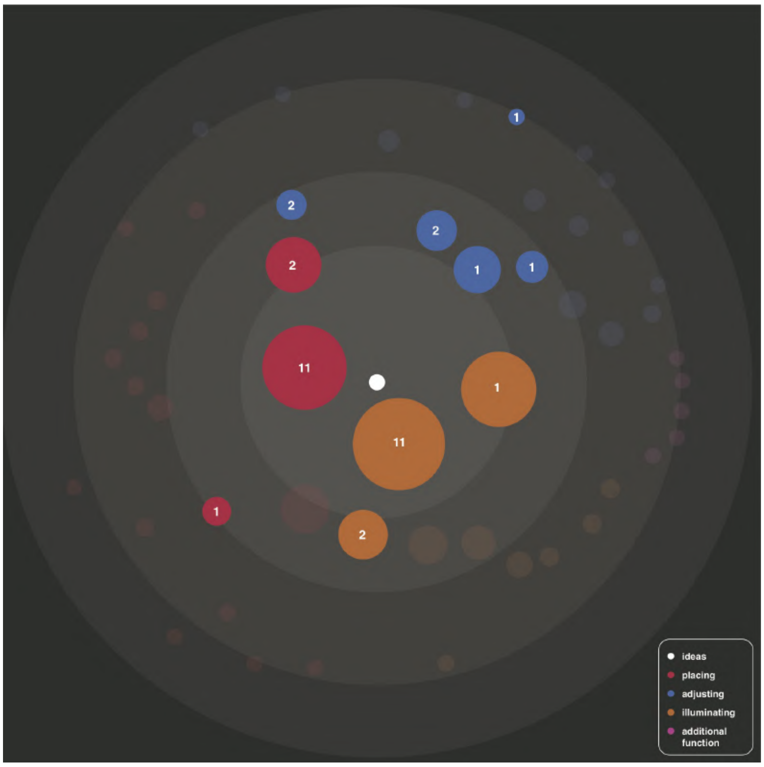

Figure 120. Distribution of the ideas that Student 29 offered within the solution space who got the lowest novelty score

Regarding the variety scores, Student 42 has the highest score. Figure 121 shows that s/he has various ideas that are spread around the solution space. On the other hand, Student 37 is the one who got the lowest variety score since s/he did not explore within the solution space well enough and therefore has very limited variety in terms of ideas (Figure 122).

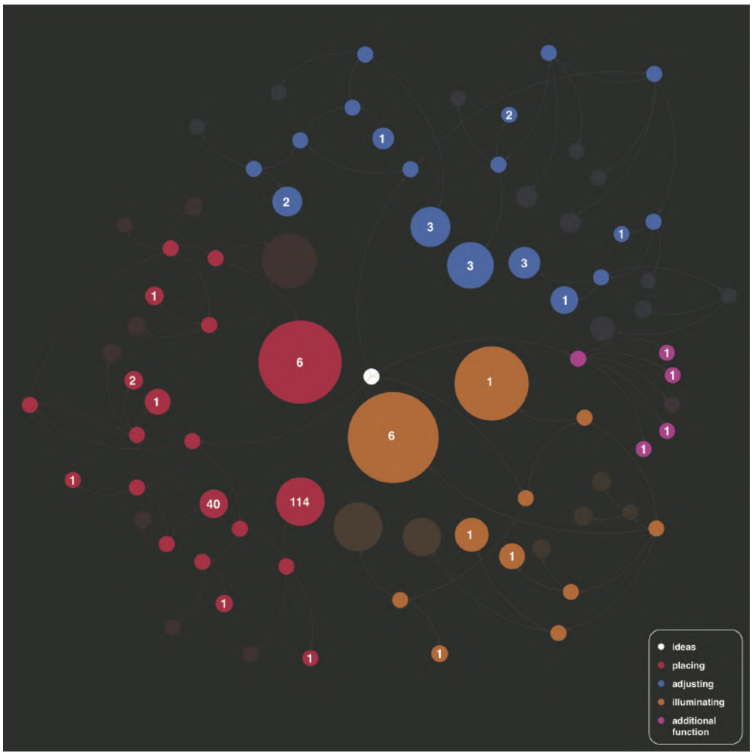

Figure 121. Representation of the variety of ideas that Student 42 offered within the solution space who got the highest variety score

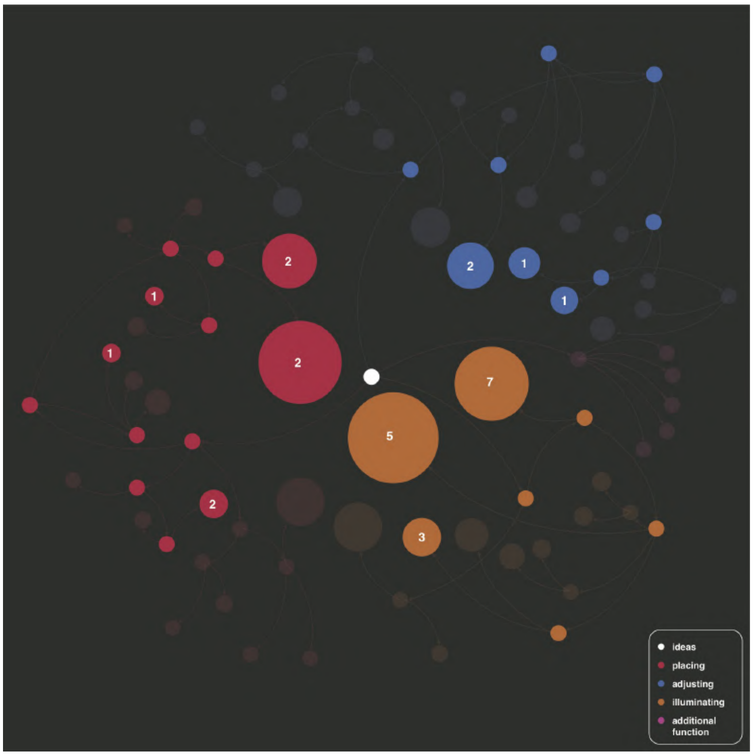

Figure 122. Representation of the variety of ideas that Student 37 offered within the solution space who got the lowest variety score

7.1.6 Determination of the Participants to the Workshops

In order to ensure the equivalence between the experiment and control groups and to determine the participants to the workshops, the average scores of the 45 students obtained from the prior achievement analysis was used. The proposed idea generation tool (Fictionation) aims to improve both novelty and variety. In this respect, during the determination of the participants, the averages of their novelty and variety scores were considered.

As mentioned in Chapter 4, 24 participants were deemed sufficient for the study. For the purpose of determining participants, the study was announced to the students as a workshop, and the first 24 students who wanted to participate were selected for the study. A matching sampling was used to establish group equivalence. For this purpose, the average scores of the students (Table 12) was considered. The purpose was to place the participants that have similar average scores to the groups equally. Grey colored students in Figure 123 represents those who wanted to participate in the workshops. Eventually by considering the average scores and the available times of the students, the participants of the control and experiment groups were determined. While participants colored in blue (s41, s15, s36, s1, s5, s6, s25, s33, s16, s44, s22, s13) were selected for the control group, participants colored in red (s34, s3, s45, s31, s8, s39, s10, s9, s21, s11, s35, s20) were selected for the experiment group (Figure 124). Nine participants of the control group were female and three were male, and eight of the participants of the experiment group were female and four were male. Eventually, 17 females and seven males participated in the workshops and their ages differed between 23 and 25.

	average score
s42	8,157
s4	7,581
s34	7,546
s3	7,543
s41	7,464
s15	7,261
s36	7,209
s45	7,184
s40	7,172
s31	7,154
s8	7,124
s26	7,097
s1	6,967
s5	6,965
s39	6,891
s7	6,886
s6	6,854
s24	6,834
s30	6,727
s10	6,715
s2	6,655
s25	6,546
s9	6,516

	average score
s27	6,464
s33	6,394
s32	6,342
s16	6,334
s21	6,282
s28	6,249
s43	6,231
s11	6,103
s44	6,028
s19	5,929
s38	5,918
s22	5,886
s18	5,883
s14	5,797
s35	5,753
s12	5,747
s37	5,672
s17	5,651
s29	5,541
s13	5,502
s20	5,414
s23	5,400

Figure 123. Participants of the workshops

7.2 Workshops for Idea Generation Using the Fictionation Tool

Following the determination of the participants, the workshop schedule was arranged considering the availability of the participants. Eventually, the workshops took place at the dates and times indicated in the Table 13. The workshops were conducted in the available classrooms in the Faculty building where there was a familiar work environment for the students, similar to the studios they generally work in, with desks for every student to work at (Figure 124). At the end of the workshops, participants were asked to preserve the confidentiality of the procedure and not to mention about the process to those who would be attending the workshops later on.

Table 13. The workshop schedules

	Workshop #	**Number of the participants**	**Date**	**Time**	**Location**
Control Group	Workshop 2	4 students	April 17th 2019	13.30 - 15.25	Archive Room
	Workshop 4	5 students	May 1st 2019	11.00 - 12.50	Room 420
	Workshop 5	3 students	May 30th 2109	14.00 - 15.50	Room 420
Experiment Group	Workshop 1	4 students	April 16th 2019	13.00 - 16.10	Room 420
	Workshop 3	4 students	April 23th 2019	10.30 - 13.30	Room 49
	Workshop 6	4 students	May 31th 2019	11.00 - 14.10	Room 420

Figure 124. The setting of the workshops (Workshop 1, Room 420)

This section will present the results of this implementation together with the results of the developed assessment technique and interviews conducted to the participants of the experiment group. At the beginning of the workshops, participants were informed about the rules and procedure through a consent form (see Appendix L).

7.2.1 Workshop Process

As mentioned in Chapter 4, the workshops were conducted with control and experiment groups. Both were separated into two sessions for the purpose of comparing the results at the end (Figure 125).

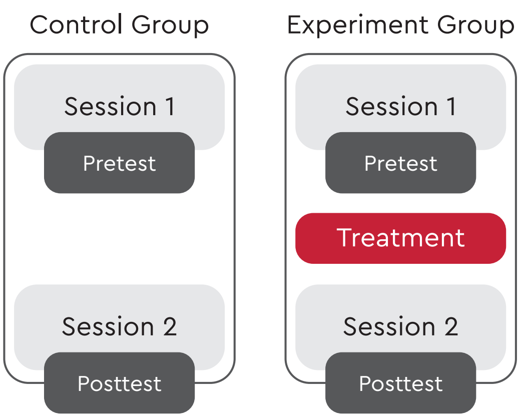

Figure 125. The design of the experiment

Control Group

The process of the control group consisted of two phases with a 15 minutes break between them. Both phases were named *initial ideas* (Figure 126).

Phase 1. At the beginning of the process, each student was delivered two initial ideas charts containing a total of 16 cells to make sketches in (see Section 6.2.5.2 for details). They were also delivered a design brief that asked them to design a kettle and make sketches regarding their design solutions on the delivered charts (see Appendix M). The duration of this phase was determined as 45 minutes.

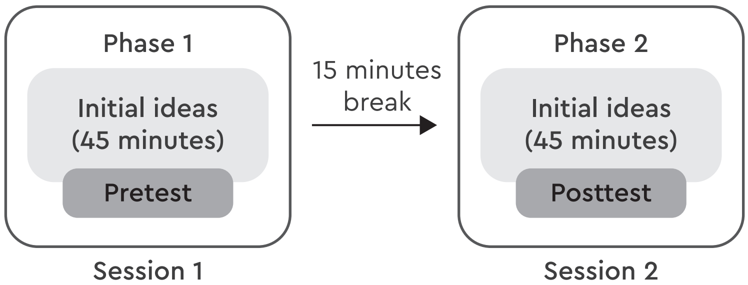

Figure 126. Process of the workshop of the control group

Phase 2. After a 15 minutes break, the process was continued with the second phase in which students were delivered two more initial ideas charts and asked to make 16 more sketches on the delivered charts. The duration of this phase was also 45 minutes.

Experiment Group

The process of the experiment group consisted of three phases with a presentation and two 15 minutes breaks. The three phases were named initial ideas, *design for divergence* and *design for convergence* respectively (Figure 127).

Phase 1. Similar to the process of the control group, the participants of the experiment group were delivered two initial ideas charts containing a total of 16 cells to make sketches in. They were delivered a design brief that asked them to design a kettle same as the control group. The duration of this phase was 45 minutes.

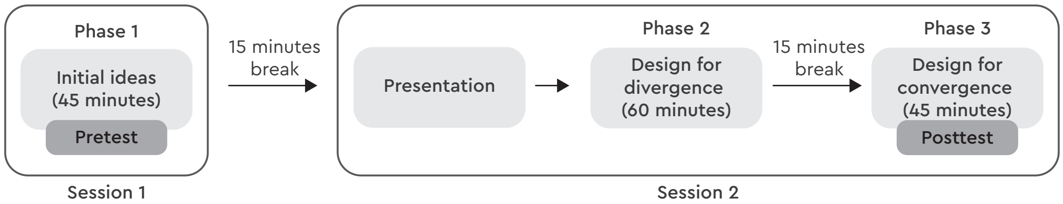

Figure 127. Process of the workshop of the experiment group

Presentation. After a 15 minutes break, they were delivered a new design brief that presented the following phases that they would be dealing with through the rest of the workshop (see Appendix N). Then, the author made a presentation on the Fictionation tool in which information about design fiction and the procedure of the design task expected from the participants in the remaining of the workshop session were included (see Appendix O).

Phase 2. Following the presentation, each participant was delivered a Fictionation card deck containing 33 cards and they were asked to pick eight out of them to work on. They were told that they could pick the cards randomly, as well as through a conscious selection. Later on, students were delivered eight design for divergence charts (see section 6.2.5.2 for details). Allocating 5 minutes for each card, students were asked to generate ideas for the what-if questions on each card in a divergent manner on the charts. The duration of 5 minutes was kept by the researcher by using a mobile timekeeper application and students were warned one minute before the end and at the end of the time.

At the end it was expected that the eight charts would contain sketches related to the different what-if questions of the eight cards. Considering the times that were given to participants in order to switch between cards and to catch their breaths, the duration of this phase was determined as 60 minutes (8 cards x 5 minutes = 40 minutes + extra 20 minutes).

Phase 3. After a 15 minutes break, participants were delivered two design for convergence charts (see section 6.2.5.2 for details) that contain a total of 16 cells. This time, they were asked to examine the sketches that they had made in the design for divergence phase and make 16 new sketches that are applicable in our contemporary world. The duration of this phase was determined as 45 minutes.

Teamwork Phase. By considering the suggestions of the participants of the pilot study, the Fictionation tool was also implemented in a teamwork session. After the procedure of the workshop was completed, a teamwork chart was delivered to each participant (see section 6.2.5.2 for details). A card deck was placed on the table and participants were asked to pick one card. Considering the cards they picked, they were asked to make a sketch in the top left cell of the chart. Then, they were asked to give their charts to the participant on their right and pick new cards. This time, they were asked to make a sketch in the next cell by considering the picked card and the sketch of the previous cell that was made by their friends on their left. This process was repeated as many as the number of the participants. Thus, students had the opportunity to be inspired from the sketches that were done by their friends and develop the design ideas further.

7.2.2 Materials Obtained from the Workshops

At the end of the three workshops made with the control group, 192 sketches (16 sketches per 12 participants) within Phase 1 and 192 sketches within Phase 2 that were made on initial ideas charts were collected (Figure 128). At the end of the three workshops made with the experiment group, 192 sketches made on initial ideas chart within Phase 1 (Figure 128), 404 sketches made on design for divergence charts within Phase 2 (Figure 129), and 192 sketches made on design for convergence charts within Phase 3 (Figure 130) were collected (Table 14). The 404 sketches of the experiment group that were made in Phase 2 were the design for divergence sketches. The participants examined these sketches to produce new ones in Phase 3. These sketches were a step to reach the final solutions. Therefore, they were not examined within this study.

The concern of this study was the sketches that were obtained in Phase 1 and Phase 2 for the control group, and the sketches that were obtained in Phase 1 and Phase 3 of the experiment group. At the end, a total of 768 sketches (192 + 192 for the control group, 192 + 192 for the experiment group, see Table 15) were examined in order to assess the novelty and variety scores of the participants within control and experiment group to see the effect of Fictionation tool for idea generation.

Besides, there was a total of 48 sketches that were made within the teamwork session on the teamwork charts (Figure 131). These sketches were not examined for measuring their success, instead, the teamwork process was questioned with the participants within the interviews that were conducted following the workshops.

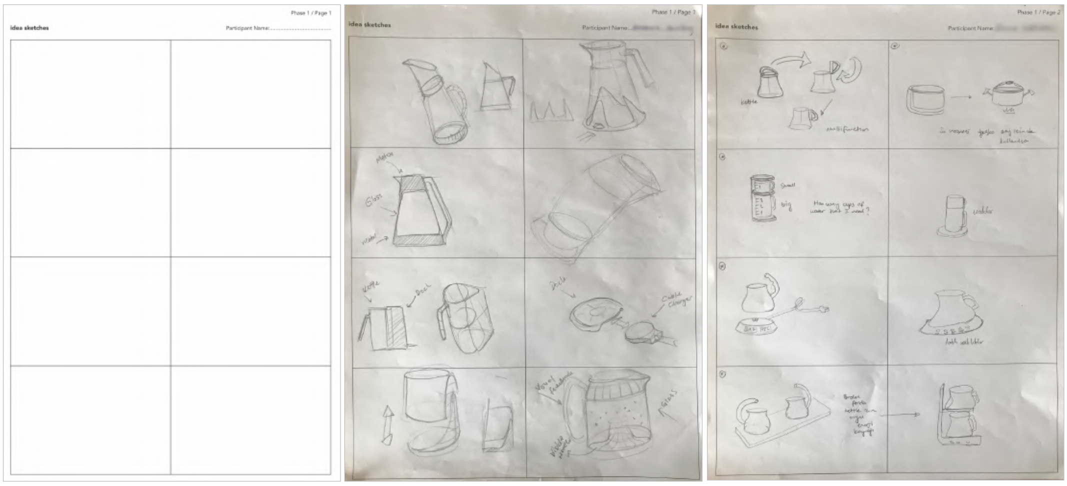

Figure 128. Materials of phase 1. Left: Initial ideas chart, Middle: An example of a chart filled in Phase 1 of the control group, Right: An example of a chart filled in Phase 1 of the experiment group

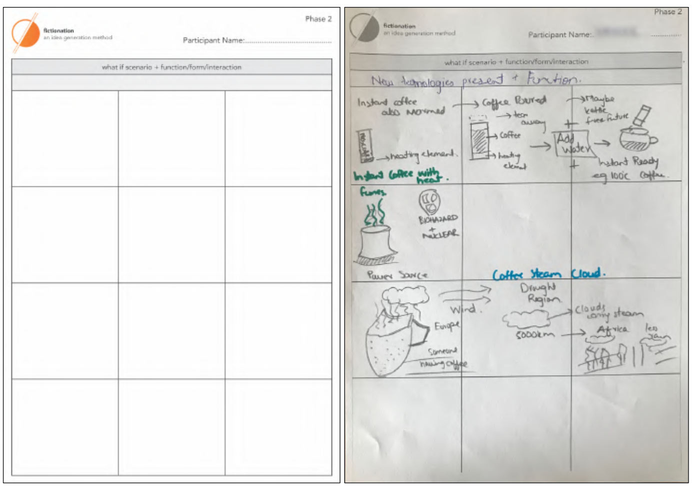

Figure 129. Materials of phase 2. Left: Design for divergence chart, Right: An example of a filled-in chart in Phase 2 of the experiment group

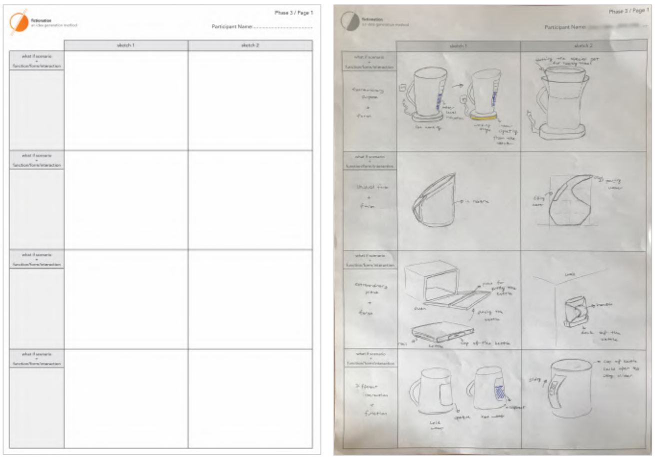

Figure 130. Left: Materials of phase 3. Left: Design for convergence chart, Right: An example of a filled-in chart in Phase 3 of the experiment group

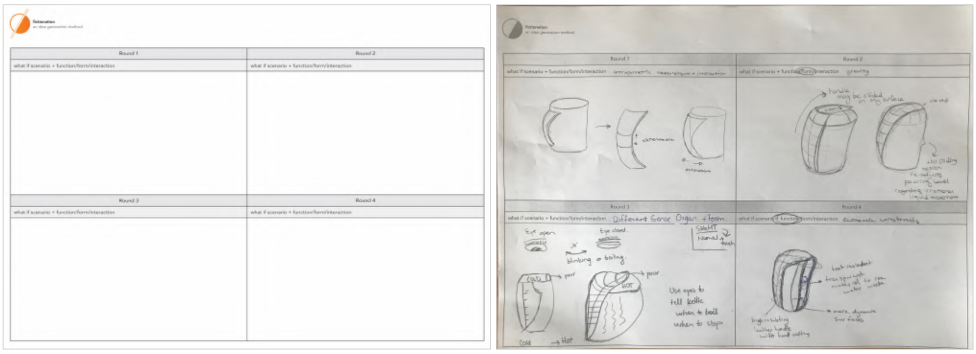

Figure 131. Materials of teamwork session. Left: Teamwork chart, Right: An example of a filled-in chart in the teamwork phase of the experiment group

Table 14. Number of sketches done by participants within the Fictionation workshops

Control group			**Experiment group**			
Participant	**Number of sketches in Phase 1**	**Number of sketches in Phase 2**	**Participant**	**Number of sketches in Phase 1**	**Number of sketches in Phase 2**	**Number of sketches in Phase 3**
s1	16	16	s3	16	37	16
s5	16	16	s8	16	40	16
s6	16	16	s9	16	29	16
s13	16	16	s10	16	30	16
s15	16	16	s11	16	24	16
s16	16	16	s20	16	36	16
s22	16	16	s21	16	24	16
s25	16	16	s31	16	30	16
s33	16	16	s34	16	28	16
s36	16	16	s35	16	30	16
s41	16	16	s39	16	40	16
s44	16	16	s45	16	56	16
total	192	192	**total**	192	404	192

Regarding the examination of the sketches, two types of sketching styles were observed. Most of the sketches were representational, presenting detailed information about the product and its environment (Figure 132, left). Besides, some of the sketches were symbolic, mainly reflecting the ideas without giving detailed information about the product (Figure 134, middle), There also were diagrammatic sketches giving information about spatial boundaries (Figure 132, right).

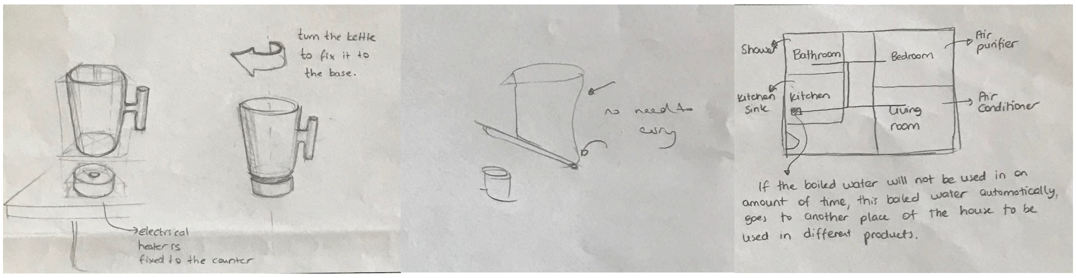

Figure 132. Sketching styles. Left: Representational sketch. Middle: Symbolic sketch. Right: Diagrammatic sketch

Furthermore, most of the participants used annotations in their sketches. While some of them used only text without any drawing, some of them used multiple-word sentences, some of them used single words and some used titles in their drawings (Figure 133). Without the annotations, some of the sketches were difficult to understand. In this respect, participants were asked to make explanations of these sketches following the workshops.

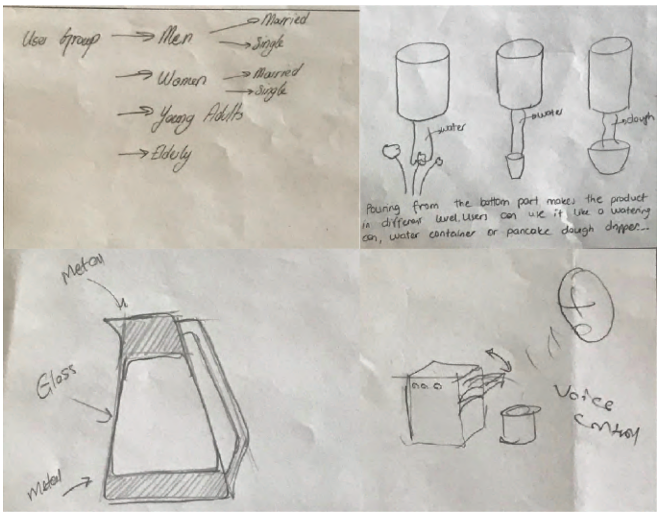

Figure 133. Annotation style examples

7.2.3 Codification of the Sketches

The 768 sketches obtained in the workshops constituted the data of this study. The sketches were examined one by one by three coders, industrial design educators who had six to seven years of experience. Implementing the technique used in the prior achievement analysis described in Section 7.1.2, each sketch was examined considering the FBS ontology to determine each function, behavior and structure alternatives. Each coder noted their findings and coder 1 achieved 39, coder 2 achieved 40, and coder 3 achieved 37 categories (Table 15).

Table 15. Proposed categories of the coders within the Fictionation workshops

Coder 1	Coder 2	Coder 3
opaque body	not transparent	opaque
transparent body	transparent	glass body
partially transparent body	-----	transparent parts
sharp outer form	sharp edges	-----
touchscreen	control with touchscreen	touchscreen
buttons	control with buttons	buttons to control heat
different heating levels	adjust heating degree	various heating degrees
dock	have a dock	bottom dock
-----	-----	side dock
stable onto the wall	stable on the wall	wall mounted
classical handle	two point handle	-----
-----	handheld	-----
tilting	pour by tilting	tilting body
-----	stable on the counter	mounted on the counter
no handle	no handle	no handle
gives sound signal	sound signal	-----
long spout	has a long spout	long spout
-----	-----	ordinary spout
heating food	it heats meal	-----
have a hinge at lid	has a lid	lid with hinge
slim outer form	-----	slim body
chargeable dock	chargeable dock	chargeable dock
two handle	has two handles	two handles
-----	control with phone	mobile phone controlled
multiple spout	has various spouts	-----
measures weight	it measures weight	-----
making tea	-----	makes tea
-----	has a digital screen	-----
has an opening on the lid	has an opening to fill water	-----
induction heater	-----	induction cooker
-----	-----	mounted to the ground
-----	-----	has a big container
-----	short body	-----
usb powered	working with usb	-----
surrounding dock	-----	-----
pumping to pour water	has a pump to pour water	has a pump

Table 15 (continued)

multiple body parts	multiple body	various body units
-----	lank body	-----
-----	-----	elastic body
downward handle	one point handle	downward handle
upward handle	-----	upward handle
pressing button to pour water	-----	pour by pressing button
speaks with the user	has a speaker	-----
gets energy by motion	powered by generator	-----
solar panel	solar panel	solar panel
heat with fire	fire	fire heated
-----	steam	steam to water
collects moisture	moisture	moisture to water
-----	rain	-----
light source	lighting	gives light
-----	-----	watch tv
air humidifier	air humidifier	air humidifier
thermos like surface	thermos	thermos body

Following the acquisition of the categories that the three coders offered, the inter-rater reliability of these codes was assessed by using the formula of Miles and Huberman (1994). The results showed that, between coders 1 and 2 there is 0.81, between coders 1 and 3 there is 0.792, and between coders 2 and 3 there is 0.789 reliability. The results were interpreted considering the guidelines of Landis and Koch (1977). The results of the encoding process fall between 0.80 and 1.0, indicating nearly perfect agreement with a mean score of 0,797 (Table 16).

Table 16. Reliability of the categorization of ideas made in the Fictionation workshops

Coders	Reliability Values	Interpretation
1-2	0,810	Perfect
1-3	0,789	Substantial
2-3	0,792	Substantial
Mean	0,797	Substantial

7.2.4 Categorization of the Sketches

Following the codification of the sketches, as implemented in the prior achievement analysis, three coders came together, and the codes were combined to obtain a genealogy tree. The achieved codes were the lowest levels of the genealogy tree. Relevant codes were identified and combined under newly created higher-level branches.

After the genealogy tree was prepared, coders started to place the sketches under relevant branches. Within this process, some new codes were created that were not offered in the codification process. After a certain point of agreement was achieved in the placement of sketches, the researcher continued the process and completed the tree diagram alone. A total of 768 sketches were examined in this process. Some of the sketches could not take place in the tree diagram since they did not offer much information regarding function, behavior, or structure, or they contained texts that described the users. Besides, many of the sketches were eliminated since they were a repetition of an idea that was already offered by the same student with some minor changes in the form of the product. For example, 12 out of 16 sketches made in Phase 2 by a participant in the control group were eliminated since they differentiated through some minor changes. 12 of them were similar in terms of offering an opaque body, a handle that touches from two points to the body of the kettle and a common spout that is available in most of the kettles in the market. Their proportions were similar. They did not offer any button or touchscreen to control the product. They only differentiated through some curvatures that were available in the body and handle of the product. (Figure 134).

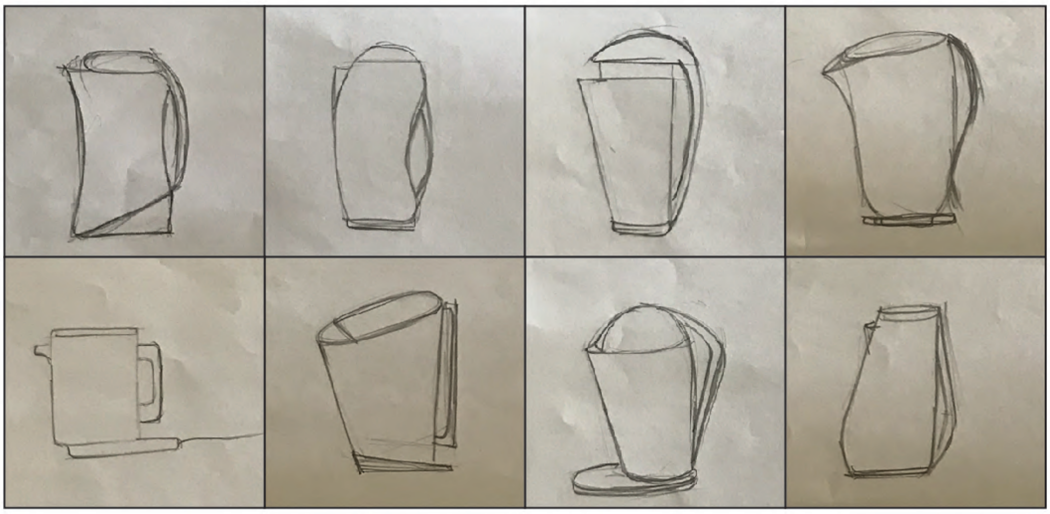

Figure 134. Eliminated ideas due to similarity with their opaque bodies, two-point touch handles, and common spouts.

Furthermore, some ideas took place under more than one category since the sketch offered multiple information. For example, the sketch represented in Figure 135 took place under five different categories by having an *opaque single body*, a *single dock*, *no handle*, a *handheld* usage, and extra surface for *energy efficiency.*

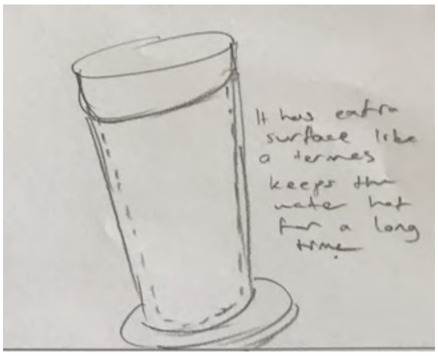

Figure 135. An example of a sketch that took place within many categories: opaque single body, single dock, no handle, handheld usage, and energy efficiency.

At the end, there were a total of 2539 sketches placed in the tree diagram (Figure 136). Table 17 presents the overall statistics regarding the sketches generated in the Fictionation workshops.

Table 17. Sketch statistics of the Fictionation workshops

		Number of sketches	**Irrelevant sketches**	**Repetitive ideas**	**Valid sketches**	**Phase 1 (Pretest): Total number of sketches in tree diagram**	**Phase 2: Total number of sketches in tree diagram**	**Phase 1+2 (Posttest): Total number of sketches in tree diagram**
Control Group	s1	32	0	12	20	48	45	93
	s5	32	3	17	12	70	63	133
	s6	32	0	17	15	68	65	133
	s13	32	0	7	25	27	42	69
	s15	32	0	3	29	67	67	134
	s16	32	0	10	22	55	64	119
	s22	32	0	17	15	40	25	65
	s25	32	0	10	22	52	45	97
	s33	32	0	7	25	49	24	73
	s36	32	0	17	15	66	48	114
	s41	32	0	8	24	80	45	125
	s44	32	0	10	22	44	20	64
	total	384	3	135	246	666	553	1219

Table 17 (continued)

		Number of sketches	Irrelevant sketches	Repetitive ideas	Valid sketches	Phase 1 (Pretest): Total number of sketches in tree diagram	Phase 3: Total number of sketches in tree diagram	Phase 1+3 (Posttest): Total number of sketches in tree diagram
Experiment Group	s3	32	0	10	22	51	44	95
	s8	32	0	4	28	54	38	92
	s9	32	0	7	25	46	58	104
	s10	32	0	9	23	59	44	103
	s11	32	0	7	25	51	65	116
	s20	32	0	4	28	42	59	101
	s21	32	0	10	22	62	66	128
	s31	32	0	7	25	69	56	125
	s34	32	0	12	20	56	51	107
	s35	32	0	15	17	44	43	87
	s39	32	0	10	22	66	69	135
	s45	32	0	10	22	61	66	127
	total	384	0	105	279	661	659	1320

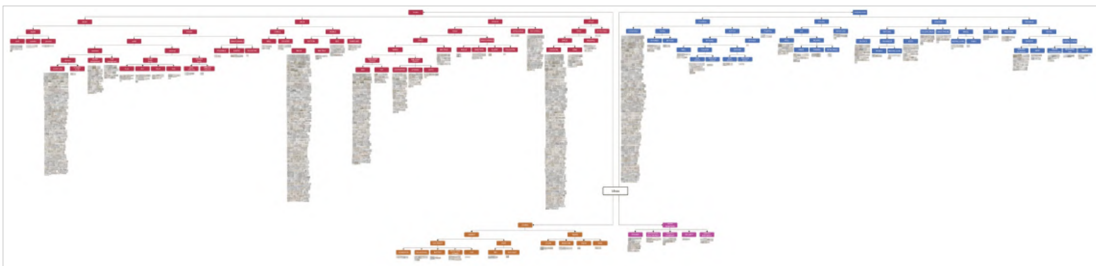

Figure 136. Tree diagram categorizing the sketches generated in the Fictionation workshops

At the highest level, the ideas were separated into four major themes: form, interaction, source, and additional function. There were 1799 ideas under the theme of *form*, 649 under the theme of *interaction*, 38 under the theme of *source*, and 53 under the theme of *additional function* (Figure 137).

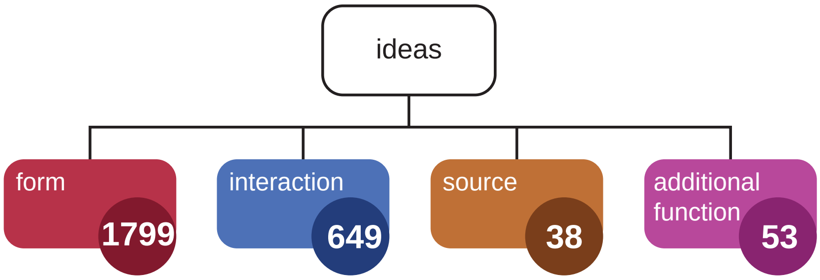

Figure 137. Highest level categories of the fictionation workshops

The theme of *form* contains ideas that are related with the outer form of the product. The theme of *interaction* contains ideas that represents the interaction between the user and the product. The theme of *source* contains ideas that give information about the sources that the product uses. Finally, the theme of *additional function* contains ideas offering to add a function to the product other than boiling the water.

7.2.4.1 Theme of *Form*

The theme of *form* separates into four categories: *body*, *dock*, *handle*, and *spout* (Figure 138). While the category of *body* presents various ideas regarding the body of the kettle, the category of *dock* is concerned with the dock of the kettle, the category of *handle* contains ideas for the handle of the kettle, and the category of *spout* contains ideas for the spout of the kettle.

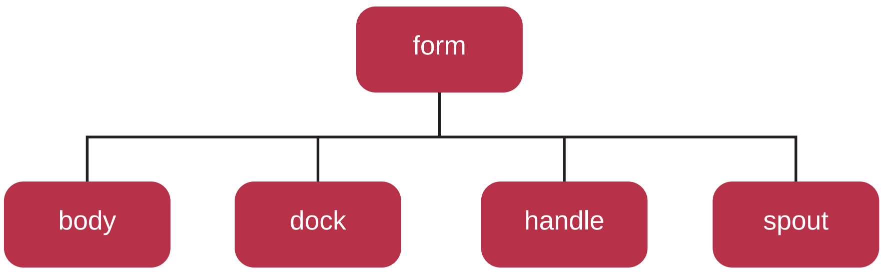

Figure 138. Branches of the category of form

The Category of *Body*

The category of *body* separates into two sub-categories: *stable* and *mobile* (Figure 139).

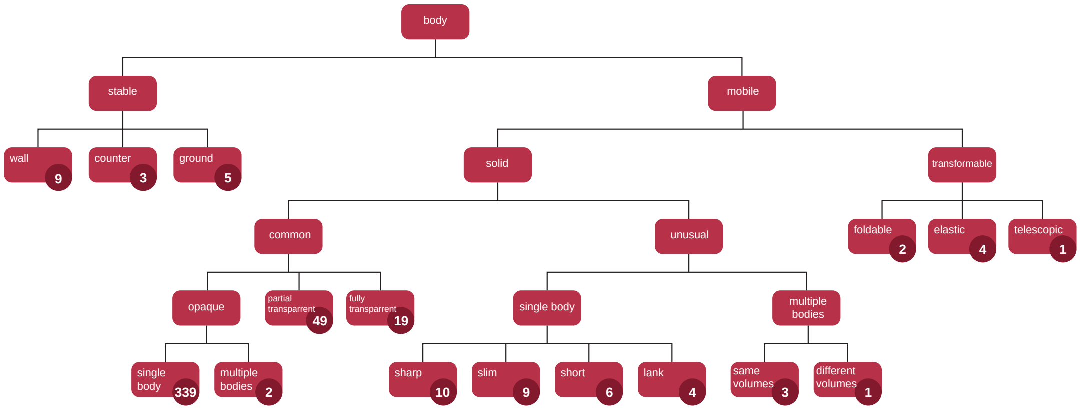

Figure 139. Branches of the category of body

- The sub-category of *stable* contains ideas in which the body of the kettle is stabilized
  - against the *wall* (Figure 140, 1),
  - on the kitchen *counter* (Figure 140, 2), or
  - on the *ground* (Figure 140, 3).

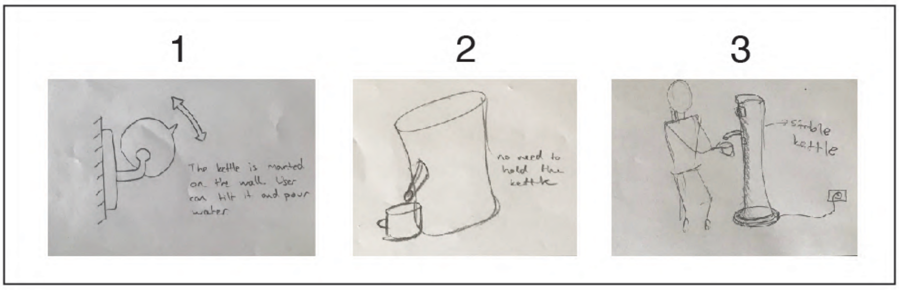

Figure 140. Sketch examples from the sub-category of stable

- The sub-category of *mobile* contains ideas in which the body of the kettle is mobile and consists of
  - a *solid* structure that represents
    - the characteristics of *common* kettles offering
      - an *opaque* body that consists of
        - a *single body* (Figure 141, 1),
        - *multiple bodies* (Figure 141, 2),
      - a *partially transparent* body (Figure 141, 3), or
      - a *fully transparent* body (Figure 141, 4),

        - the characteristics of an *unusual* kettle offering alternative solutions that consist of
            - a *single body* that has
                - a *sharp* body form (Figure 141, 5),
                - a *slim* body form (Figure 141, 6),
                - a *short* body form (Figure 141, 7), or
                - a *lank* body form (Figure 141, 8),
            - *multiple bodies* that have
                - the *same volumes* (Figure 141, 9), or
                - *different volumes* (Figure 141, 10)
    - a *transformable* structure that has
        - a *foldable* structure (Figure 142, 1),
        - an *elastic* structure (Figure 142, 2), or
        - a *telescopic* structure (Figure 142, 3).

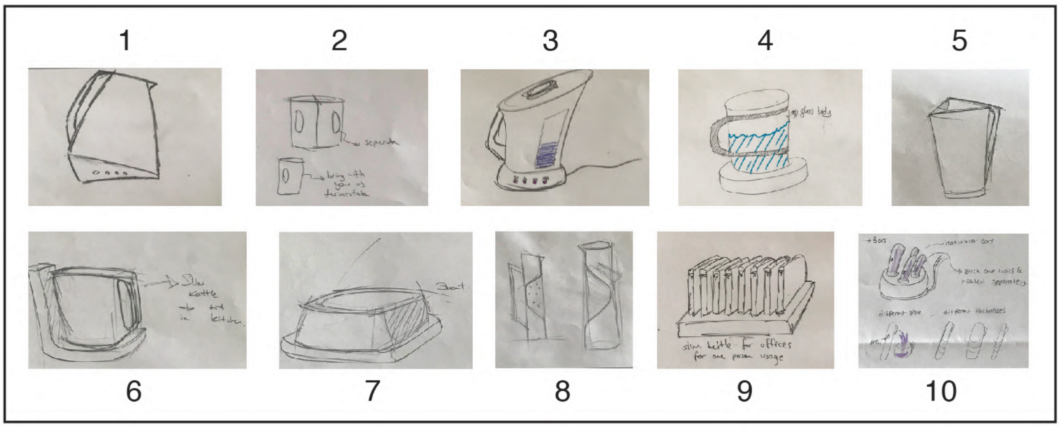

Figure 141. Sketch examples from the sub-category of mobile/solid.

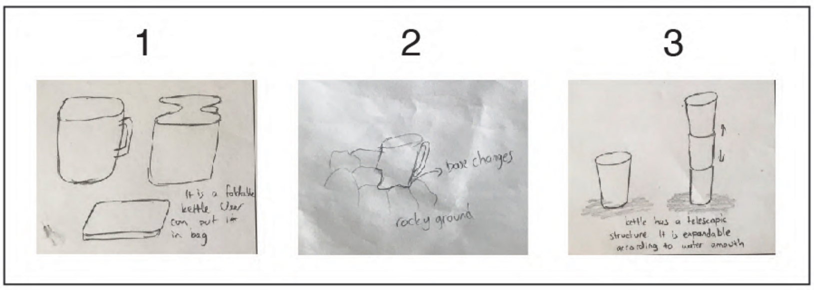

Figure 142. Sketch examples from the sub-category of mobile/transformable

The Category of *Dock*

The category of *dock* separates into two sub-categories: *stable* and *mobile* (Figure 143).

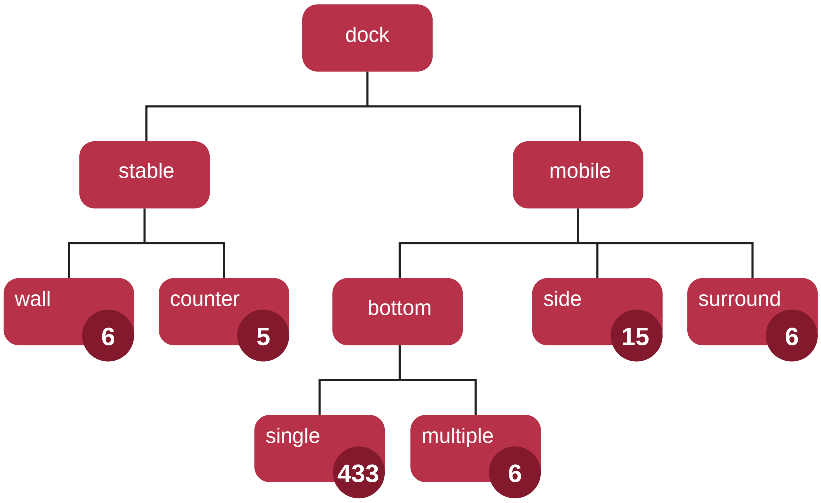

Figure 143. Branches of the category of dock

- The sub-category of *stable* contains ideas in which the dock of the kettle is stabilized
    - against the *wall* (Figure 144, 1), or
    - on the kitchen *counter* (Figure 144, 2).
- The sub- category of *mobile* contains ideas in which the dock of the kettle is mobile, and the dock is located
    - on the *bottom* of the kettle that contains either
        - a *single* piece (Figure 144, 3), or
        - *multiple* pieces (Figure 144, 4)
    - on the *side* of the kettle (Figure 144, 5), or
    - in a way that *surrounds* the kettle (Figure 144, 6).

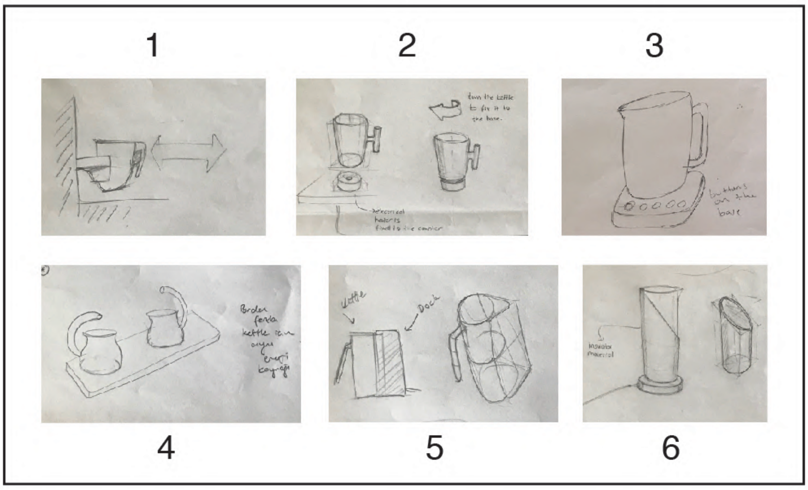

Figure 144. Sketch examples from the sub-category of dock

The Category of *Handle*

The category of *handle* separates into three sub-categories: *fixed*, *detachable*, and *no handle* (Figure 145).

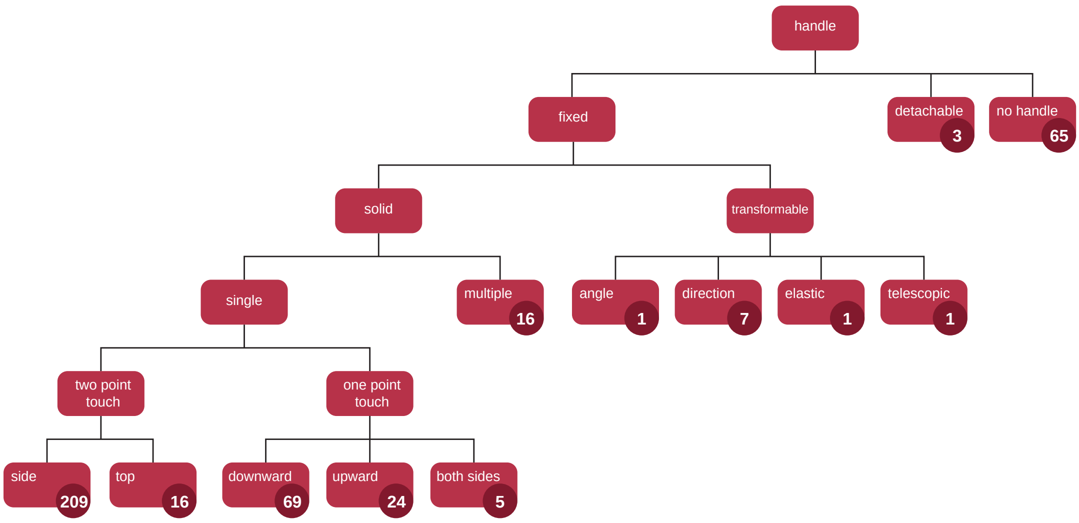

Figure 145. Branches of the category of handle

- The sub-category of *fixed* contains ideas in which the handle of the kettle is fixed to the body of the kettle through
    - a *solid* structure that consists of
        - a *single* piece that merges with the body through
            - *two-point touch* that is located either

            - on the *side* of the kettle (Figure 146, 1), or
            - on *top* of the kettle (Figure 146, 2)
        - *one-point* touch that extend towards either
            - *downward* (Figure 146, 3),
            - *upward* (Figure 146, 4), or
            - *both sides* (Figure 146, 5)
    - *multiple* pieces (Figure 146, 6)
- a *transformable* structure that changes the form of the handle with
    - a change in the *angle* (Figure 147, 1),
    - a change in the *direction* (Figure 147, 2),
    - an *elastic* structure (Figure 147, 3), or
    - a *telescopic* structure (Figure 147, 4)

- The sub-category of *detachable* contains ideas in which the handle is detachable from the body of the kettle (Figure 147, 5).
- The sub-category of *no handle* contains ideas in which the kettle has no handle (Figure 147, 6).

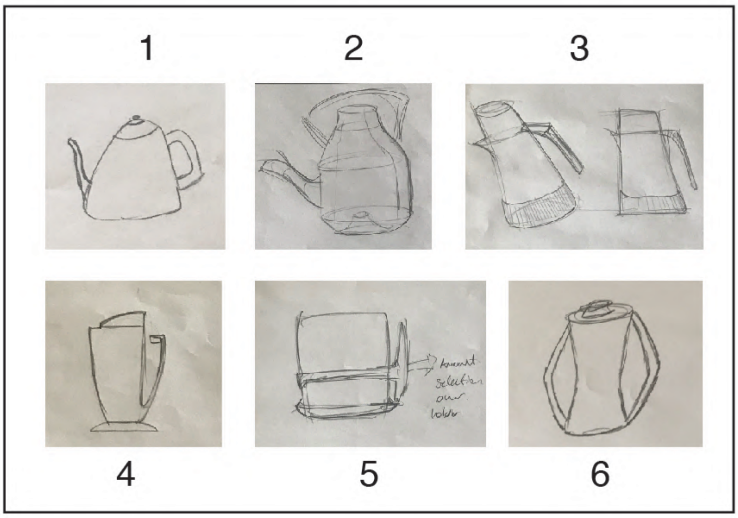

Figure 146. Sketch examples from the sub-category of fixed/solid

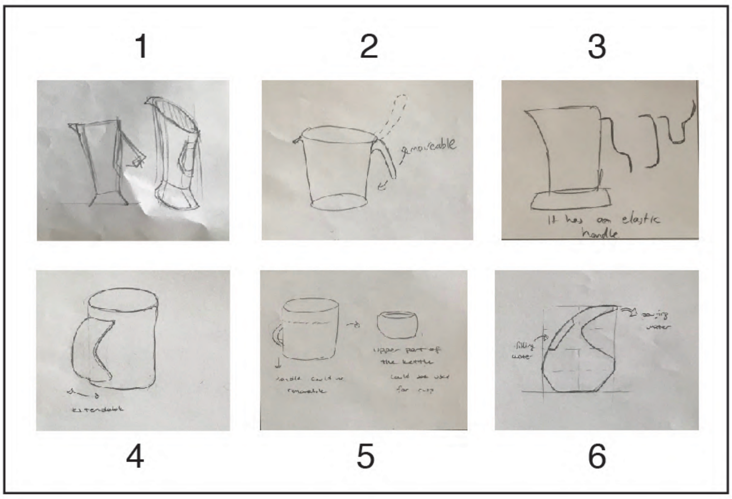

Figure 147. Sketch examples from the sub-categories of fixed/transformable, detachable and no handle

The Category of *Spout*

The category of *spout* separates into two sub-categories: *fixed* and *detachable* (Figure 148).

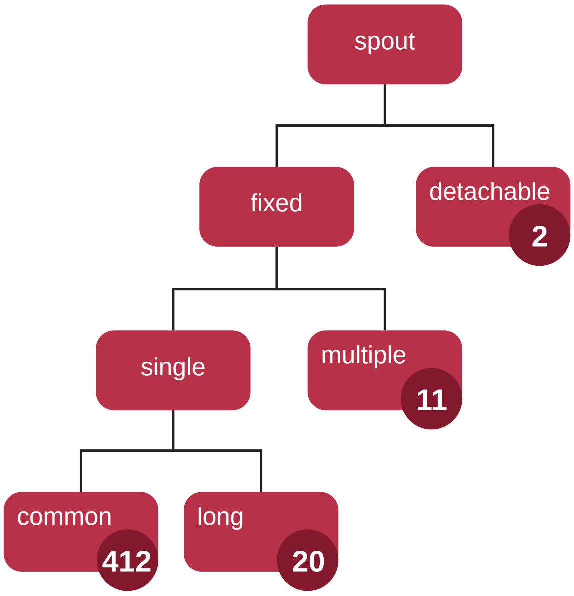

Figure 148. Branches of the category of spout

- The sub-category of *fixed* contains ideas in which the spout of the kettle is fixed to the body of the kettle and consists of
    - a *single* piece that contains either

        - a *common* shaped piece (Figure 149, 1), or
        - a *long*-shaped piece (Figure 149, 2)
    - *multiple* pieces (Figure 149, 3)
- The sub-category of *detachable* contains ideas in which the spout of the kettle is detachable from the body of the kettle (Figure 149, 4).

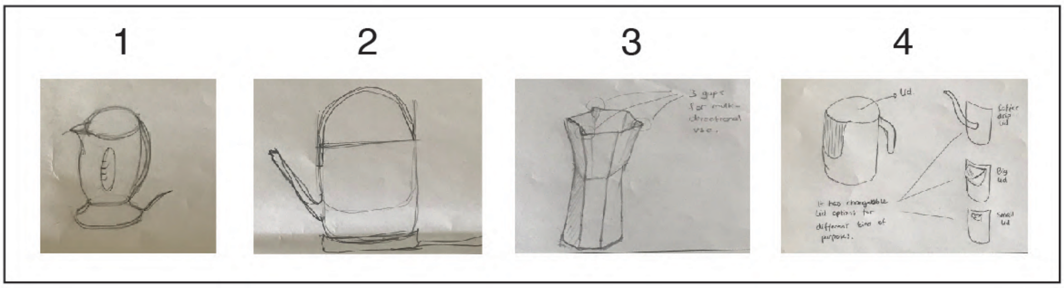

Figure 149. Sketch examples from the category of spout

An expanded version of the sketches within the theme of *form* can be seen in Appendix P.

7.2.4.2 Theme of *Interaction*

The theme of *interaction* separates into four categories: *pouring*, *filling*, *controls*, and *feedback* (Figure 150). While the category of *pouring* presents various ideas for the ways in which the user pours the water from the kettle, the category of *filling* suggests ideas for the ways in which the user fills the kettle, the category of *controls* presents ideas for the ways in which the user controls the kettle, and the category of *feedback* contains ideas for the ways in which the kettle gives feedback to the user.

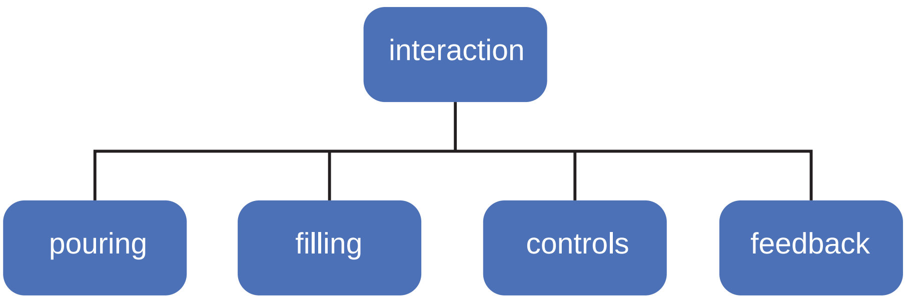

Figure 150. Branches of the theme of interaction

The Category of *Pouring*

The category of *pouring* separates into four sub-categories: *handheld, tilting, button* and *pumping* (Figure 151).

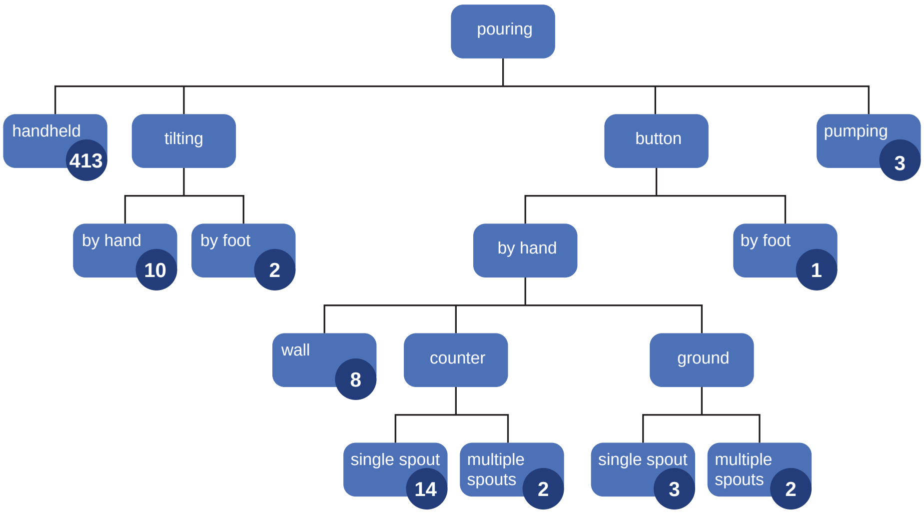

Figure 151. Branches of the category of pouring

- The sub-category of *handheld* contains ideas in which the user can pour water by holding the kettle (Figure 152, 1).
- The sub-category of *tilting* contains ideas in which the user can pour water by tilting the kettle either
    - *by hand* (Figure 152, 2), or
    - *by foot* (Figure 152, 3).
- The sub-category of *button* contains ideas in which the user can pour water by pressing a button
    - *by hand,* in which the kettle is located
        - on the *wall* (Figure 152, 4)
        - on the kitchen *counter*, where the water is poured either
            - from a *single spout* (Figure 152, 5), or
            - from *multiple spouts* (Figure 152, 6)
        - on the *ground*, where the water is poured either
            - from a *single spout* (Figure 152, 7), or
            - from *multiple spouts* (Figure 152, 8)
    - *by foot* (Figure 152, 9).

- The sub-category of *pumping* contains ideas in which the user can pour water by using a pump (Figure 152, 10).

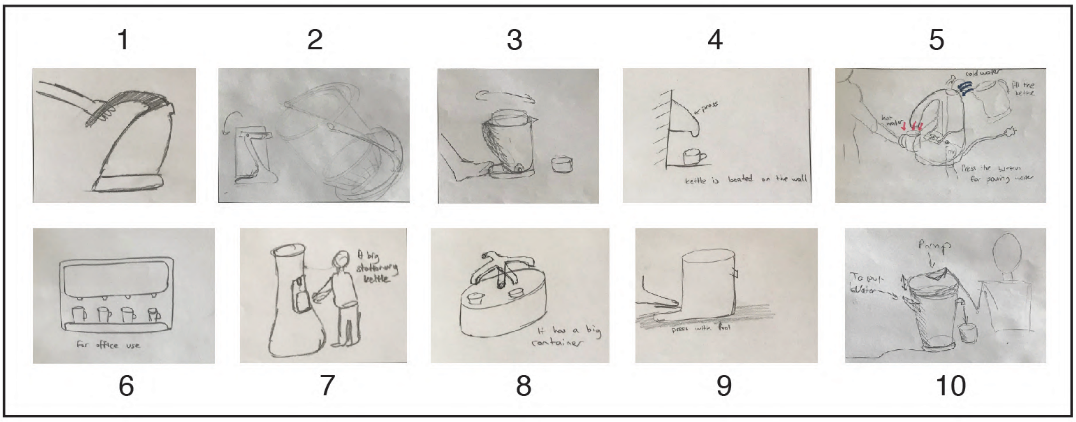

Figure 152. Sketch examples from the category of pouring

The Category of *Filling*

The category of *filling* separates into two sub-categories: *lid* and *waterline* (Figure 153).

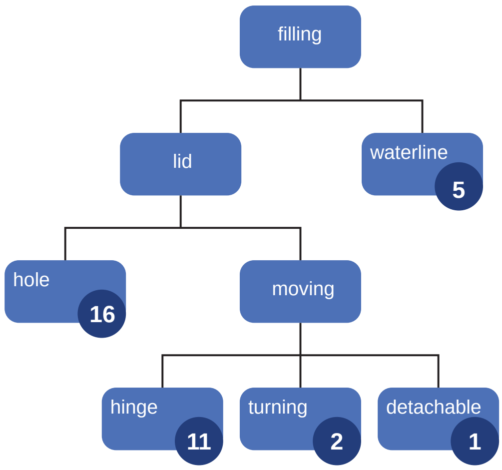

Figure 153. Branches of the category of filling

- The sub-category of *lid* contains ideas in which the user can fill water into the kettle through a lid that either
    - has a *hole* (Figure 154, 1), or
    - has a *moving* structure, with
        - a *hinge* (Figure 154, 2),

- a *turning* mechanism (Figure 154, 3), or
- a *detachable* piece (Figure 154, 4)

- The sub-category of *waterline* contains ideas in which the kettle is filled through the waterline system of the building (Figure 154, 5).

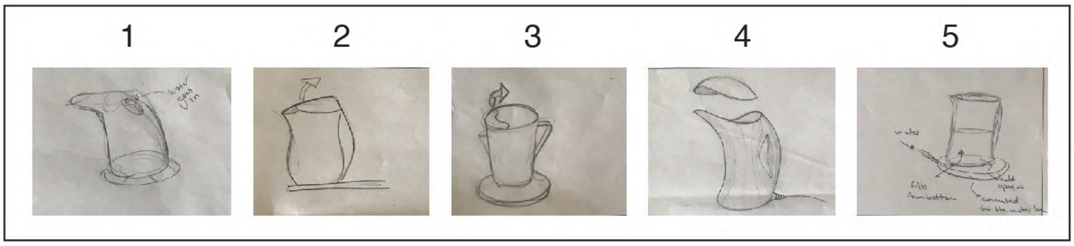

Figure 154. Sketch examples from the category of filling

The Category of *Controls*

The category of *controls* separates into five sub-categories: *buttons, touchscreen, smart phone, wheel* and *voice* (Figure 155).

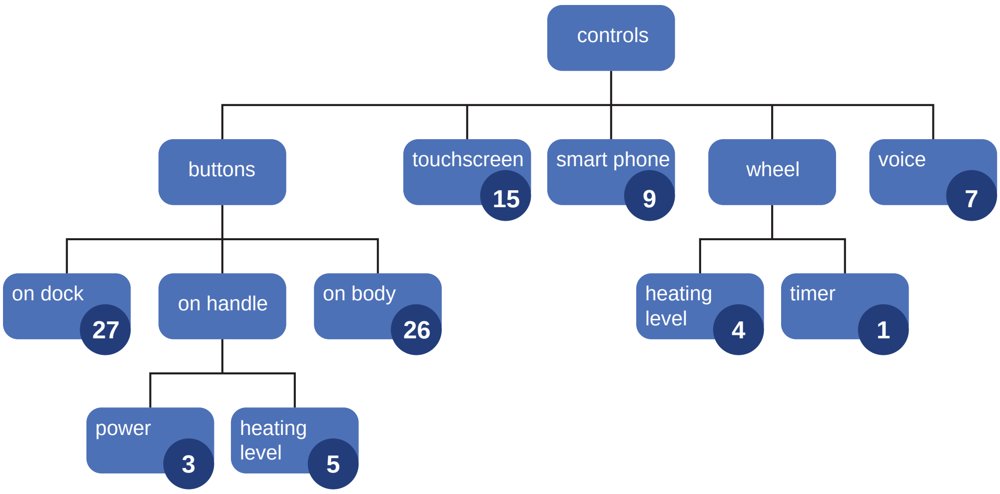

Figure 155. Branches of the category of controls

- The sub-category of *buttons* contains ideas in which the kettle is controlled through buttons that are either located
  - on the *dock* (Figure 156, 1),
  - on the *handle*, from where the user can either
    - turn the *power* on (Figure 156, 2), or
    - adjust the *heating level* (Figure 156,3)

- on the *body* of the kettle (Figure 156, 4).

- The sub-category of *touchscreen* contains ideas in which the kettle is controlled from a touchscreen (Figure 156, 5).
- The sub-category of *smart phone* contains ideas in which the kettle is controlled using a smart phone (Figure 156, 6).
- The sub-category of *wheel* contains ideas in which the kettle is controlled with a wheel, from which the user can control either
  - the *heating level* (Figure 156, 7), or
  - the *timer* (Figure 156, 8).
- The sub-category of *voice* contains ideas in which the kettle is controlled via voice (Figure 156, 9).

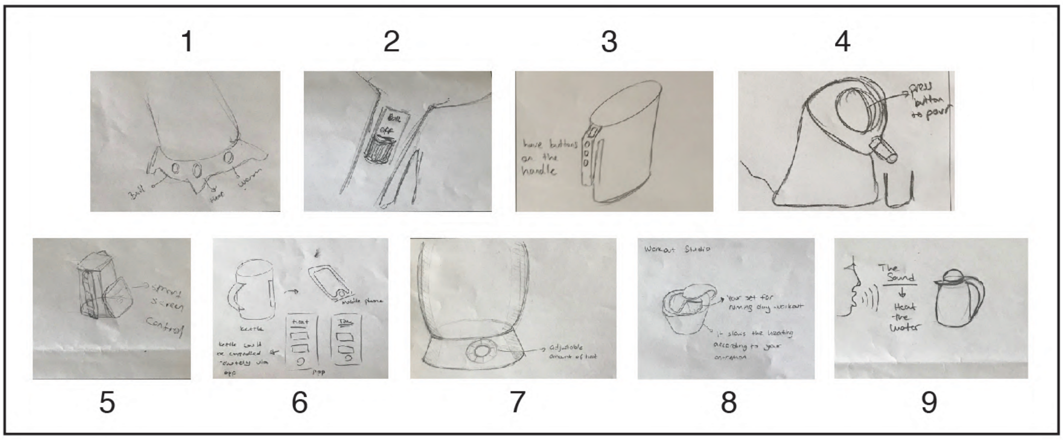

Figure 156. Sketch examples from the category of controls

The Category of *Feedback*

The category of *feedback* separates into two sub-categories: *auditory* and *visual* (Figure 157).

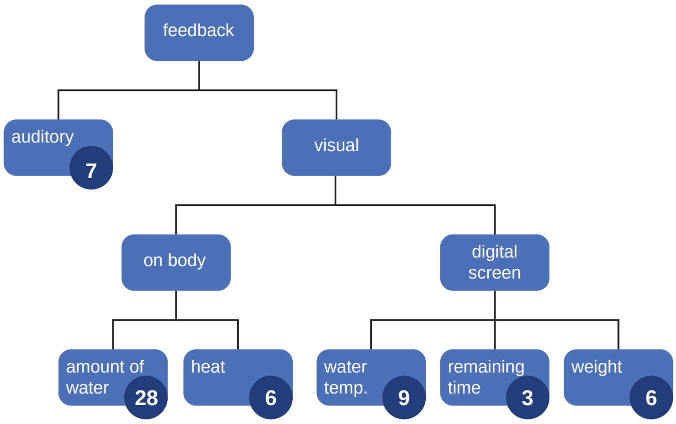

Figure 157. Branches of the category of feedback

- The sub-category of *auditory* contains ideas in which the kettle gives auditory feedback to the user (Figure 158, 1).
- The sub-category of *visual* contains ideas in which the kettle gives visual feedback to the user through
    - its body, regarding
        - the amount of water (Figure 158, 2), or
        - the heat (Figure 158, 3) is presented to the user
    - a digital screen, regarding
        - the water temperature (Figure 158, 4),
        - the remaining time for boiling (Figure 158, 5), or
        - the weight of the water and other foodstuff (Figure 158, 6).

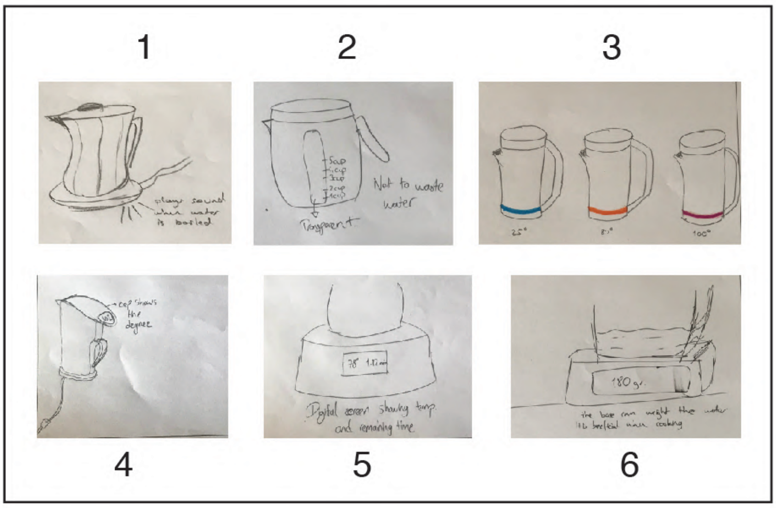

Figure 158. Sketch examples from the category of feedback

An expanded version of the sketches within the theme of *interaction* can be seen in Appendix Q.

7.2.4.3 Theme of *Source*

The theme of *source* separates into two categories: *energy*, and *water* (Figure 159). While the category of *energy* presents various ideas regarding the energy source of the kettle, the category of *water* presents ideas regarding the water source of the kettle.

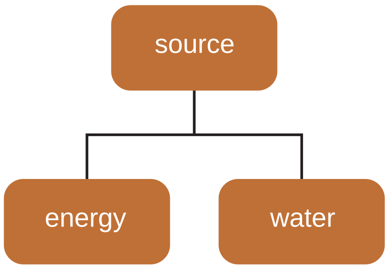

Figure 159. Branches of the theme of source

The Category of *Energy*

The category of *energy* separates into two sub-categories: *electricity* and *heat* (Figure 160).

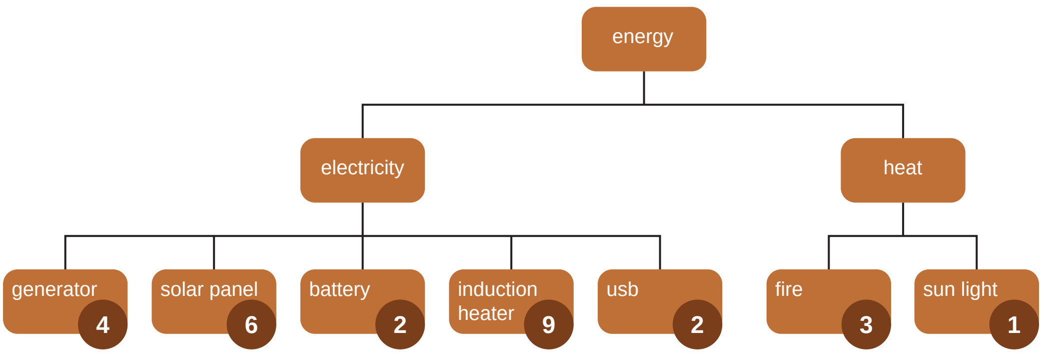

Figure 160. Branches of the category of energy

- The sub-category of *electricity* contains ideas in which the kettle is energized through electricity and its source is either

- o a *generator* (Figure 161, 1),
  - o a *solar panel* (Figure 161, 2),
  - o a *battery* (Figure 161, 3),
  - o an *induction heater* (Figure 161, 4), or
  - o a *USB* connection (Figure 161, 5)
- The sub-category of *heat* contains ideas in which the water inside the kettle is boiled through heat energy that is provided through either
  - o a *fire* source (Figure 161, 6), or
  - o *sun light* (Figure 161, 7).

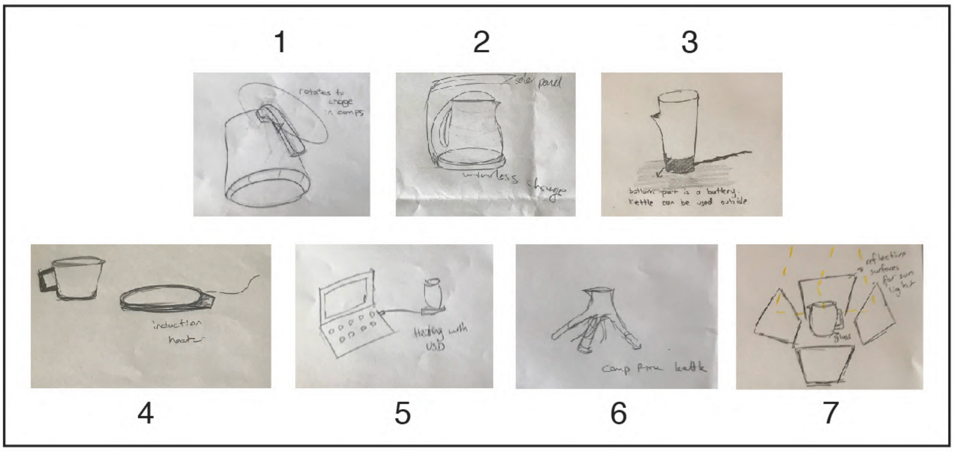

Figure 161. Sketch examples from the category of energy

The Category of *Water*

The category of *water* separates into four sub-categories: *steam, moisture, snow* and *rain* (Figure 162).

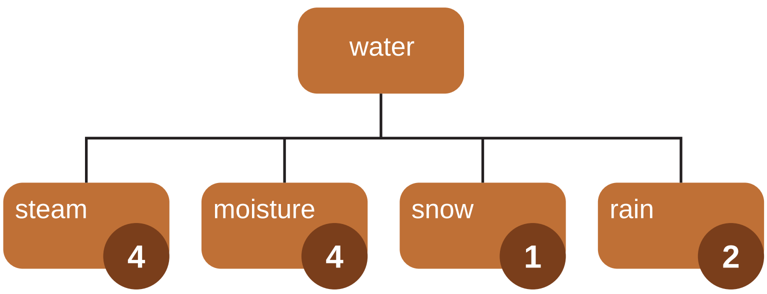

Figure 162. Branches of the category of water

- The sub-category of *steam* contains ideas in which the kettle obtains water through steam (Figure 163, 1).
- The sub-category of *moisture* contains ideas in which the kettle obtains water through moisture (Figure 163, 2).
- The sub-category of *snow* contains ideas in which the kettle obtains water from snow (Figure 163, 3).
- The sub-category of *rain* contains ideas in which the kettle obtains water from rain (Figure 163, 4).

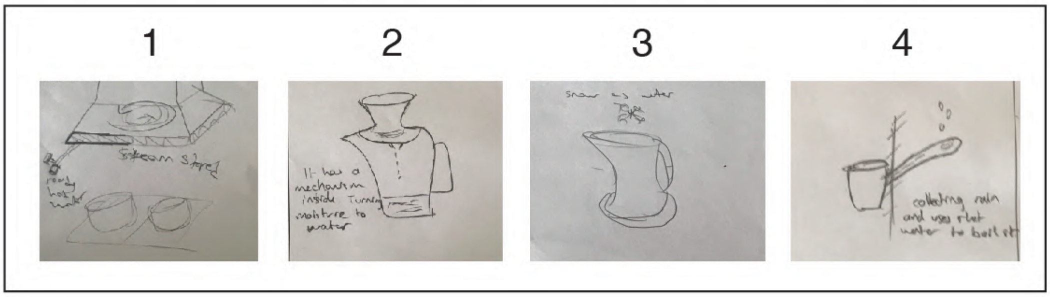

Figure 163. Sketch examples from the category of water

An expanded version of the sketches within the theme of *source* can be seen in Appendix R.

7.2.4.4 Theme of Additional Function

The theme of *additional function* separates into five categories: *kitchen*, *appliances/electronics, health/comfort, safeness* and *energy efficiency* (Figure 164).

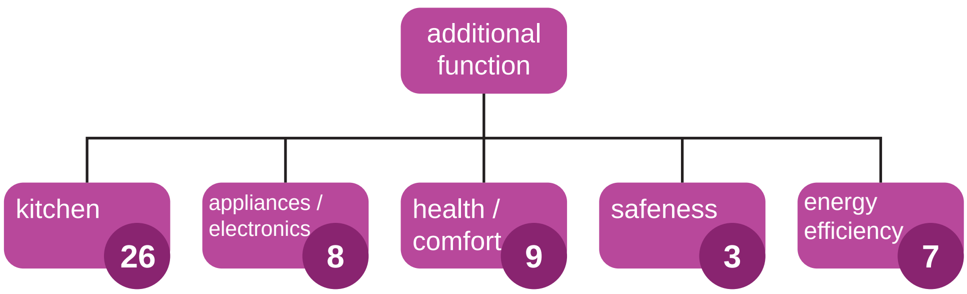

Figure 164. Branches of the theme of additional function

The Category of *Kitchen*

The category of *kitchen* presents various ideas in which the kettle has an additional function regarding the kitchen context such as heating food or heating milk in baby's bottle (Figure 165, 1).

The Category of *Appliances/Electronics*

The category of *appliances/electronics* presents ideas in which the kettle serves as an appliance or an electronic product other than for boiling the water such as night lamp, blender, or TV (Figure 165, 2).

The Category of *Health / Comfort*

The category of *health/comfort* includes ideas in which the kettle has an additional function concerned with the health or comfort of the user, such as humidifying the air or filtering water (Figure 165, 3).

The Category of *Safeness*

The category of *safeness* includes ideas in which the kettle has an additional feature in that considers the safety of the user, such as preventing burns (Figure 165, 4).

The Category of *Energy Efficiency*

The category of *energy efficiency* contains ideas in which the kettle has an additional feature that it is energy efficient, such as having two outer surface layers to keep the water warm for a longer time (Figure 165, 5).

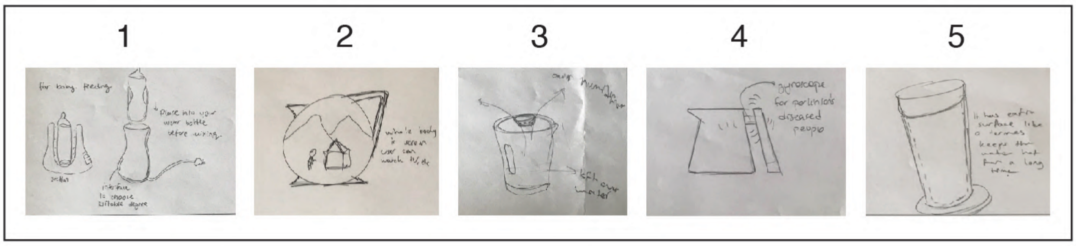

Figure 165. Sketch examples from the theme of additional function

An expanded version of the sketches within the theme of *additional function* can be seen in Appendix S.

7.2.5 Calculation of the Scores

7.2.5.1 Novelty Scores

After each idea was placed under relevant categories, the novelty scores of each idea group were calculated. In this respect, the assessment technique mentioned in Section 4.4.3.4.1 was used. The novelty scores of the themes of *form* and *interaction* were calculated considering the number of the ideas under that categories. However, the novelty scores of the themes of source and *additional function* were calculated considering all of the ideas since these ideas could be implemented to all of the design solutions. For example, the novelty score of the category *sharp* within the theme of *form* was calculated considering the number of the ideas under the theme of *form,* which was 1799. There were 10 ideas in the category of *sharp.* The novelty score of that category was calculated as (1799 – 10) x 10 / 1799 = 9,944. Besides, the novelty score of the category of *generator* within the theme of *source* was calculated considering the number of the whole ideas. There were 4 ideas in the category of *generator*. The novelty score of that category was calculated as (2539 – 4) x 10 / 2539 = 9,984. The novelty scores of each category were calculated in this way (Table 18).

Table 18. Novelty scores of the categories revealed from the Fictionation workshops

Form		Interaction		Source		Additional function	
body / wall	9,950	handheld	3,636	generator	9,984	kitchen	9,898
body / counter	9,983	tilting / by hand	9,846	solar panel	9,976	appliances/electronics	9,968
body / ground	9,972	tilting / by foot	9,969	battery	9,992	health/comfort	9,965
single body	8,116	wall	9,877	induction heater	9,965	safeness	9,988
multiple bodies	9,989	counter / single spout	9,784	USB	9,992	energy efficiency	9,972
partial transparent	9,728	counter / multiple spouts	9,969	fire	9,988		
fully transparent	9,894	ground / single spout	9,954	sun light	9,996		
sharp	9,944	ground / multiple spouts	9,969	steam	9,984		
slim	9,950	button / by foot	8,885	moisture	9,984		
short	9,967	pumping	9,954	snow	9,996		
lank	9,978	hole	9,753	rain	9,992		
same volumes	9,983	hinge	9,831				
different volumes	9,994	turning	9,969				
body / foldable	9,989	detachable	9,985				
body / elastic	9,978	waterline	9,923				
body / telescopic	9,994	on dock	9,584				
dock / wall	9,967	power	9,954				
dock / counter	9,972	button / heating level	9,923				
dock / single	7,593	on body	9,599				
dock / multiple	9,967	touchscreen	9,769				
dock / side	9,917	smart phone	9,861				
dock / surround	9,967	wheel / heating level	9,938				
handle / side	8,838	timer	9,985				
handle / top	9,911	voice	9,892				
downward	9,616	auditory	9,892				
upward	9,867	amount of water	9,569				
both sides	9,972	heat	9,908				
handle / multiple	9,911	water temperature	9,861				
angle	9,994	remaining time	9,954				
direction	9,961	weight	9,908				
handle / elastic	9,994						
handle / telescopic	9,994						
handle / detachable	9,983						
no handle	9,639						
spout / common	7,710						
long	9,889						
spout / multiple	9,939						
spout / detachable	9,989						

As it is seen in the Table, there are some categories that involve a great number of sketches and therefore have a lower score, such as dock/single, spout/common and handheld. On the other hand, there are some categories in which participants proposed less ideas and therefore have a higher score, such as snow, sun light, timer and detachable.

7.2.5.2 Variety Scores

Following the calculation of the novelty scores of each category, the variety scores were calculated. There were seven hierarchical levels in the total genealogy tree and the values for each level were determined as **30**, **20, 15, 10, 5, 2** and **1** respectively from the top to the bottom (Figure 166).

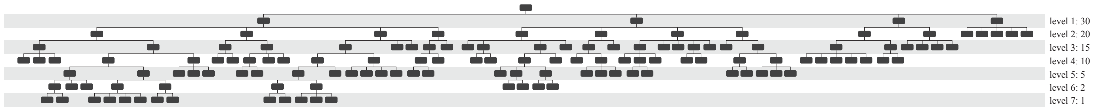

Figure 166. Values of each level of the tree diagram obtained from the Fictionation workshops

While there were four idea categories at the top level which has a value of 30, there were 15 at the second, 28 at the third, 34 at the fourth, 28 at the fifth, 11 at the sixth, and 13 at the seventh levels. As mentioned in Section 4.4.3.4.1, counting the branches at a hierarchical level, the number of the differentiations between branches, which is one less than the number of branches, was counted. In this respect, the variety score of the total solution space was calculated as:

(3 x **30**) + (14 x **20**) + (27 x **15**) + (33 x 10) + (27 x **5**) + (10 x **2**) + (12 x 1) = 1272.

While the themes of *form* and *interaction* have a greater variety by containing many categories beneath them, the themes of *source* and *additional function* have a low variety by having fewer categories beneath them.

7.2.5.3 Scores of the Participants

The novelty scores for each idea category were used for the calculation of the novelty scores of each participant. The novelty score of a participant is the average of the novelty scores of the ideas that are produced under different categories.

The variety scores of the participants were also calculated. In this respect, the categories in which the participant offered ideas were considered and divided into the variety score of the total genealogy tree, as implemented in section 7.1.4.2.

The novelty and variety scores of the participants were calculated by using Microsoft Excel that contains the number of the sketches offered by each participant within the pretest and posttest and the themes of form, interaction, source and additional function (Figure 167). For the purpose of making a comparison and meaningful inferences, the scores of the control and experiment groups and the pretest and posttests were calculated separately and the results are represented in Table 19.

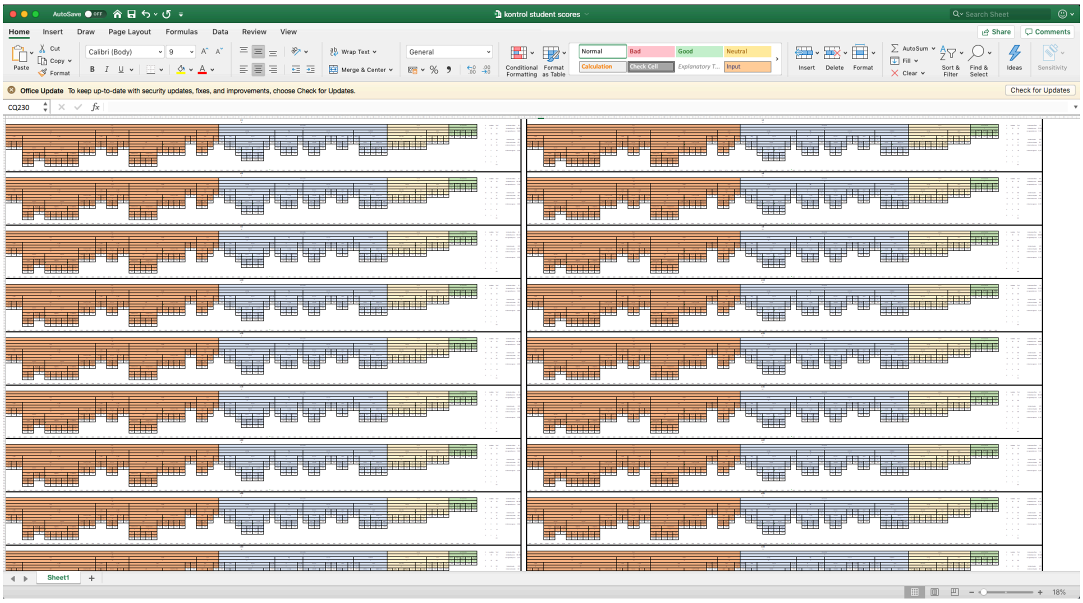

Figure 167. Screenshot of the Microsoft Excel document

Table 19. Novelty, variety and average scores of the participants of the Fictionation workshops

	Pretest					Posttest			
Control Group		**Novelty**	**Variety**	**Average**			**Novelty**	**Variety**	**Average**
	s1	7,733	3,719	5,726		s1	7,716	4,646	6,181
	s5	7,733	4,253	5,993		s5	7,580	4,843	6,212
	s6	7,684	3,373	5,529		s6	7,608	3,836	5,722
	s13	7,634	2,013	4,824		s13	7,520	2,822	5,171
	s15	8,088	4,017	6,053		s15	7,801	5,621	6,711
	s16	7,553	3,042	5,298		s16	7,467	4,733	6,100
	s22	7,604	1,981	4,793		s22	7,548	2,382	4,965
	s25	7,682	3,325	5,504		s25	7,655	4,182	5,919
	s33	7,771	3,160	5,466		s33	7,583	3,200	5,392
	s36	7,975	4,230	6,103		s36	7,627	4,701	6,164
	s41	7,972	4,929	6,451		s41	7,882	5,291	6,587
	s44	7,627	2,649	5,138		s44	7,413	2,649	5,031
	Average	7,755	3,391	5,573		**Average**	7,617	4,076	5,846

Table 19 (continued)

	Pretest					Posttest			
		Novelty	**Variety**	**Average**			**Novelty**	**Variety**	**Average**
Experiment Group	s3	8,266	4,434	6,350		s3	8,333	6,423	7,378
	s8	7,808	4,127	5,968		s8	7,983	5,283	6,633
	s9	7,377	2,940	5,159		s9	8,148	6,164	7,156
	s10	7,772	3,381	5,577		s10	7,987	4,858	6,423
	s11	7,423	2,704	5,064		s11	7,914	4,552	6,233
	s20	7,451	2,296	4,874		s20	8,031	5,731	6,881
	s21	7,569	3,593	5,581		s21	7,950	5,739	6,845
	s31	7,577	3,616	5,597		s31	7,821	5,228	6,525
	s34	7,896	4,497	6,197		s34	8,007	5,786	6,897
	s35	7,663	2,783	5,223		s35	7,877	4,678	6,278
	s39	7,688	3,695	5,692		s39	7,916	6,022	6,969
	s45	7,974	4,395	6,185		s45	8,110	6,093	7,102
	Average	7,705	3,538	5,554		**Average**	8,006	5,546	6,683

7.2.5.4 Distribution of the Scores

For achieving a result that shows the distribution of the success of the students, the normal distribution variable was calculated. The normal distribution is used to compare the scores of two or more groups. The result of this distribution presents a shape that is often referred to as the bell shape or the bell curve (Musselwhite & Wesolowski, 2018). The formula considers the mean value and the standard deviation of the related group. The calculation was conducted through Microsoft Excel and the results are presented in figures 168, 169 and 170.

Regarding the pretest-posttest results of the control group, while the success of the group (mean score) is increased from the score of 5,573 to 5,846, the standard deviation is also increased from 0,51649 to 0,59022 (Figure 168).

On the other hand, regarding the pretest-posttest results of the experiment group, while the success of the group (mean score) is increased from the score of 5,622 to 6,776, the standard deviation is decreased from 0,48157 to 0,36076 (Figure 169).

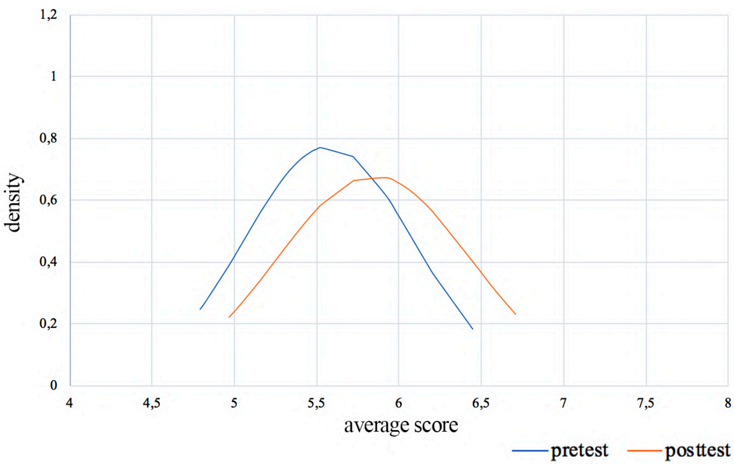

Figure 168. The normal distribution diagram of the control group

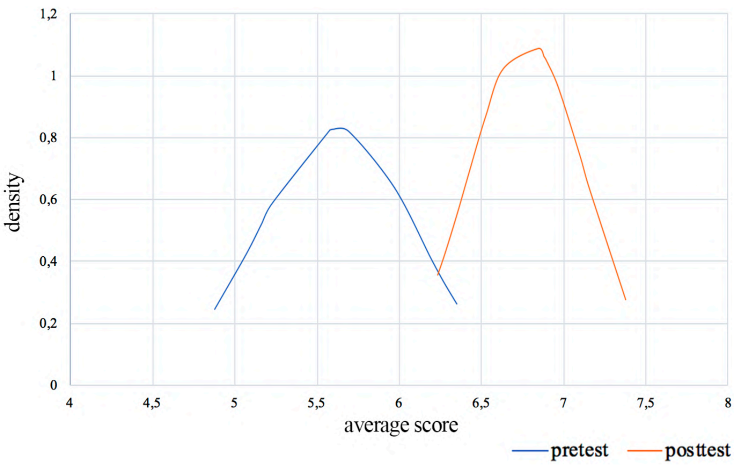

Figure 169. The normal distribution diagram of the experiment group

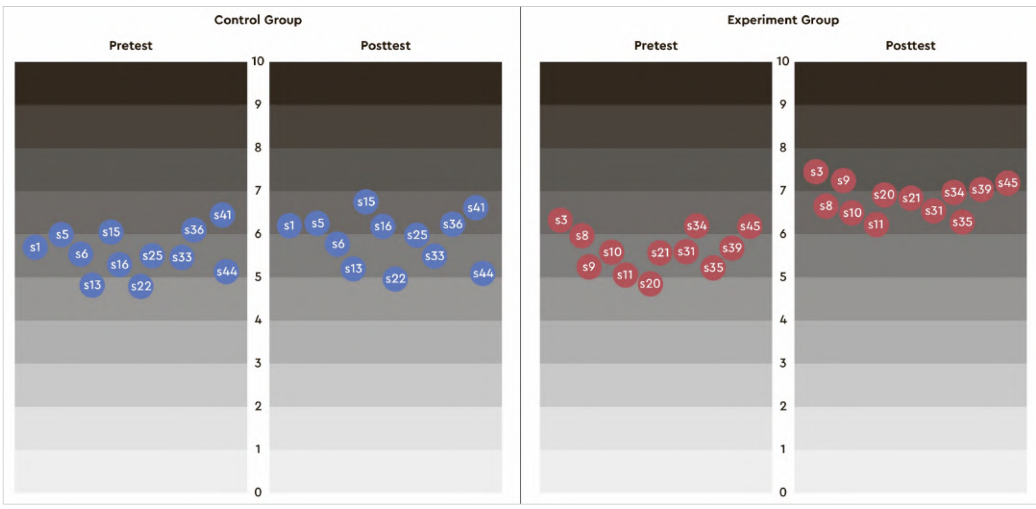

Figure 170. Representation of the pretest and posttest scores of the participants within the fictionation workshops

Up to this point, this chapter presented the implementation and the results of the Fictionation workshops. As it was mentioned in the previous chapters that focuses on previous studies, first a needs assessment study was conducted to investigate how students carry out their idea generation process in a studio project. Then the mediums of the Fictionation tool: cards and charts were developed and tested within a pilot study. After making revisions on the mediums of the Fictionation tool considering the results of the pilot study, the participants of the workshop were determined with a prior achievement analysis and finally the workshops were conducted, and the results were presented. In the following section, these results, together with the results of the interviews will be discussed and the Fictionation tool will be evaluated in terms of its usability, applicability and effectiveness.

7.3 Evaluation of the Fictionation Tool Considering Scores and Interview Results

According to Corremans (2011), having knowledge on the usability, applicability, and effectiveness of a chosen method is more important than having knowledge about various existing methods. Therefore, a proposed method or tool should be tested in order to measure its usability, applicability and effectiveness.

The usability of the Fictionation tool was evaluated through the observations that were performed during the workshops by the researcher, and interviews that were conducted following the workshops with the participants of the experiment group. The applicability of the Fictionation tool was evaluated through the interviews conducted with the participants of the experiment group. Besides, the effectiveness of the Fictionation tool was measured through the interviews and some statistical analyses of collected data that aimed to compare the obtained scores of the generated ideas of the control and experiment groups.

7.3.1 Usability of the Fictionation Tool

The usability of the tool was evaluated based on the observations that were performed during the workshops by the researcher, and the opinions declared by the participants during the interviews that were conducted following the workshops.

During the observations, it was seen that,

- Participants did not encounter any critical problem and performed the tasks smoothly.
- Both the participants of the control and experiment groups had problems in generating new ideas after the 5th or 6th sketches during phase 1.
- Participants did not ask any questions regarding the texts on the cards.
- Participants had fun and performed the tasks cozily.

During the interviews, participants declared opinions regarding the process, cards, and charts. Regarding the process,

- All of the participants evaluated the process as clear and understandable.
  "*The process was very clear; I did not encounter any difficulties throughout the workshop*."
- One participant indicated that in phase 2 (design for divergence), the allocated 5 minutes for each card created a pressure on them, but that situation caused the creation of many ideas.
  "*The time limitation within phase 2 created a pressure on me. But within the next phase I realized that, the pressure made me generate more ideas*."
- Eight participants indicated that they liked the process and the flow of tasks.
  "*The flow of tasks was very reasonable in terms of thinking in a broader way first, and then narrowing and developing ideas further*."
- None of participants indicated that they had encountered any problems.
- Seven participants indicated that they had fun.
  "*It was a cheerful process, as you see we laughed many times*."
- Two participants evaluated the individual tasks involved in the procedure as cumulatively progressing.

"*The individual part of the workshop progressed more cumulatively than the group part*."

- One participant evaluated the teamwork task involved in the procedure as entertaining but challenging in terms of developing someone else's idea.

  "*The group part was entertaining, you can see the nonsense ideas of your friends (laughing), but it was also challenging in terms of developing these ideas*."

- None of the participants indicated any negative comment regarding the process.

Regarding the cards,

- All of the participants evaluated the design of the cards as very successful and neat.

  "*The design of the cards was very professional. The font and bold parts were effective. I first thought that these cards were available in the market, but I was surprised when I learnt that you made them*."

- All of the participants evaluated the texts on the cards as neat and understandable.

  "*I did not have any difficulties in understanding the texts on the cards*."

- Six participants indicated that the what-if scenarios that were written on the cards were well chosen and sensible.

  "*The what-if scenarios were sensible; they really reflect our constraints within the process. The gravity scenario was interesting. Yes, it is always there but we ignore it*."

- Five participants indicated that the typeface that were used on the cards was easy to read.

  "*The selection of font for the text was successful. Although the text size is small, the font selection made it easy to read*."

- Ten participants evaluated the bold written texts on the cards as helpful in understanding the texts easily.

  "*The bold written texts ease the understanding process. After reading a couple of cards, I did not read the whole text. I just looked at the bold text* *and the indication of form, function, or interaction. It was enough to understand the scenario*."

- Nine participants indicated that because of the availability of many cards, they did not have any problem in choosing from among them.

  "*There were lots of cards. Therefore, I did not have difficulty in selecting eight cards to work on*."
- Three participants indicated that when they first looked at the cards, the what-if scenarios instantly helped them to create some visualizations in their minds. This situation helped in the process of choosing eight cards.

  "*... after all, when I looked at the cards, and read the texts, some visualizations instantly formed in my mind. I chose the cards in this way*."
- None of the participants indicated any negative comment regarding the cards.

Regarding the charts,

- Nine of the participants evaluated the size of the charts as appropriate to make sketches on.

  "*A3 size is very suitable. It is big enough to make sketches on, and it is small enough not to occupy a place on table*."
- All of the participants indicated that the size of the cells was big enough to make sketches in.

  "*The size of the cells was enough to make sketches in. Therefore, there is no need to enlarge the A3 size*."
- While five participants indicated that the number of the ideas that were expected from them was reasonable within the allocated time, one of them indicated that it was excessive.

  "*The allocated time was enough to make that number of sketches.*"

  "*I sweated to generate that number of ideas in such time. It was a little excessive*."

In the light of this information, it can be stated that, the usability of the of the Fictionation tool was smooth and joyous. The process, the design of the cards and charts were neat.

7.3.2 Applicability of the Fictionation Tool

The applicability of the tool was evaluated considering the opinions of the participants that they have declared during the interviews.

- Ten participants stated that it would be beneficial to use the tool in the design process.
  "*The Fictionation tool would be very beneficial for the design process*."
- Nine participants stated that, the tool could be used in the studio projects.
  "*I would definitely utilize the tool in our studio projects*."
- Three participants indicated that, it would be necessary to know about the market and user of the product that will be designed before using the tool therefore, it would be more appropriate to use the tool after the research phase of the design process.
  "*I think, you should have knowledge on the market and the user in order to utilize the tool. In that way you can get the best out of it.*"
- Seven participants stated that the Fictionation tool could be used in the idea generation phase.
  "*It can be utilized in the idea generation phase, while generating ideas*."
- Four participants stated that it would be appropriate to use the tool after generating some ideas.
  "*I think some ideas should be generated before the utilization of the tool as we did today. The tool is helpful when we run out of ideas*."

In the light of this information, the Fictionation tool was found applicable to the design process. Furthermore, it was suggested that, it would be appropriate to use the tool after making research and generating some ideas.

7.3.3 Effectiveness of the Fictionation Tool in terms of Idea Generation

The effectiveness of the Fictionation tool was measured through the interviews and some statistical analyses of collected data that aimed to compare the obtained scores of the generated ideas of the control and experiment groups.

During the interviews, participants declared opinions regarding the effectiveness of the tool.

- All of the participants evaluated the tool as beneficial for generating novel ideas.

  "*I think, it (Fictionation tool) helped me to generate novel ideas. Even though the design problem was as simple as designing a kettle, I believe I generated many novel ideas*."
- Eight participants indicated that the tool helped them to look from a new perspective.

  "*In the first phase I know that I generated ordinary ideas. But through the utilization of the tool, I generated different solutions. It helped me to look from a different perspective*."
- Four participants evaluated the tool as beneficial for removing the constraints in their minds during the idea generation process.

  "*I realized that I consider the issues such as cost, producibility, and materials too much. Without considering them, I obtained more creative ideas*."
- Two participants stated that it was constantly asked from them to generate novel ideas within the studio projects. This tool would be a guide for them to actualize that request.

  "*In the studio, instructors always demand us to generate novel ideas. We did not know how to do it. This tool might be a solution to it*."
- Seven participants evaluated the tool as helpful in thinking in a freer way.

  "*Without the constraints, we are able to think in a freer way and become more creative*."
- One participant stated that the tool was helpful for adding some additional functions to the products that could not be thought of before.

  "*... besides, the tool is helpful in adding some additional function to the product. In our projects, we always try to do it, but did not know how. Now, I can use this tool for that purpose*."
- Six participants evaluated the tool as helpful in branching and diversifying the ideas.

> "*It (Fictionation tool) helps to generate diversified ideas by considering different scenarios*."

The effectiveness of the tool was also measured by comparing the scores of the generated ideas of the control and experiment groups. As mentioned in Section 4.4.3.1, the workshop process was divided into two sessions in which the control group generated ideas on their own in two different sessions, and the experiment group generated ideas on their own in session 1 and use the Fictionation tool in session 2. As Tovey et al. (2003) and Goldschmidt (1994) stated, making sketches leads to new ideas. If the workshop process was not divided into two sessions, it would not be possible to argue whether the results were obtained through the effect of the Fictionation tool or due to the successive generation of sketches. The aim of the Fictionation tool was to expand the design solution space by increasing the quantity, variety and novelty of the generated ideas and eliminating fixation. In this context, separating the workshop process into two sessions and comparing the results allowed to examine whether generating new ideas enabled quantity, variety and novelty in ideas, or whether it was the Fictionation tool that enabled this. The difference between the pretest and posttest results of the control group was expected to show the effect of the situation in which generating ideas leads to new ideas. Besides, the difference between the pretest and posttest results of the experiment group was expected to show both the previously mentioned situation and the effect of the Fictionation tool.

To see if there is a meaningful difference between the pretest and posttest results of each group, a Paired-Samples T Test was performed by using IBM SPSS Statistics. First, the pretest and posttest results of the control group (average scores that were presented in Table 19) were compared and the results are presented in Table 20. Then, the pretest and posttest results of the experiment group (average scores that were presented in Table 19) were compared and the results are presented in Table 21.

Table 20. T test results of the control group

Paired Samples Statistics

	Mean	N	Std. Deviation	Std. Error Mean
pretest	5.5732	12	.51649	.14910
posttest	5.8463	12	.59022	.17038

Paired Samples Correlations

	N	Correlation	Sig.
pretest & posttest	12	.962	.000

Paired Samples Test

	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
				Lower	Upper			
pretest - posttest	-.27308	.16913	.04882	-.38055	-.16562	-5.593	11	.000

Table 21. T test results of the experiment group

Paired Samples Statistics

	Mean	N	Std. Deviation	Std. Error Mean
pretest	5.6223	12	.48157	.13902
posttest	6.7767	12	.36076	.10414

Paired Samples Correlations

	N	Correlation	Sig.
pretest & posttest	12	.975	.000

Paired Samples Test

	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
				Lower	Upper			
pretest - posttest	-1.15442	.15256	.04404	-1.25135	-1.05749	-26.213	11	.000

When the results are examined, since the Sig. (2-tailed) values are below 0.05 in both cases, it can be said that there are meaningful differences between the results of both the control and experiment groups. Therefore, both the argument of making sketches leads to new ideas and the Fictionation tool created a difference for the ideas that were generated within session 2. When an effect exists, to see how big the effect is, a calculation that measures the effect size offered by Cohen (1988) can be performed. This measurement is named Cohen's *d* and it divides the difference of means to the pooled standard deviations. It is calculated using the following formula: $(M_2 - M_1) / \sqrt{((SD_1^2 + SD_2^2)/2)}$. When this formula is applied to the results of the control group, the score of $(5{,}5732 - 5{,}8463) / \sqrt{((0{,}51649^2 + 0{,}59022^2) / 2)} = -0{,}49244$ is obtained. Besides when the formula is applied to the results of the experiment group, the score of $(5{,}6223 – 6{,}7767) / \sqrt{((0{,}48157^2 + 0{,}36076^2) / 2)} = -2{,}71312$ is obtained.

Regarding the interpretation of these results, Cohen (1988) suggested some benchmarks: if *d* is smaller than 0,2 the effect is interpreted as small, if *d* is between 0,2 and 0,8 the effect is interpreted as medium, and id *d* is larger than 0,8 the effect is interpreted as large. When the results are interpreted considering these benchmarks, the effect size of the control group, which was the case of *making sketches leads to new ideas,* can be interpreted as a medium effect. On the other hand, the effect size of the experiment group, which was the case of both *making sketches leads to new ideas* and *implementation of the Fictionation tool*, can be interpreted as a quite large effect. In the light of this information, it can be said that, the Fictionation tool created a big effect on the generated ideas of the students. Since the mean score of the session 2 is bigger than 1, the effect is positive.

Apart from indicating that the Fictionation tool created a big effect on the generated ideas, it would be useful to investigate whether the tool has fulfilled its aims. As mentioned before, the aim of the Fictionation tool was to expand the design solution space by increasing the quantity, variety and novelty of the generated ideas and eliminating fixation.

7.3.3.1 Effect of the Fictionation Tool on the Design Solution Space

In order to see the effect of the Fictionation tool on the design solution space, a solution space visualization was prepared as it was done for the prior achievement analysis presented in Section 7.1.5. In this visual, the numbers represent the number of sketches that took place in a category. The more sketches are included in a category, the bigger the size of that corresponding node is, and the closer it is to the center of the solution space. The nodes that are close to the outer borders of the solution space represent less studied ideas which are novel. The top image in Figure 171 presents the nodes with their connections to other nodes as it was done within the genealogy tree, and the bottom image in the figure presented the nodes without the connections placed within layers, which is a more suitable way to show the solution space.

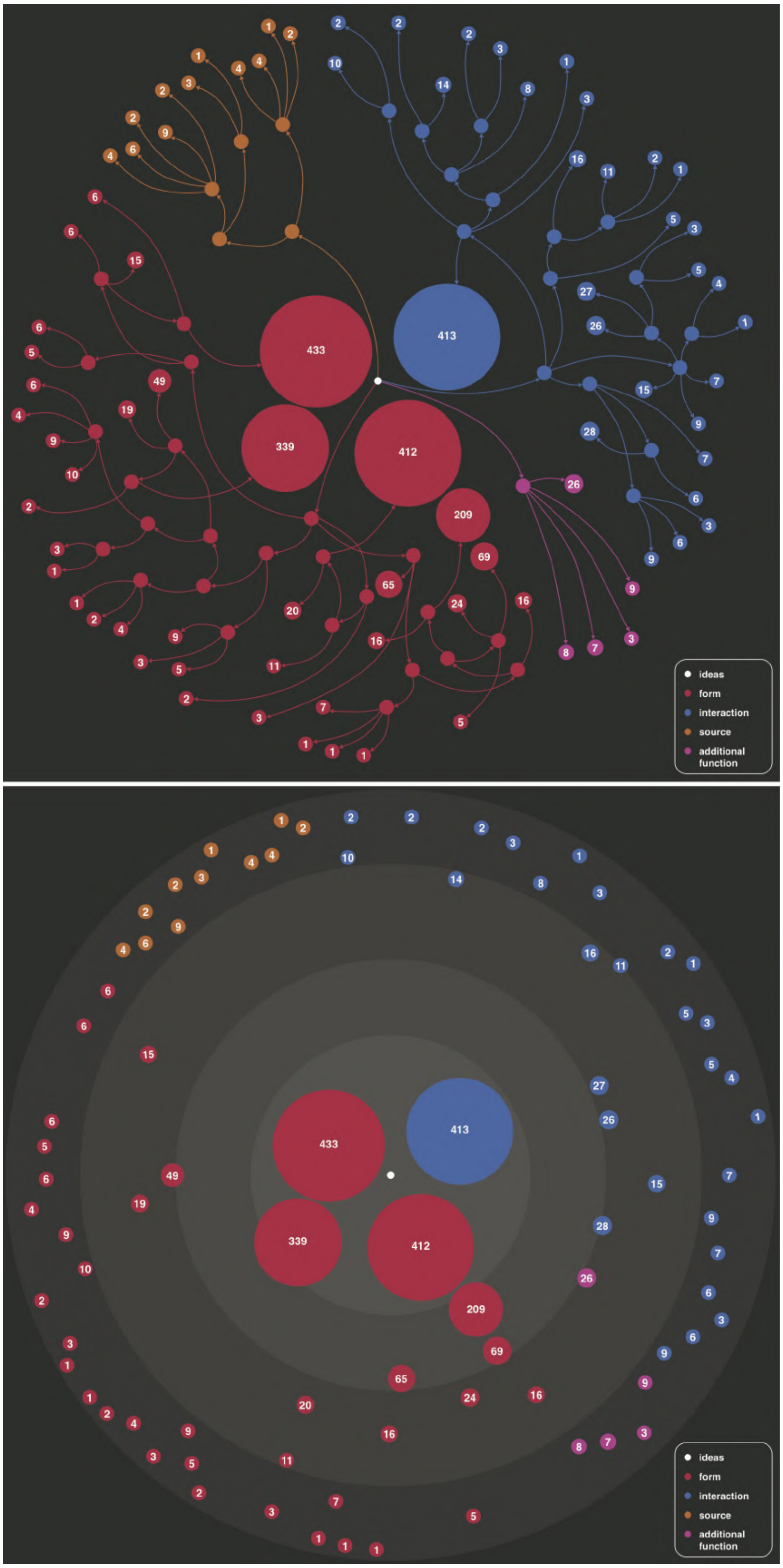

Figure 171. Solution space visualization of the workshop. Top: Nodes with their connections to other nodes. Bottom: Nodes without the connections

Once the solution space was acquired, it was adapted to the sessions of the control and experiment groups. While Figure 172 presents the alteration of the solution spaces between the pretest and posttest within the control group, Figure 173 presents the alteration of the solution spaces between the pretest and posttest within the experiment group.

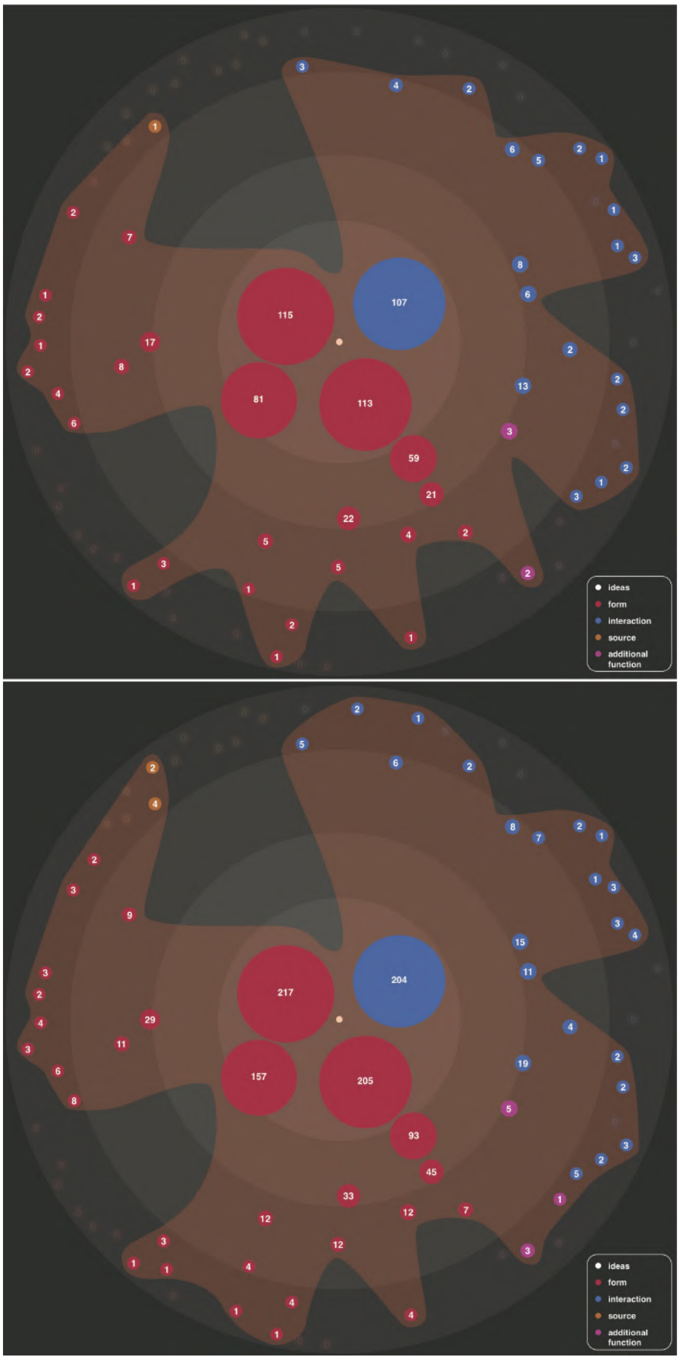

Figure 172. The alteration of the solution spaces between the pretest and posttest within the control group. Top: The solution space of the pretest. Bottom: The solution space of the posttest

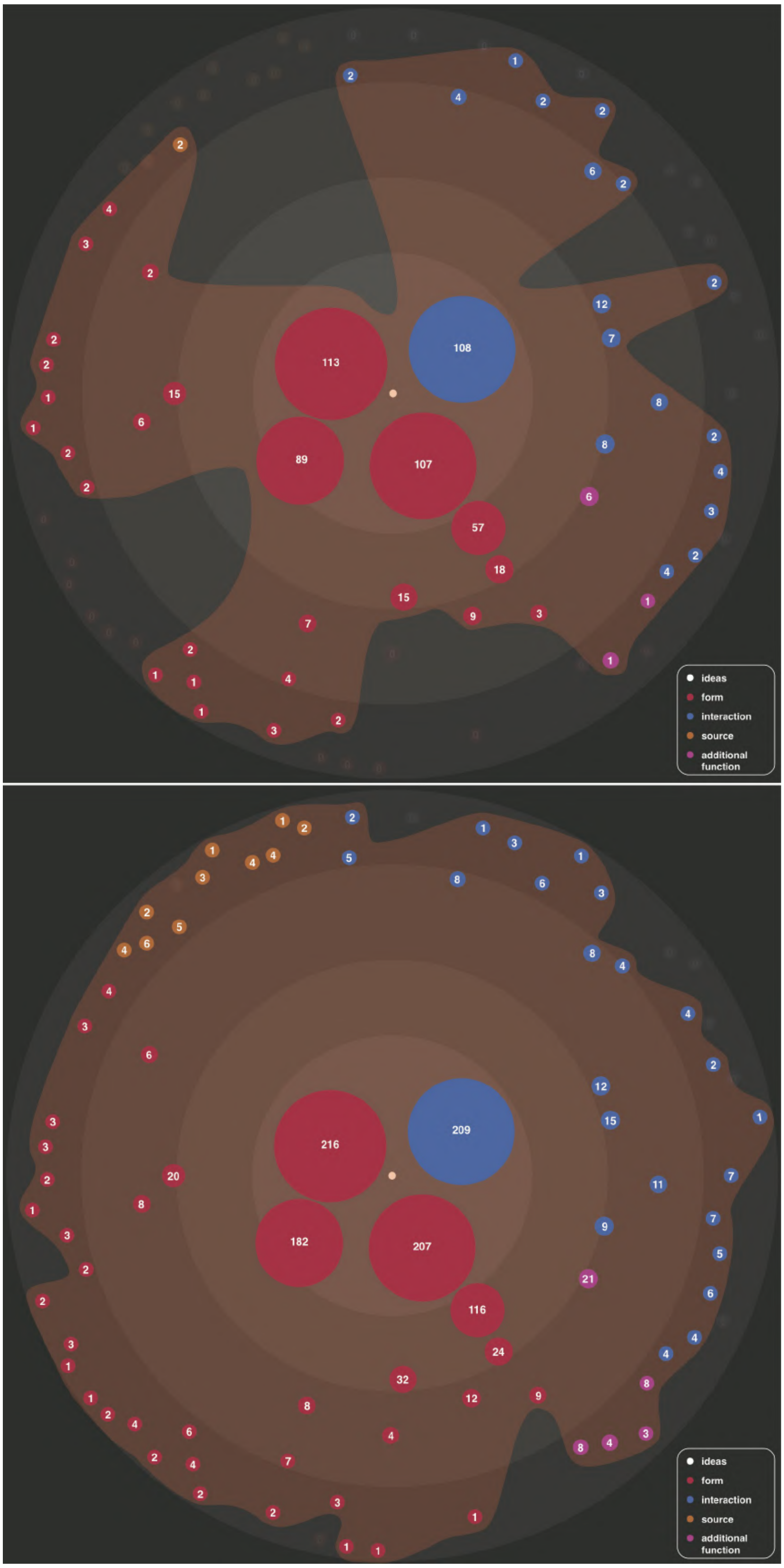

Figure 173. The alteration of the solution spaces between the pretest and posttest within the experiment group. Top: The solution space of the pretest. Bottom: The solution space of the posttest

The representations indicate that, while there is a slight enlargement in the solution space of the control group, there is a quite large enlargement in the solution space of the experiment group. Therefore, it can be said that the Fictionation tool has achieved its aim of expanding the design solution space.

7.3.3.2 Effect of the Fictionation Tool on Quantity and Fixation

Increasing quantity and eliminating fixation were the other aims of the Fictionation tool. Within the control group, even though the number of offered sketches were equal among session 1 and session 2, the valid sketches, which were obtained after eliminating similar ideas, decreased from 134 to 112 (Table 22).

Table 22. Valid sketches among the participants of the control group

	Phase 1			**Phase 2**		
		Number of Sketches	**Valid Sketches**		**Number of Sketches**	**Valid Sketches**
Control Group	s1	16	11	s1	16	9
	s5	16	8	s5	16	4
	s6	16	10	s6	16	5
	s13	16	13	s13	16	12
	s15	16	14	s15	16	15
	s16	16	13	s16	16	9
	s22	16	9	s22	16	6
	s25	16	11	s25	16	11
	s33	16	13	s33	16	12
	s36	16	7	s36	16	8
	s41	16	15	s41	16	9
	s44	16	10	s44	16	12
	Total	192	134	**Total**	192	112

On the other hand, within the experiment group, even though the number of offered sketches were equal among session 1 and session 2, which were 192, the valid sketches increased from 129 to 150 (Table 23). Therefore, it can be said that, one of the aims of the Fictionation tool, which was increasing quantity, was achieved. Furthermore, as mentioned before, fixation can occur as a result of either becoming attached to an early idea during idea generation and stopping to look for other alternatives, or becoming attached to existing products that causes designers to propose similar alternatives (Christian et al., 2012; Kavakli et al., 1998; Linsey et al., 2010; Ullman et al., 1988). Both situations cause offering similar ideas. While this situation is visible within the control group, since the number of the valid ideas decreased, it is eliminated within the experiment group, since the number of the valid ideas increased.

Table 23. Valid sketches among the participants of the experiment group

	Phase 1				Phase 3		
Experiment Group		**Number of Sketches**	**Valid Sketches**			**Number of Sketches**	**Valid Sketches**
	s3	16	10		s3	16	12
	s8	16	14		s8	16	14
	s9	16	11		s9	16	14
	s10	16	11		s10	16	12
	s11	16	10		s11	16	15
	s20	16	13		s20	16	15
	s21	16	8		s21	16	14
	s31	16	13		s31	16	12
	s34	16	10		s34	16	10
	s35	16	8		s35	16	9
	s39	16	10		s39	16	12
	s45	16	11		s45	16	11
	Total	192	129		**Total**	192	150

7.3.3.3 Effect of the Fictionation Tool on Novelty

A critical aspect for the success of an idea generation process is novelty. While some ideas in the design solution space are obvious and can be thought of quickly by most of the people, novel ideas are less obvious and require more time and effort to surface. These novel ideas ensure the enlargement of the boundaries of the design solution space through creating new areas to work on (Christian et al., 2012; Daly et al., 2016).

As it seen in figures 168 and 169, while the solution space of the control group is slightly enlarged, the solution space of the experiment group enlarged greatly, due to the generation of novel ideas that are situated at the boundaries of the solution space. Besides, when the results in Table 19 are considered, while the novelty score of the control group decreased from 7,755 to 7,617 within pretest and posttest, the novelty score of the experiment group increased from 7,705 to 8,006 within pretest and posttest. These results show that the control group generated more obvious ideas within the second session and this situation resulted in the decrease of the novelty score. Fixation might be the reason of this situation as it caused repeating the same solutions that were generated in the first session. On the other hand, the experiment group generated more in number less obvious ideas and this situation resulted in the increase of the novelty score. Therefore, it can be said that, Fictionation tool achieved its aim of increasing the novelty of the generated ideas.

The increase in the novelty score might be seen as a minor increase as it has increased only 3,9 %. However, it should be considered that many of the generated ideas in the second session still belong to the categories of obvious ideas (103 ideas belong to the category of *dock-single* that has a novelty score of 7,593; 100 ideas belong to the category of *spout-common* that has a novelty score of 7,710; 101 ideas belong to the category of *handheld* that has a novelty score of 3,636). These ideas are the ones that repress the increase of the novelty score. For example, the idea that is presented in Figure 174 offers a novel solution for the security of the patients with the Parkinson's disease by offering to attach a gyroscope to the handle part that prevents the swing of the kettle. During the idea categorization process, the sketches for this idea was placed under the category of *additional function-safeness*, as well as the categories of *handheld*, *spout-common*, *handle-downward*, and *body-single body*. Despite of being a novel idea, the characteristics that it presents led to it being a part of the categories that consist of obvious ideas. Even though being novel, such examples increased the number of obvious ideas and thus affecting the novelty score negatively. Therefore, it is not because there were few novel ideas generated in the second session, it is because of that situation as the novelty score showed a minor increase instead of a remarkable amount. While there were 55 ideas placed under the categories with a novelty score higher than 9,900 within the first session of the control group, there were again 55 ideas in this situation in the second session. On the other hand, while there were 50 ideas that were placed under the categories with a novelty score higher than 9,900 within the first session of the experiment group, there were 111 ideas in this situation in the second session. Besides the increase in the novelty score, this situation presents the success of the Fictionation tool in fostering novelty.

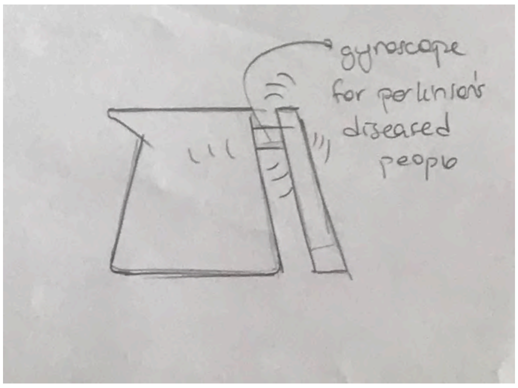

Figure 174. A novel idea for the patients with the Parkinson's disease

7.3.3.4 Effect of the Fictionation Tool on Variety

When the genealogy trees of the control group were investigated, eight new categories (one within the second hierarchical level, two within the third hierarchical level, two within the fourth hierarchical level, one within the fifth hierarchical level, and two within the sixth hierarchical level) were generated within the posttest compared with the pretest (Figure 175). This led to an increase in the average of the variety scores of the students from 3,391 to 4,076 within pretest and posttest results (Table 19).

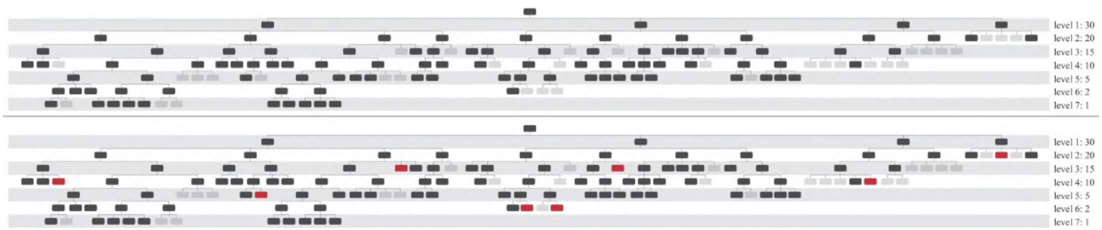

Figure 175. The genealogy trees of the pretest and posttest within the control group. Top: The genealogy tree of the pretest. Bottom: The genealogy tree of the posttest

Furthermore, when the genealogy trees of the experiment group were investigated 27 new categories (two within the second hierarchical level, seven within the third hierarchical level, eight within the fourth hierarchical level, five within the fifth hierarchical level, one within the sixth hierarchical level, and four within the seventh hierarchical level) were generated within the posttest compared with the pretest

(Figure 176). This led to an increase in the average of the variety scores of the students from 3,538 to 5,546 within pretest and posttest results (Table 19).

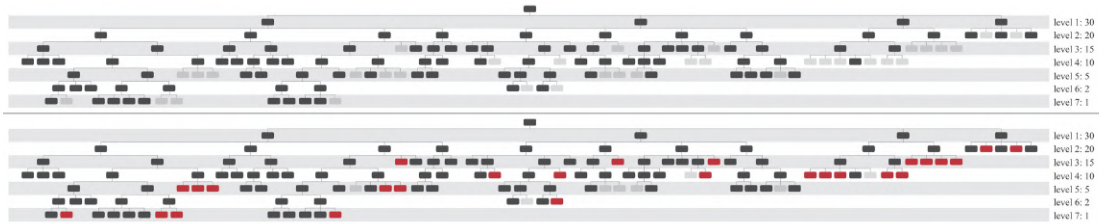

Figure 176. The genealogy trees of the pretest and posttest within the experiment group. Top: The genealogy tree of the pretest. Bottom: The genealogy tree of the posttest

While the average of the variety scores of the students of the control group increases 20,2%, the average of the variety scores of the students of the experiment group increases 56,7%. Besides, apart from evaluating the individual variety scores, when the group variety score, which is the combination of all ideas of the members of the group, is investigated, the variety score of the control group increases from 6,926 to 7,586 within pretest and posttest results, and the variety score of the experiment group increases from 7,131 to 9,631 within pretest and posttest results, which means a 9,5% increase within the control group and a 35% increase within the experiment group.

The results show that, the variety scores of both groups were increased. This might be the result of the arguments of Tovey et al. (2003) and Goldschmidt (1994) that argue that making sketches leads to new ideas. As the participants of both groups generated ideas and made sketches, new ideas came to their minds and that situation created an increase in the variety of the ideas between pretest and posttest results. However, when the results of both groups were compared, it is obvious that the variety score of the experiment group increased far more than the variety score of the control group. Therefore, it can be said that the Fictionation tool enabled this situation by fostering the variety of the generated ideas.

CHAPTER 8

CONCLUSION

This thesis explores the idea generation process of design students through a study that aimed to offer a strategy towards expanding the design solution space by increasing the quantity, variety, and novelty of the generated ideas and eliminating fixation. For this end, the thesis offers the integration of design fiction into the idea generation process, a design tool (Fictionation) so as to produce various and novel ideas, and an assessment technique to measure the effectiveness of the idea generation process and proposed design methods and tools. In order to enable these contributions, this thesis has searched answers to the following research questions:

Main research question:

> How can the performance of design students in terms of design divergence and novelty be increased during the idea generation process?

Sub-questions:

1. What are the needs of design students in terms of guidance and support in fostering the outcomes of the idea generation process?
2. What are the various design tools and methods available to be used in design education? What are their limitations and strengths?
3. How can the performance of design students in terms of quantity, novelty and variety be assessed?
4. To what extent does the Fictionation design tool affect the quantity, novelty and variety scores of design students?
5. In which ways does the Fictionation design tool affect the idea generation process and design education?

This concluding chapter will discuss the contribution of the thesis to the literature by revisiting the research questions. In order to maintain the flow of information, the research questions will be answered in a mixed order. Later, this chapter will reveal the position of this study within the design literature and its contributions together with its limitations and suggestions for future studies.

8.1 Revisiting the Research Questions

8.1.1 Needs of Design Students within the Idea Generation Process (Sub-Question 1)

In order to offer a strategy for the purpose of fostering the outcomes of the idea generation process, first the requirements of the idea generation process and the needs of the design students should be determined.

As it was mentioned by many researchers, idea generation is one of the most important phases of the design process by having the highest impact on the quality of the final design solution (Corremans, 2011; Christian et al., 2012; Shroyer et al., 2018). Without reaching a desirable outcome as a result of the idea generation phase, the remaining phases would be built upon a weak base.

The idea generation phase demands from designers to generate as many design alternatives as possible in a divergent manner (Aspelund, 2014; Baxter, 1995; Corremans, 2011; Lawson, 2005; Liu et al., 2003; Shah et al., 2003). Meaning that, designers should generate many design solutions without being critical in order to create a diverse pool of alternatives. In the following phases of the design process, these alternatives would be evaluated and one or more of them selected to develop further. In order to increase the chance to reach a better design solution, besides being outnumbering, the generated ideas should be different from each other and novel (Christian et al., 2012; Shah et al., 2003; Saunders & Pourmohamadi, 2009).

In the light of this information, it can be deduced that design students should generate many design solutions that are diversified and novel within the idea generation process. Therefore, the aim of fostering the outcomes of the idea generation process of design students should focus on ensuring design divergence and novelty.

Furthermore, the results of the observation and peer debriefing sessions conducted within the first study of this research show that design students are having difficulties in generating various and novel ideas during the idea generation process. Based on the expressions of the students and discussions made with the colleagues within the peer debriefing sessions, it was determined that the mentioned difficulties originates from the concern of the students about the further steps of the design process as they restrict themselves with considerations such as production, cost and material constraints.

In order to ensure guidance and support for design students in fostering the outcomes of the idea generation process in terms of design divergence and novelty, and eliminating the restriction that they put to themselves, design methods and tools can be the solution. There are various design methods and tools and the next research question addresses this issue by examining their limitations and strengths.

8.1.2 Examination of Design Methods and Tools (Sub-Question 2)

Design methods and tools are guides, plan of actions and ways of working to aid the design activity and to overcome design problems (Cross, 2008; Goldschmidt, 1994; Tovey et al., 2003; Wallace, 2011). While a design method may consist of various procedures, techniques, aids, and tools, a design tool may have the potential to become a design method on its own (Haritaipan, 2019; Roy & Warren, 2019; Wölfel & Merritt, 2013; Yoon, Desmet & Pohlmeyer, 2016).

Design methods can be classified into two categories: creative methods and rational methods. They are not completely different from each other. In fact, they both aim to foster creativity and offer ways of working to reach better outcomes. The difference of them is their approaches. While creative methods are more freewheeling compared to rational methods, rational methods adopt a more systematic approach (Aurum & Gardiner, 2003; Cross, 2008; Gonçalves et al., 2014; Shroyer et al., 2018; Wright, 1998).

The creation of design methods and design tools dates back to the mid-20th century. However, with the beginning of the 21st century, a tremendous increase in the development of design tools occurred. Almost 90% of the design tools are card-based design tools, as they are simple, tangible, and easy to use (Haritaipan, 2019; Roy & Warren, 2019; Wöfel & Merritt, 2013). Design tools can be classified into two categories: idea triggering design tools and guiding design tools. Design tools can be associated with rational design methods as they bring a systematic approach and mediums to the process. Likewise, guiding design tools can be associated with rational methods as they provide directions by offering methods, checklists or giving information, whereas idea triggering design tools can be associated with the creative methods as they encourage novelty.

Idea triggering design tools can be categorized considering their context, as they offer random triggers, context related triggers or instructions. On the other hand, guiding design tools can be categorized considering their context as well, as they offer tactics, checklists or information regarding the design process.

The availability of all these methods and tools are beneficial for design students since they guide and provide tactics to students within the design process. However, most of them have never been tested experimentally in terms of outcomes. Instead, they were evaluated qualitatively by asking participants whether they have benefitted from them or not. However, because of the complexity and ill-structured nature of design issues, it is hard to express and evaluate the outcomes in words (Dorst & Reymen, 2004). Therefore, it is not possible to claim whether the design methods and tools are beneficial or not in terms of outcomes (Haritaipan, 2019; Roy & Warren, 2019). This situation has caused a lack of methodology that experimentally tests the outcomes of an idea generation process and provides comparable results.

Furthermore, Kris (2000) argues that existing design tools provide already existing triggers such as objects, living creatures, and emotions, or provide easily applicable instructions that can be applied by the designer without the utilization of the tool. However, based on cognitive studies, creative thinking should be supported with illogical thinking such as dreams and fantasy instead of existing things (Haritaipan, 2019; Kris, 2000). In the light of this information, in order to ensure guidance and support for design students in fostering the outcomes of the idea generation process in terms of design divergence and novelty, and eliminating the restriction that they put to themselves, a card-based design tool supporting illogical thinking was offered as a response to the main research question.

8.1.3 Fictionation: Proposed Design Tool (Main Research Question)

The answers of the previous two research questions, together with the literature review enabled a convenient foundation for the development and proposal of a design tool that could increase the performance of design students in terms of design divergence and novelty during the idea generation process. In this section, firstly the characteristic of the Fictionation tool will be summarized, then it will be compared with the other design tools.

8.1.3.1 Characteristics of the Fictionation Tool

Considering the needs of the design students and requirements of the idea generation process and creative thinking, design fiction was determined as a potential solution. The idea was that, the feature of design fiction that enables the creation of a fictional, unreal and conceptual world where there are no industrial production or marketplace constraints would enable the design students to explore new ideas and possibilities. In this respect, the what-if scenarios of design fiction were used. The aim was to trigger creative thinking and support students in overcoming restricting considerations by creating a fictional world where they can explore, produce and develop different than they do in the real world.

In this respect, the main issues considered by the students during the idea generation process were determined within the peer debriefing sessions. These considerations were transformed in the format of what-if questions. Furthermore, in order to increase the diversity, the contexts of form, function and interaction were added to the questions (Table 7). As the preliminary version of the Fictionation tool, 30 cards (10 what-if scenarios x 3 (form, function, interaction)) were prepared (Figure 72). These cards constituted 30 different scenarios in which students can think and design in a conceptual world. Furthermore, in order to document the ideas and systematize the process, charts were prepared (Figures 74, 75, 76).

The tool was initially tried out with a pilot study, and the deficiencies of the tool regarding the procedure and mediums were revised. A new what-if scenario was added to the card deck and the charts were redesigned according to the change in the number of expected ideas within the process (Figures 82, 83, 84). At the end there were 33 cards (11 what-if scenarios x 3 (form, function, interaction)) (see Appendix E).

The revised version of the tool was tested within a quasi-experimental study that contained a control and an experiment group. The results of this study showed that, both the design divergence and novelty of the students increased within the idea generation process. As it was determined within the literature review, using cards as the medium of the tool ease the process for students. Furthermore, integrating design fiction into idea generation brought successful results in terms of enabling creative and illogical thinking. Therefore, the Fictionation design tool can be considered as a successful tool in increasing the performance of design students in terms of design divergence and novelty during the idea generation process.

8.1.3.2 Comparison of the Fictionation Tool with the Other Design Tools

Firstly, it should be clarified that the Fictionation tool can be positioned in between creative methods and rational methods: the tool is a creative method since it adopts a freewheeling process in which participants are free to think and generate whatever they want. In other respects, the tool is also a rational method since it brings a systematic approach to the idea generation process by following a procedure, involving cards that contain prompts, and charts that are adequate to make sketches on.

Since available methods and tools have not been experimentally tested, as mentioned in Section 2.5, it is not possible to compare the Fictionation tool with the others based on design outcomes. In this respect, further studies are needed. However, they can be compared by considering their mediums, procedure and thinking styles.

It should be clarified that, Fictionation is an idea triggering design tool; therefore, it should be compared with the tools in that category. With regard to mediums,

- Fictionation includes random prompts that are determined following several studies. These prompts include phrases related with form, function and interaction, which are the issues of every design problem. Due to this characteristic of Fictionation, it can be utilized in any kind of design projects that contains a product, system or service.
- Contrary to the prompts of the available methods and tools that uses already existing things such as objects, living creatures and emotions, the prompts of Fictionation are based on fantasy and fiction. Therefore, they support illogical thinking that is an essential part of creative thinking (Haritaipan, 2019; Kris, 2000).
- While other types of fantasy-based design methods (such as the fourth analogy type -fantasy analogy- used for the Synectics method that requires the imagination of magical or impossible wishes in order to find solutions to design problems) do not provide any guidance to the designer apart from an open-ended question, Fictionation provides more solution-oriented prompts that include fantasy and fiction.
- While many methods and tools such as SCAMPER, TRIZ, Oblique Strategies and Design Heuristics use specific instructions as prompts, Fictionation uses open-ended prompts. Instruction prompts of the other methods might lead to similar solutions among designers since they ask for

specific actions. However, it is seen in the results that the open-ended prompts of Fictionation lead to variety and divergence among generated ideas.

- Based on the literature research, Fictionation is the only tool that promotes the usage of both cards and charts simultaneously. While cards provide prompts that designers could get inspired from, charts offer a matrix that is helpful in documenting ideas.

Furthermore, regarding the procedure of the Fictionation tool and the other available methods and tools,

- Many available methods and tools are applicable individually or within a group. However, the offered procedure of the Fictionation tool allows for both individual and group application.
- All design methods and design tools that were investigated allow for either divergence or convergence. They are either utilized for enlarging the solution space to achieve divergence or evaluating design solutions to achieve convergence. However, the procedure of Fictionation allows for both divergence and convergence. First, it asks designers to generate ideas by using the provided prompts to reach divergence, then it asks for the evaluation and evolution of the ideas to reach convergence. Through this approach, Fictionation also aims for the transformation of illogical thinking into logical thinking.

Regarding the thinking styles of the available methods and tools and those of the Fictionation tool,

- As mentioned, Fictionation adopts both illogical and logical thinking styles that are not simultaneously available within other design methods and tools.
- While many of the available design methods and tools adopt linear thinking towards achieving an intended goal, or as de Bono (1967) indicated, towards digging a deeper and bigger hole, Fictionation adopts lateral thinking along with linear thinking towards achieving divergence, or as de Bono (1967) indicated, towards digging another hole somewhere else. While the

characteristic of Fictionation, which encourages the designer to search for ideas within different contexts such as form, function and interaction, enables lateral thinking, several prompts available within these contexts enable linear thinking.

8.1.4 Methodological Contribution of the Study (Sub-Question 3)

As mentioned in Section 8.1.2, there is a lack of a methodology that experimentally tests the outcomes of an idea generation process and provides comparable results. Due to of this lack, it is not possible to measure the success of an idea generation process, as well as the success of a proposed design method or tool. In response to this issue, this thesis offers an assessment technique that adopts quantitative content analysis strategies.

The literature review showed that, many of the available design methods and tools and those that are newly proposed were not evaluated in terms of their success. The ones that were evaluated were analyzed qualitatively by asking participants their opinions or mainly based on the opinions of the researcher her/himself. There was no methodology, experimentally measuring the idea generation process and its outcomes quantitatively, and therefore allowing for the assessment and comparison of the success of a method or tool.

In this respect, the literature was reviewed to find valuable techniques. As a result of this review, a technique created by Shah et al. (2003) and further developed by Nelson et al. (2009) was determined. However, this technique had flaws in terms of mathematical formulas and was created more towards the usage of the field of mechanical engineering. As part of this research, the flaws were eliminated to obtain more valid results and the technique was adapted to the usage of the field of industrial design by integrating the FBS ontology in order to categorize idea sketches.

Eventually, the proposed measurement technique offers the usage of quantitative content analysis strategies by breaking down the idea sketches into their components through the function, behavior and structure ontology (FBS) followed by the genealogy tree technique that works for the categorization of ideas into sub-categories in the shape of a tree diagram that consists of different levels. It is suggested that more than one coder is needed in this process to increase reliability. After the acquisition of the genealogy tree, this research offers mathematical formulas to calculate novelty and variety scores for each participant.

Through applying this technique within an experimental environment that consist of control and experiment groups, scores of each participants as well as the overall score of the group can be calculated and the results enable to see the effects of the tool in terms of quantity, variety and novelty, which are the essential requirements of the idea generation process. By assigning different design tools to different groups, this technique can be used to compare various design tools as well. Furthermore, the technique can also be used by the instructors of a design course that contains an idea generation session to evaluate and grade the success of the students within the idea generation phase.

8.1.5 Effect of the Fictionation Tool on Design Outcomes, Idea Generation Process and Design Education (Sub-Questions 4 and 5)

By using the developed measurement technique, together with the results of the interviews, it was possible to see the effect of the Fictionation tool on the outcomes of the idea generation process in terms of quantity, variety and novelty. Furthermore, these results enabled to evaluate the effect of the Fictionation tool on design education.

8.1.5.1 Effects in terms of Outcomes and Idea Generation Process

The results of the measurement technique show that quantity, variety and novelty scores of the participants who utilized the Fictionation tool are higher than those who did not utilize the tool.

In terms of quantity, while the number of the valid sketches, which were the sketches that were obtained after the elimination of similar ideas, made by the participants of the control group decreased from 134 to 112 among session 1 and session 2; the number of the valid sketches made by the participants of the experiment group increased from 129 to 150 among session 1 and session 2 after they utilized the Fictionation tool. In this respect, it is possible to say that the Fictionation tool increased the quantity of the generated ideas.

In terms of variety, while the average variety scores of the participants of the control group increased from 3,391 to 4,076 among pretest (session 1) and posttest (session 1 + session 2); the average variety scores of the participants of the experiment group increased from 3,538 to 5,546. The results show that, the variety score of the control group increased 20,2% and the variety score of the experiment group increased 56,7%. In this respect, it is possible to say that the Fictionation tool increased the variety of the generated ideas, which means, the Fictionation tool enables the generation of ideas that are different from each other.

In terms of novelty, while the average novelty scores of the participants of the control group decreased from 7,755 to 7,617 among pretest (session 1) and posttest (session 1 + session 2); the average novelty scores of the participants of the experiment group increased from 7,705 to 8,006. In this respect, it is possible to say that the Fictionation tool increased the novelty of the generated ideas.

The effect of the increase in the quantity, variety and novelty scores can also be seen in the solution space of the experiment group. The representations in Figures 172 and 173 show that, the solution space of the experiment group enlarged far too much than the solution space of the control group. Therefore, when all these results are considered, it is possible to say that the Fictionation tool positively affected the outcomes of the idea generation process.

Furthermore, based on the interview results, many of the participants declared that the Fictionation tool would be beneficial to the idea generation process in terms of providing a guide and support in generating novel ideas, looking from a different perspective, removing the constraints in minds, thinking in a freer way, and diversifying the ideas. Therefore, beside fostering the outcomes, it is possible to say that the Fictionation tool enhances the efficiency of the idea generation process.

8.1.5.2 Effect of the Fictionation Tool on Design Education

Creativity is one of the important objectives of design education and it can be associated with novelty. While Linsey, Markman, and Wood (2008) explain creativity as a thinking style to achieve novel and previously unseen solutions, Oman, Tumer, Wood, and Seepersad (2013) describe creativity as a process to generate novel ideas, and Jagtap (2018) evaluates novelty as a creative idea and a main element of creativity. Therefore, just like creativity, novelty is also another concept that should be taught and developed within design education.

Apart from novelty, researchers indicate the importance of exploration and divergent thinking within design education. While Lin (2014) argues that design education should contain teaching methods to foster exploration and carefree thinking, Christian et al. (2012) argue that novice designers should be supported with methods and tools that enable divergent thinking.

In the light of these arguments, as creativity (novelty), exploration (design solution space), and divergent thinking (variety) are important components of idea generation and therefore design education, the Fictionation tool can be evaluated as a successful contribution to design education.

Furthermore, when educational objectives are considered, increasing the academic success of the students and narrowing the width between the best and worst student in terms of their academic success should be the priority of an educational program (Ülgen, 1995).

Through narrowing the width between the best and worst student in terms of their academic success, a more homogeneous student group is achieved. Studies show that, students of a homogeneous group perform better and get better results compared with students of a heterogeneous group (Adodo & Agbayewa, 2011). Besides, Hallinan (1994) and Uysal and Banoğlu (2018), argue that, by achieving homogeneous groups, an efficient teaching environment and thus more qualified educational outcomes could be reached.

When the distribution of the scores were investigated, regarding the pretest-posttest results of the control group, while the success of the group (mean score) was increased from the score of 5,573 to 5,846, the standard deviation was also increased from 0,51649 to 0,59022 (Figure 170). Hence, this situation caused an expansion in the width of the distribution between the best and worst students in terms of their academic success. This is an undesirable result that causes heterogeneity in a group.

On the other hand, regarding the pretest-posttest results of the experiment group, while the success of the group (mean score) is increased from the score of 5,622 to 6,776, the standard deviation is decreased from 0,48157 to 0,36076 (Figure 171). Hence, this situation caused a narrowing in the width of the distribution between the best and worst students in terms of their academic success. This is a desirable result that causes homogeneity in a group. As a consequence, while the Fictionation tool increases the academic success of the students, it also narrows down the width between the best and worst student in terms of their academic success and causes a more homogeneous group. Therefore, it can be said that, the Fictionation tool helps in achieving an efficient teaching environment and thus more qualified educational outcomes.

8.2 Position of the Thesis in the Literature and Its Contributions

This thesis positions itself in the intersection of idea generation, design education, creative thinking and design fiction literatures and also has support from the educational sciences literature.

This thesis contributes to the idea generation, design education and creative thinking literature by examining the nature, nurture, methods and tools of design

It investigates the nature of design as an activity, as a result and as a process and evaluates the phases of the design process and put emphasis on the idea generation phase. It investigates the nurture of design by presenting its setting and aims. It presents detailed information about design methods and tools and contributes to this literature by presenting a new idea generation tool.

Furthermore, this thesis investigates the concept of design fiction by presenting its value, similar approaches and conducted studies. Furthermore, this thesis contributes to the design fiction literature by presenting a strategy in which design fiction and design research are integrated in order to provide knowledge that can be utilized within the design process.

This thesis is significant in terms of combining design research with educational sciences literature. It investigates the experimental design models and implements the quasi-experiment model within a design research.

Furthermore, this thesis contributes to the design literature by offering an assessment technique that quantitatively measures the outcomes of the idea generation process. This technique can be used by researchers and designers to evaluate and compare a design method or tool that they have generated. It can also be used by the instructors of a design course that contains an idea generation session to evaluate and grade the success of the students within the idea generation phase. Besides, the solution space visualizations used in this thesis are a new way of visualizing the experimental output that presents a massive amount of visual data consists of idea sketches. Through this technique, researchers can visualize the situation revealed through their data.

8.3 Limitations of the Study and Suggestions for Further Studies

This thesis offers a design tool in order to guide and support design students in terms of fostering the outcomes and increasing the performance regarding design divergence and novelty during the idea generation process. It has a critical importance to inspire future studies and practices related to idea generation, design education, design fiction and creative thinking. However, it has several limitations due to the time constraints and practical reasons. These limitations can show directions for further studies. This section presents these limitations and suggestions.

Due to practical reasons and time constraints, the studies were conducted with a student group that study in the same department. Despite having a control group and an experiment group to increase the trustworthiness of the findings, applying the tool in various universities and different grade levels will increase the sampling and thus increase the trustworthiness of the findings.

The target group of the tool was determined as design students. However, since it is an idea generation tool, and idea generation is part of the activity of the design profession, it can be tested with professional designers. This effort would help to generalize the findings. Furthermore, although the content of the Fictionation cards allow for the utilization in any kind of design project, preparing cards that are specialized for different industries such as automotive, home appliances, furniture, electronics, medical, etc. will enrich the card deck and therefore can reach to larger masses.

The Fictionation tool was tested within a design project that was related with an electrical kitchen appliance. Due to the characteristic of the Fictionation tool that contains random prompts related with form, function and interaction, it can be utilized in any kind of design projects that contains a product, system or service. However, in order to claim this argument robustly and see the effects of the Fictionation tool with different design problems, it should be tested in different projects that contain design problems focusing on different product categories.

The Fictionation tool was tested with a control group and an experiment groups that contained participants who generated ideas on their own and utilized the Fictionation tool. For further studies, it can be tested and compared with other design tools to see their effects comparatively.

Finally, the genealogy trees presented in this thesis were created via design softwares such as Adobe Photoshop and Adobe Illustrator. Due to the massive processing load the software crashed several times. For those that will create such genealogy trees, it is recommended to use a computer that has powerful hardware properties or to print out the sketches and create the genealogy tree on a large wall manually.

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APPENDIX A

LIGHTING PROJECT BRIEF

Middle East Technical University Faculty of Architecture, Department of Industrial Design, Spring 2017-18, ID 302 Industrial Design IV
Asst. Prof. Dr. Naz A.G.Z. Börekçi, Asst. Prof. Dr. Fatma Korkut, Asst. Prof. Dr. Senem Turhn, Inst. Aernout Kruithof, Res. Assist. Itır Güngör Boncukçu, Res. Assist. Başak Topal, Res. Assist. Mert Kulaksız, Res. Assist. Aslıhan Tokat

12 February 2018

Project I: Sustainable Outdoor Lighting Family for METU Campus in Collaboration with Moonlight

This project will be undertaken in collaboration with Moonlight, a major company in professional outdoor lighting located in Sincan, Ankara. The project involves the development of a family of outdoor lighting units aligned with the institutional identity of the METU campus, and in accordance with sustainable design considerations. The project will have a particular focus on maintenance and repair, and design solutions inspired by nature. The outdoor lighting family will consist of three types of lighting fixtures: Bollards (or stelae), pole/post tops, and wall and/or pillar mounted fixtures. The project scope excludes street lighting.

Developing design solutions which consider the whole lifespan of a product including both the use and post-use phases (i.e. repair, re-use and recovery/upgrading) is a critical sustainable design consideration. This project will focus on the following dimensions in particular, which emphasize both technical and aesthetic aspects of the product lifespan:

- **Product maintenance and repair:** Maintenance and product part replacement are among the sustainable design considerations to prolong product lifespan. In this project, this consideration includes ease of maintenance, repair and cleaning, component interchangeability, refurbishing, replacing or renewing outdated or worn-out parts technically or aesthetically (e.g. adding new functions or offering optional design features such as color and graphic applications).
- **Interactional qualities:** Smart interactions enabling connectivity among lighting units themselves, and between lighting units and campus residents, also supporting efficient use of resources, including energy efficiency.
- **Design solutions inspired by nature:** The natural environment of METU campus is an important part of its institutional identity. In relation to this aspect, we are going to use

nature as a source of inspiration, and explore models, systems, processes and elements in nature to develop sustainable solutions. Biomimicry will be used as an approach to generate sustainable ideas.

Project Phases

- **Literature search and campus observation (team):** Prior to idea generation phase, one of the main stages of this project is literature search which will be conducted in teams. The literature search will include a review and analysis of various topics related to the project context. The field observation phase will cover interviews with campus users and maintenance staff as well as observation and documentation of outdoor lighting units and their usage in various areas of METU campus in different times of the day. Based on the results of the literature search and field observation, the teams will suggest insights and findings.
- **Generating diverse design ideas through biomimicry (individual):** Biomimicry is an approach that encourages design solutions inspired by nature. In this project we will employ this approach for exploring strategies and principles inspired by nature such as attach-detach, assemble, modularize, etc. to generate diverse ideas. Seminars which introduce examples demonstrating nature's "knowledge" or ways of doing things will be incorporated into the idea generation phase of the design process.
- **Developing ideas towards a product family:** Students will develop design solutions visualized through mock-ups and sketches. Receiving user feedback on site and scheduled crits will be the important parts of this phase.
- **Design detailing and final evaluations:** The students will finalize the design solution in detail and prepare the final presentation for evaluation. The final presentation will include 2D boards and rapid prototyped 3D models reflecting the important features of the product family.

Grading:

Literature search: %7.5

Campus observation: %7.5

Mid-project portfolio evaluation (A3 bound sketch book)

Biomimicry portfolio (collection/analysis/design insights): %10

Initial ideas portfolio (matrix exercise, switch task exercise: %15

Design development and trials with mockups and models): %15

Final screening and technical drawings: %10

Final jury: %35

APPENDIX B

LIGHTING PROJECT CALENDAR

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
12.Feb Distribution of brief. Discussions. Distribution of research topics.	13.Feb	14.Feb	15.Feb Visit from firm, "product dissection session". Literature search presentations.	16.Feb	17.Feb	18.Feb
19.Feb Campus observation presentations.	20.Feb	21.Feb	22.Feb Biomimicry expedition and collection of samples in campus.	23.Feb	24.Feb	25.Feb
26.Feb Biomimicry analysis seminar and transfer session.	27.Feb	28.Feb	1.Mar Matrix exercise. Switch task exercise.	2.Mar	3.Mar	4.Mar
5.Mar Initial ideas, mockup development and trials.	6.Mar	7.Mar	8.Mar Initial ideas and models desk critiques.	9.Mar	10.Mar	11.Mar
12.Mar Desk critiques.	13.Mar	14.Mar	15.Mar Open table critique session (experts from Moonlight)	16.Mar	17.Mar	18.Mar
19.Mar Desk critiques.	20.Mar	21.Mar	22.Mar Final screening and technical drawings.	23.Mar	24.Mar	25.Mar
26.Mar Desk critiques.	27.Mar	28.Mar	29.Mar Final jury (one design solution)	30.Mar	31.Mar	1.Apr

APPENDIX C

DISCUSSION QUESTIONS OF THE PILOT STUDY

- What do you think about the design tool that you utilized?
  - Was it beneficial?
  - How did you benefit from it?
  - Would you use the design tool in design process? If yes how?

- Was the design tool easy to use?
  - Did you encounter any difficulties?

- Was the text on the cards understandable?
  - Should a new scenario be added into cards?

- Do you have any suggestions for the improvement of the design tool?

APPENDIX D

INTERVIEW QUESTIONS

- What do you think about the Fictionation tool? Could you say something about the process in general?
  - Was the process clear to you?
  - What are your thoughts about the allocated time for each assignment?
  - What do you think about the number of the sketches that you made?
- What do you think about the charts that you made sketches on?
  - What do you think about the size of the charts?
  - Were the cells enough in number and size?
- What do you think about the design and language of the cards?
  - Was the design user friendly?
  - Were the sentences and keywords easy to understand?
- Can you evaluate the eight cards that you picked?
  - Why did you prefer to make sketches regarding that cards?
  - How would you evaluate the number of cards that you picked? Should it be more or less than eight?
- Can you compare the individual and group sessions of the process?
  - Which one was more efficient in your opinion? Why?
- What was the aim of this tool in your opinion?
  - Do you think you have achieved those aims? In what ways?
  - How would you evaluate your performance and the ideas you developed through the workshop?
- Do you think this method could be used within the design process?
  - Which phases of the design process are more suitable to use this tool? Why?
- Did you face any difficulties during the workshop?
  - What are your suggestions to eliminate those?
- Do you have any suggestion for the improvement of this tool?
  - About the process?
  - About the charts?
  - About the cards?

APPENDIX E

FICTIONATION CARDS


what if
there were a **different interaction** with the product than the accustomed one, how would the function of the product change
?
function
what if
there were a **different interaction** with the product than the accustomed one, how would the form of the product be
?
form
what if
there were a **different interaction** with the product than the accustomed one, how would the user interact with the product
?
interaction
what if
the **antropometric measurements** of the user changed,how would the function of the product change
?
function
what if
the **antropometric measurements** of the user changed, how would the form of the product be
?
form
what if
the **antropometric measurements** of the user changed, how would the user interact with the product
?
interaction
what if
there were **new technologies** that are not present in the contemporary world, how would the function of the product change regarding that technology
?
function
what if
there were **new technologies** that are not present in the contemporary world, how would the form of the product be regarding that technology
?
form
what if
there were **new technologies** that are not present in the contemporary world, how would the user interact with the product regarding that technology
?
interaction


what if
the product were designed for an **extraordinary user**, how would the function of the product change
function
what if
the product were designed for an **extraordinary user**, how would the form of the product be
form
what if
the product were designed for an **extraordinary user**, how would the user interact with the product
interaction
what if
the user interacted with the product through a **different sense organ**, how would the function of the product change
function
what if
the user interacted with the product through a **different sense organ**, how would the form of the product be
form
what if
the user interacted with the product through a **different sense organ**, how would the user interact with the product
interaction
what if
the product had an **unusual form** that is different than the ones in the market, how would the function of the product change
function
what if
the product had an **unusual form** that is different than the ones in the market, how would the form of the product be
form
what if
the product had an **unusual form** that is different than the ones in the market, how would the user interact with the product
interaction


what if
the product were designed for an extraordinary purpose, how would the function of the product change
?
function
what if
the product were designed for an extraordinary purpose, how would the form of the product be
?
form
what if
the product were designed for an extraordinary purpose, how would the user interact with the product
?
interaction
what if
the product were designed for an extraordinary place, how would the function of the product change
?
function
what if
the product were designed for an extraordinary place, how would the form of the product be
?
form
what if
the product were designed for an extraordinary place, how would the user interact with the product
?
interaction

APPENDIX F

CONSENT FORM FOR THE PILOT STUDY

Consent Form for Participation in Research
Study Title: Investigating methods for integrating design fiction into idea generation process

Investigator: Ümit Bayırlı, Research Assistant, Middle East Technical University Department of Industrial Design, ubayirli@metu.edu.tr

The Aim of the Study
This study is part of a thesis that aims to provide a guidance for the design students by which they can isolate themselves from the subsequent concerns of the product development process and focus on the idea generation process in a divergent manner to propose various and novel ideas. To achieve this goal, it offers a tool that integrates design fiction into the idea generation process for the purpose of expanding the design solution space and producing novel ideas.

Procedures
You will be asked to sketch ideas by considering some cards that guides to think differently.

Confidentiality
The process will be photographed, and names will be used as anonymous in the study. After this process the researcher may need to interview with you and tape record the process.

Optional Permission
The researchers may want to use a shot for illustrative reasons in presentations of this work for scientific or educational purposes. I give my permission to do so provided that my name and face will not appear.
Please initial here: ________YES ________NO

Rights
Your participation is voluntary. You are free to stop your participation at any point. Refusal to participate or withdrawal of your consent or discontinued participation in the study will not result in any penalty or loss of benefits or rights to which you might otherwise be entitled.

Voluntary Consent
By signing below, you agree that the above information has been explained to you and all your current questions have been answered. You are encouraged to ask questions about any aspect of this research study during the course of the study and in the future. By signing this form, you agree to participate in this research study.

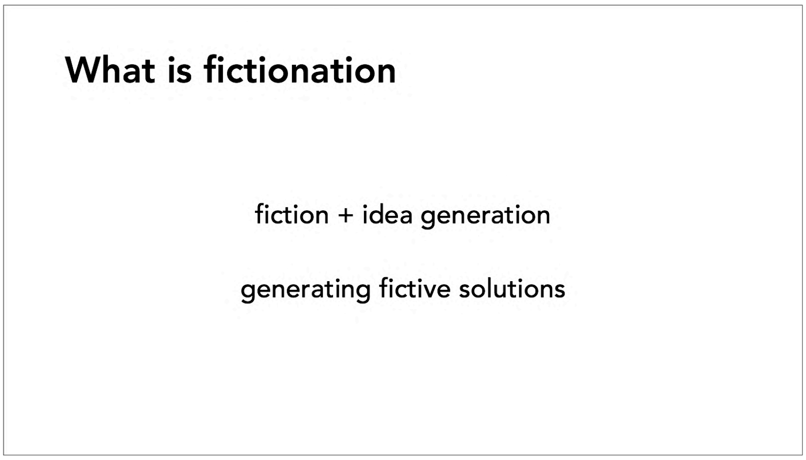
PARTICIPANT SIGNATURE **DATE**

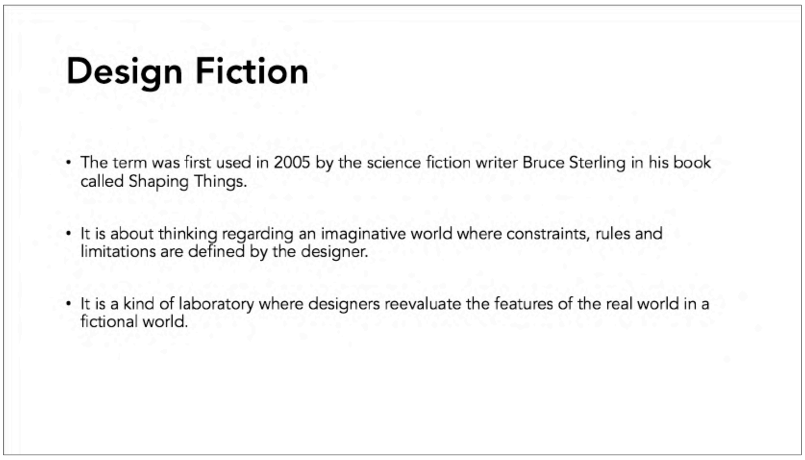
I certify that I have explained the nature and purpose of this research study to the above individual. Any questions the individual has about this study have been answered and any future questions will be answered as they arise.

SIGNATURE OF THE RESEARCHER **DATE**

APPENDIX G

PRESENTATION WITHIN THE PILOT STUDY

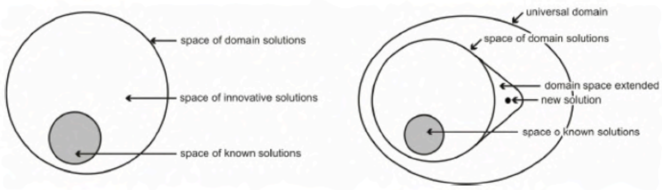




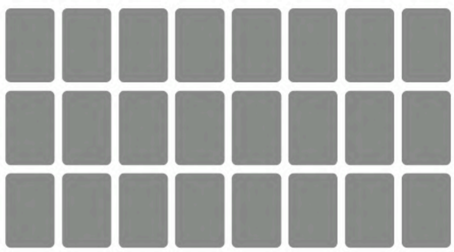
The Purpose of the Workshop

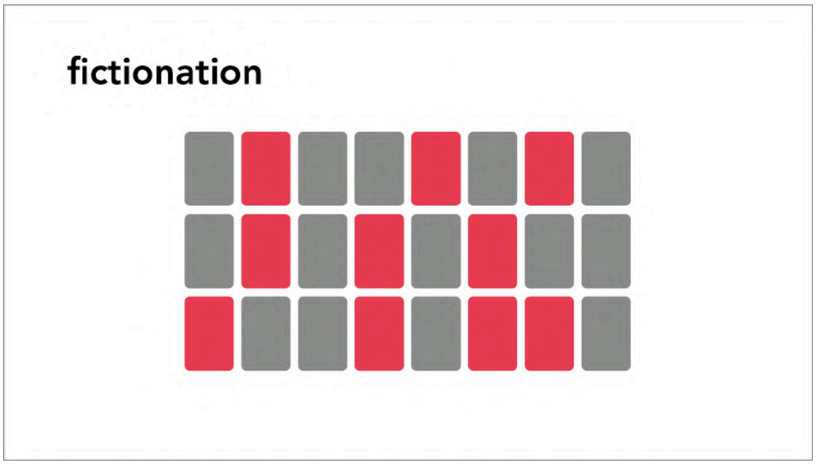
- The effectiveness of the idea generation process can be measured by the quantity, variety, and novelty of the generated ideas throughout this process.
- The sum of the generated ideas for a specific design problem composes a theoretical space named as 'design solution space'.
- Some ideas of the 'design solution space' are obvious and can be thought quickly by most of the people. On the other hand, less obvious ideas, which are novel ideas, need more time and effort to find out. These novel ideas are the ones that enlarge the boundaries of the design solution space and create less well-known and innovative spaces.

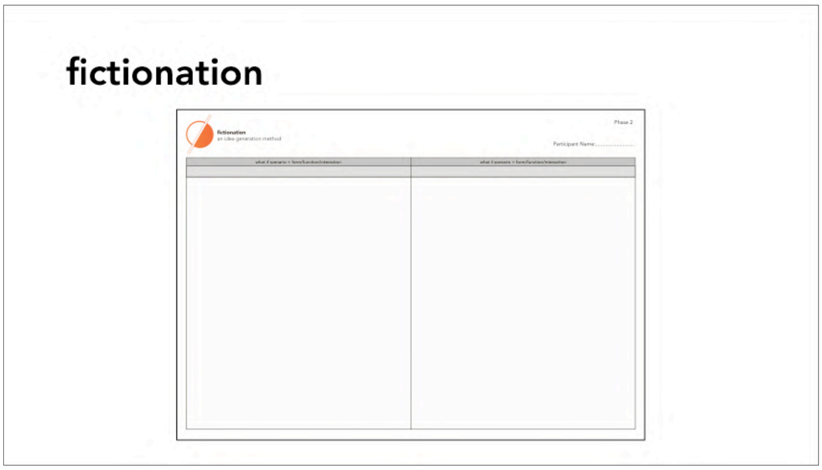
The Purpose of the Workshop

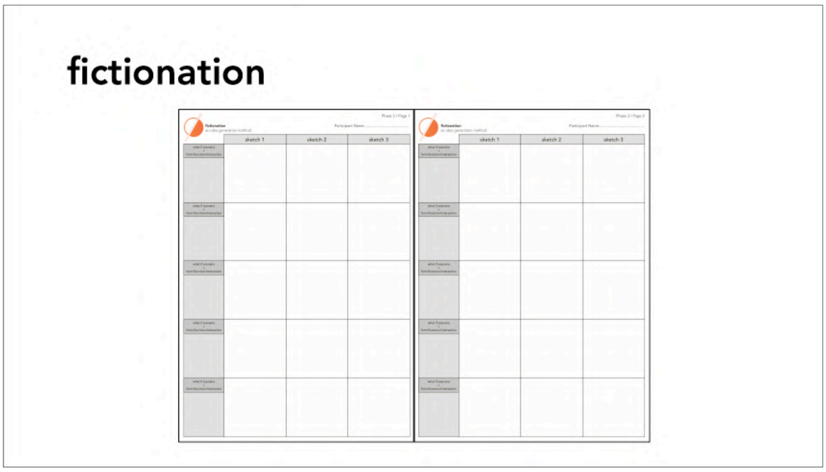


fictionation




fictionation

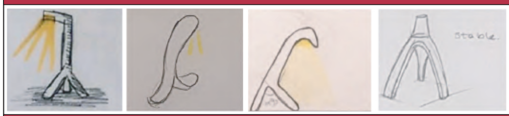

fictionation


fictionation

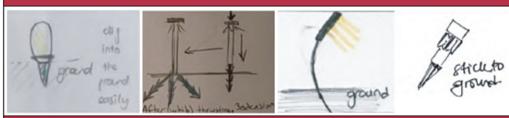
APPENDIX H

SKETCH EXAMPLES OF THE CATEGORY OF PLACING

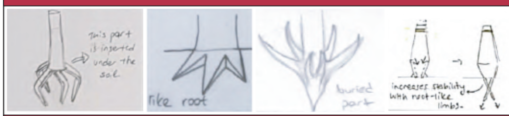
placing – pole – stabilization – support



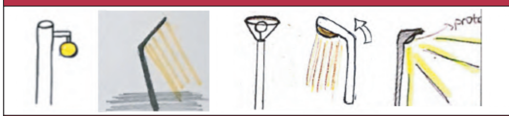
placing – pole – stabilization – prick



placing – pole – stabilization – root

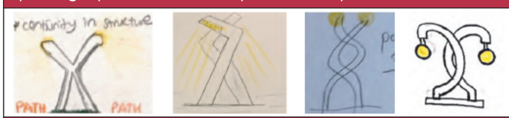


placing – pole – number of poles – one pole – rod



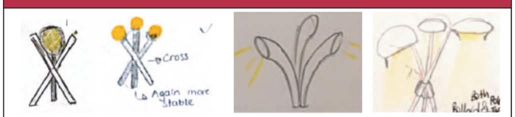
placing – pole – number of poles – one pole – branch

placing – pole – number of poles – two poles – vertical

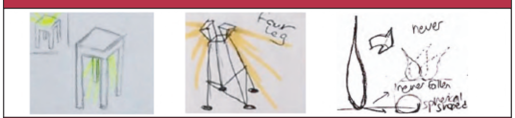


placing – pole – number of poles – two poles – bridge

placing – pole – number of poles – three poles

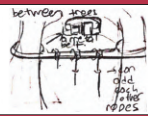


placing – pole – number of poles – other

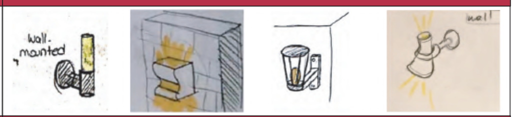


placing – attach – tree – on trunk

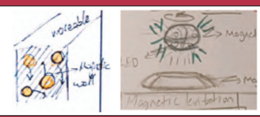
placing – attach – tree – between trees



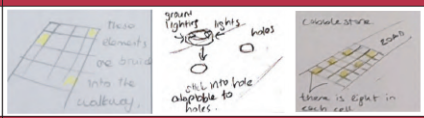
placing – attach – surface – wall



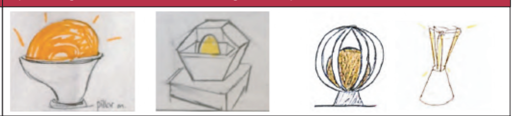
placing – attach – surface – metal



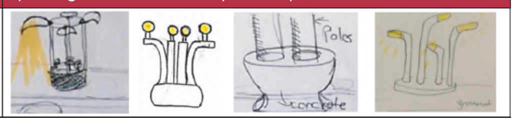
placing – attach – surface – ground



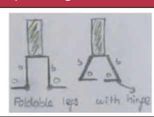
placing – base – stable – light atop



placing – base – stable – pole atop



placing – base – changeable



APPENDIX I

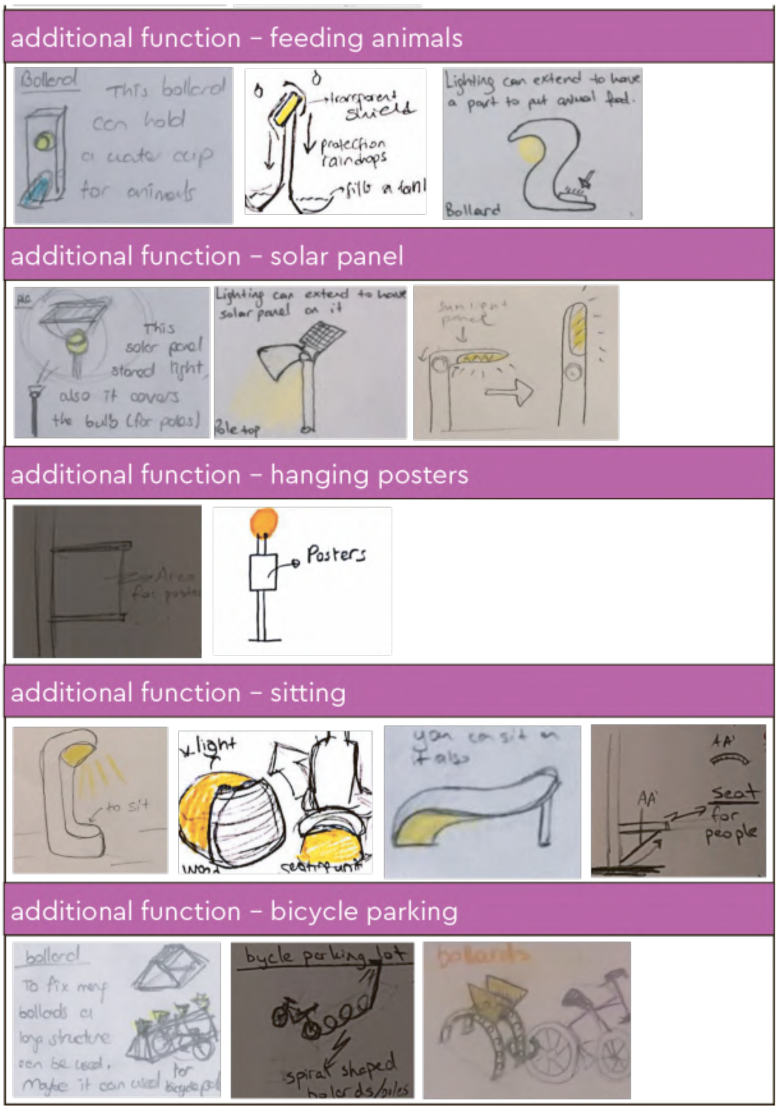
SKETCH EXAMPLES OF THE CATEGORY OF ADJUSTING

APPENDIX J

SKETCH EXAMPLES OF THE CATEGORY OF ILLUMINATING

APPENDIX K

SKETCH EXAMPLES OF THE CATEGORY OF ADDITIONAL FUNCTION



APPENDIX L

CONSENT FORM FOR THE WORKSHOPS

Consent Form for Participation in Research
Study Title: Investigating methods for integrating design fiction into idea generation process

Investigator: Ümit Bayırlı, Research Assistant, Middle East Technical University Department of Industrial Design, ubayirli@metu.edu.tr

The Aim of the Study
This thesis aims to provide a guidance for the design students by which they can isolate themselves from the subsequent concerns of the product development process and focus on the idea generation process in a divergent manner to propose various and novel ideas. To achieve this goal, it offers a tool that integrates design fiction into the idea generation process for the purpose of expanding the design solution space and producing novel ideas.

Procedures
You will be asked to sketch ideas by considering some cards that guides to think differently.

Confidentiality
The process will be photographed, and names will be used as anonymous in the study. After this process the researcher may need to interview with you and tape record the process.

Optional Permission
The researchers may want to use a shot for illustrative reasons in presentations of this work for scientific or educational purposes. I give my permission to do so provided that my name and face will not appear.
Please initial here: ________YES ________NO

Rights
Your participation is voluntary. You are free to stop your participation at any point. Refusal to participate or withdrawal of your consent or discontinued participation in the study will not result in any penalty or loss of benefits or rights to which you might otherwise be entitled.

Voluntary Consent
By signing below, you agree that the above information has been explained to you and all your current questions have been answered. You are encouraged to ask questions about any aspect of this research study during the course of the study and in the future. By signing this form, you agree to participate in this research study.

PARTICIPANT SIGNATURE **DATE**

I certify that I have explained the nature and purpose of this research study to the above individual. Any questions the individual has about this study have been answered and any future questions will be answered as they arise.

SIGNATURE OF THE RESEARCHER **DATE**

APPENDIX M

DESIGN BRIEF OF THE CONTROL GROUP

IDEA GENERATION WORKSHOP

Designing a kettle

In this project, you are expected to design a kettle and make 32 sketches regarding your design solutions.
You are free to decide on the design requirements such as power source, material, target user, usage area, etc.

The product should differ from the competitors in the market regarding some design attributes. It should be aesthetically pleasant, affordable, easy to use, safe and energy efficient.

You can use pens, pencils, colored pencils, markers, etc.
You can make research by using your computers or smartphones.

Timetable of the Workshop

Phase 1: Making 16 sketches	45 minutes
Break	15 minutes
Phase 2: Making 16 sketches	45 minutes

APPENDIX N

DESIGN BRIEF OF THE EXPERIMENT GROUP

IDEA GENERATION WORKSHOP

Designing a kettle

In this part of the workshop, you will be using an idea generation method called fictionation.

In the first phase of the workshop you have produced 16 design solutions.

In the second phase, you will be given 33 fictionation cards that have different 'what if' scenarios related with either form, function or interaction. You are required to select 8 fictionation cards and generate new ideas considering the given scenarios of the cards that you picked. This is the phase in which you will propose new ideas in a divergent manner. Therefore making lots of sketches will ease your job in the third phase.

In the third phase, you are required to examine and get inspirations from the sketches that you made in the second phase and propose 16 new ideas. This is the phase in which you will propose new ideas in a convergent manner.

Timetable of the Workshop

Phase 1: Making 16 sketches	45 minutes
Break	15 minutes
Presentation	10 minutes
Phase 2: Divergence	60 minutes
Break	15 minutes
Phase 3: Convergence	45 minutes

APPENDIX O

PRESENTATION WITHIN THE WORKSHOPS

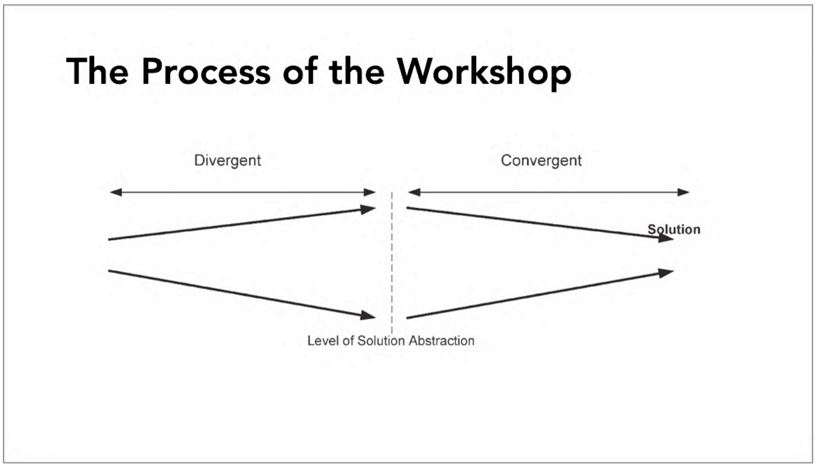
What is fictionation

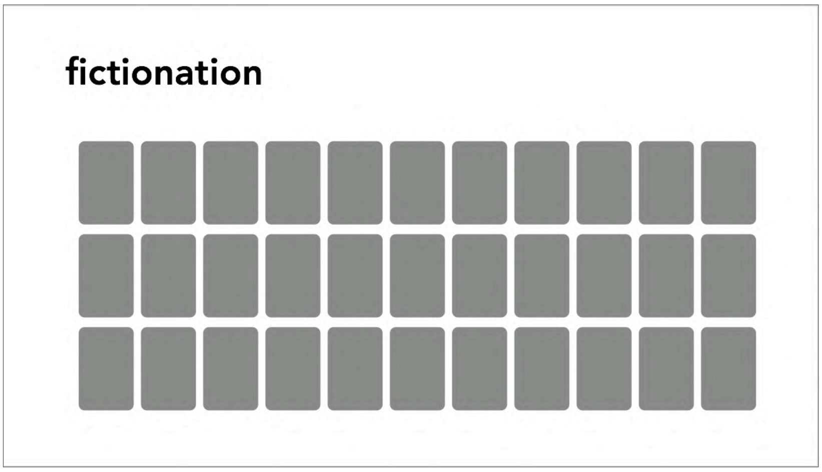
fiction + idea generation

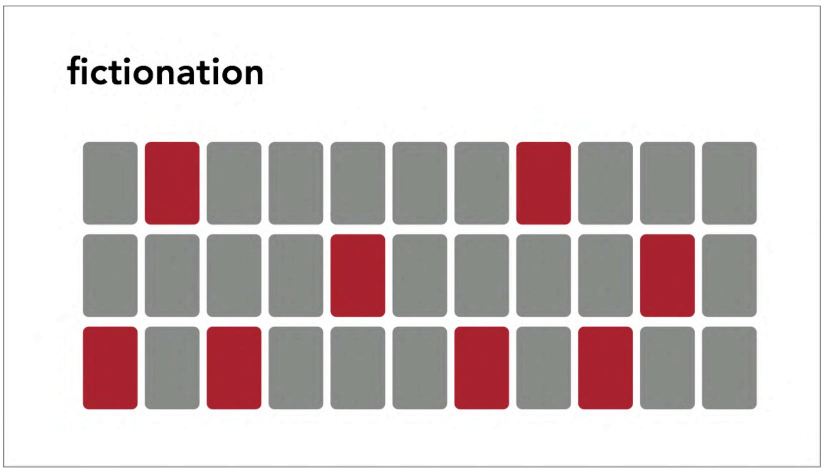
generating fictive solutions

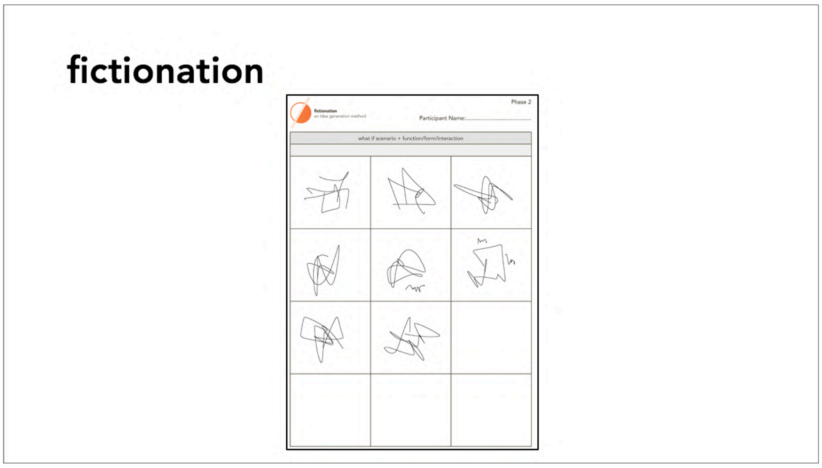
Design Fiction

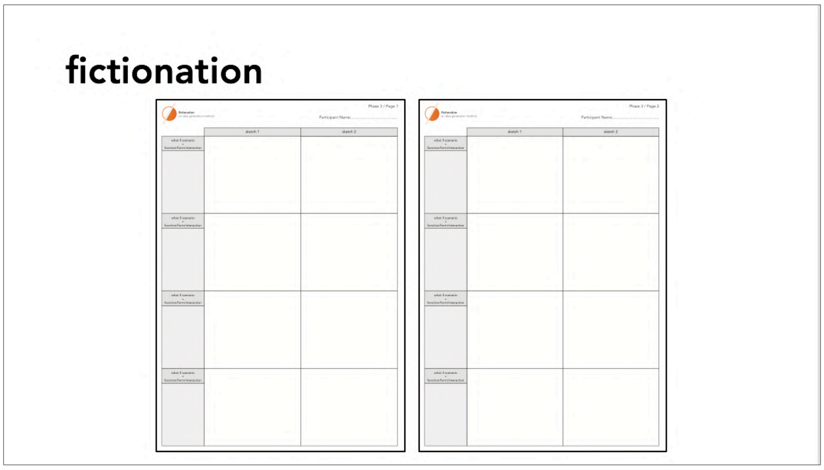
- The term was first used in 2005 by the science fiction writer Bruce Sterling in his book called Shaping Things.
- It is about thinking regarding an imaginative world where constraints, rules and limitations are defined by the designer.
- It is a kind of laboratory where designers reevaluate the features of the real world in a fictional world.


The Process of the Workshop
Divergent
Convergent
Solution
Level of Solution Abstraction


fictionation


fictionation


fictionation
Phase 2
Participant Name:
what if scenario + function/form/interaction


fictionation

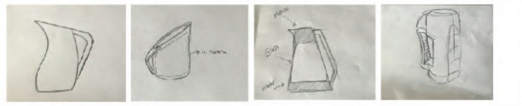
APPENDIX P

SKETCH EXAMPLES OF THE CATEGORY OF FORM

form – dock – mobile – side

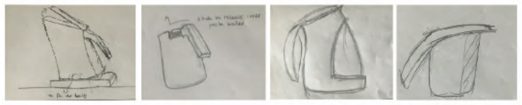
form – dock – mobile – surround

form – handle – fixed – solid – single – two point touch – side

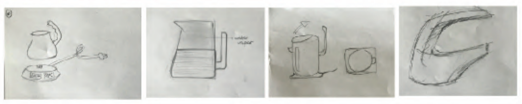


form – handle – fixed – solid – single – two point touch – top

form – handle – fixed – solid – single – one point touch – downward



form – handle – fixed – solid – single – one point touch – upward



form – handle – fixed – solid – single – one point touch – both sides

form – handle – fixed – solid – multiple

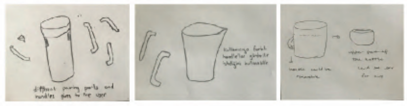
form – handle – fixed – transformable – angle

form – handle – fixed – transformable – direction

form – handle – fixed – transformable – elastic

form – handle – fixed – transformable – telescopic

form – handle – detachable

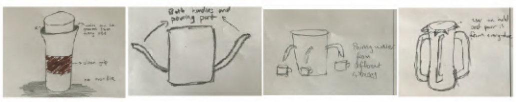


form – handle – no handle

form – spout – fixed – single – common

form – spout – fixed – single – long

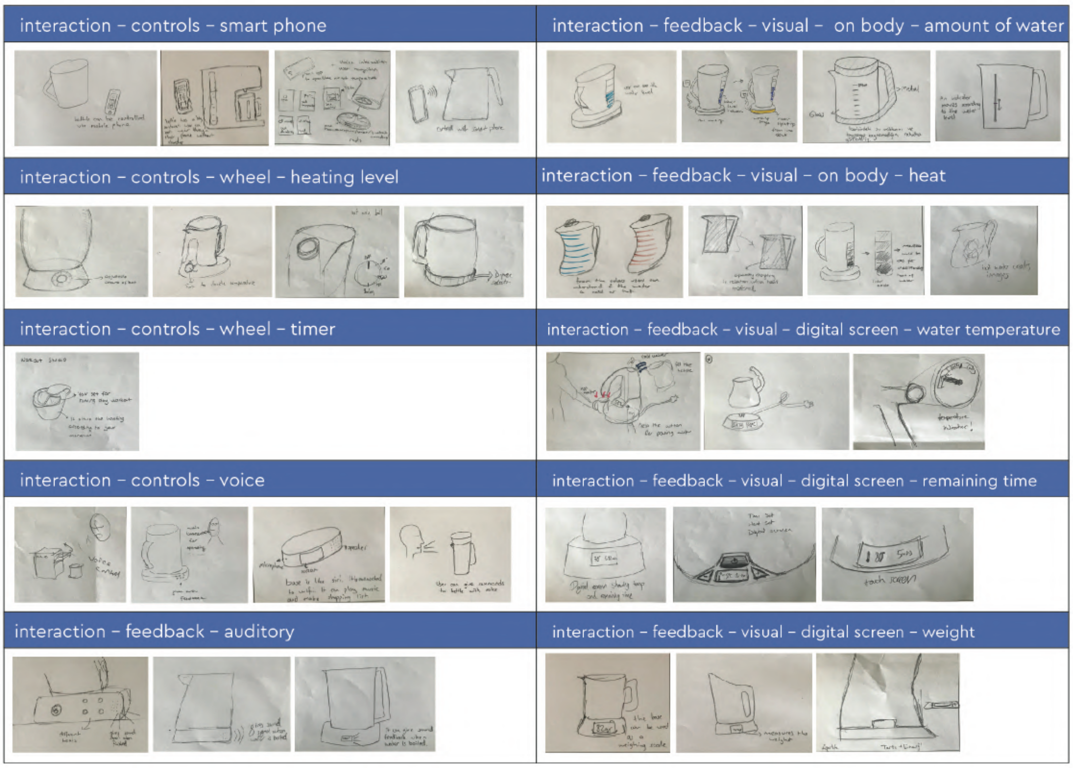
form – spout – fixed – multiple



form – spout – detachable

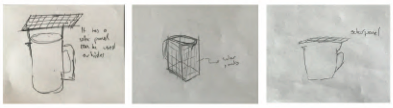
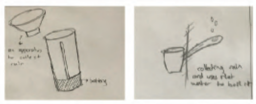
APPENDIX Q

SKETCH EXAMPLES OF THE CATEGORY OF INTERACTION


interaction – controls – smart phone
interaction – feedback – visual – on body – amount of water
interaction – controls – wheel – heating level
interaction – feedback – visual – on body – heat
interaction – controls – wheel – timer
interaction – feedback – visual – digital screen – water temperature
interaction – controls – voice
interaction – feedback – visual – digital screen – remaining time
interaction – feedback – auditory
interaction – feedback – visual – digital screen – weight

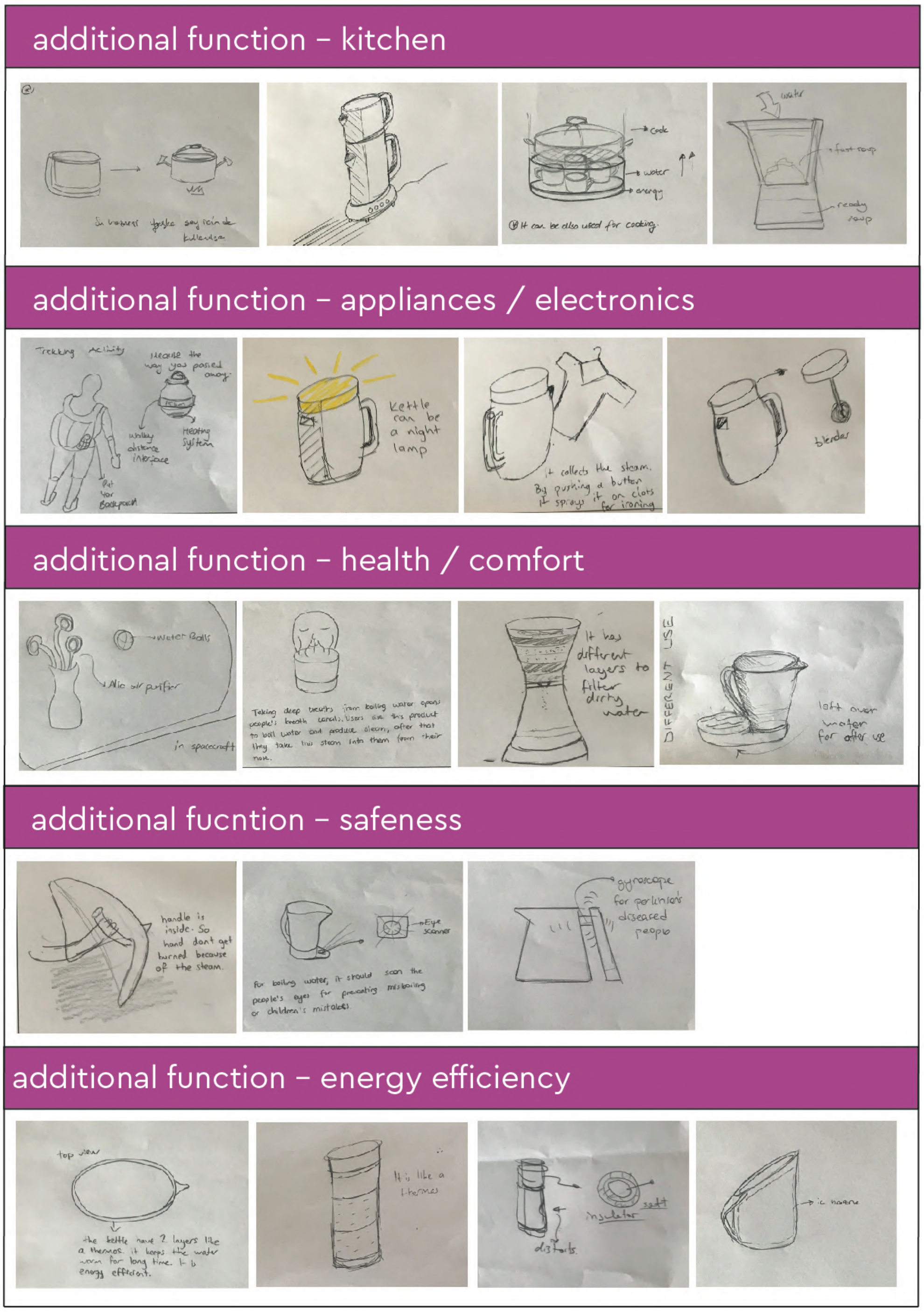
APPENDIX R

SKETCH EXAMPLES OF THE CATEGORY OF SOURCE

source – energy – electricity – generator	source – energy – heat – sun light
	
source – energy – electricity – solar panel	**source – water – steam**
	
source – energy – electricity – battery	**source – water – moisture**
	
source – energy – electricity – induction heater	**source – water – snow**
	
source – energy – electricity – usb	**source – water – rain**
	
source – energy – heat – fire	
	

APPENDIX S

SKETCH EXAMPLES OF THE CATEGORY OF ADDITIONAL FUNCTION



CURRICULUM VITAE

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ACADEMIC EXPERIENCE

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2012-2019	Middle East Technical University Department of Industrial Design	Research Assistant
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Advanced English, Beginner Italian

PUBLICATIONS

Bayırlı, Ü., & Börekçi, N.A.G.Z. (2020). Tasarım sürecinde kullanılan fikir geliştirme yöntemlerinin etkisini nicelik yönünden değerlendirmek için bir ölçüm tekniği önerisi. Paper Presented at the UTAK 2020 Conference, Ankara, Turkey, September 8-10.

Bayırlı, Ü., Paksoy, İ. Y., & Börekçi, N.A.G.Z. (2019). Idea generation using the Fictionation design tool in an interactive prototyping course for industrial designers. Paper presented at the 10th UNIDCOM/IADE International Conference Senses & Sensibility – Lost in (G)localization, Lisbon, Portugal, November 27-29.

Bayırlı, Ü., & Özgen Koçyıldırım, D. (2016). An evaluation of basic design education at Middle East Technical University, Department of Industrial Design. Paper presented at the 10th International Conference on Design Principles & Practices, Rio de Janeiro, Brazil, February 25-27.