“But, it’s just a really good idea!”

Investigating the guidance of design feedback processes to mitigate pupils' fixation and stimulate their creative thinking

Schut, A.

DOI
10.4233/uuid:5ac369fa-595c-41b1-a5e0-d96337abe1e8

Publication date
2022

Document Version
Final published version

Citation (APA)
Schut, A. (2022). *“But, it’s just a really good idea!”: Investigating the guidance of design feedback processes to mitigate pupils' fixation and stimulate their creative thinking.* [Dissertation (TU Delft), Delft University of Technology]. https://doi.org/10.4233/uuid:5ac369fa-595c-41b1-a5e0-d96337abe1e8

Important note
To cite this publication, please use the final published version (if applicable).
Please check the document version above.

But, it's just a

really good idea!

Alice Schut

“But, it’s just a really good idea!”

Investigating the guidance of design feedback processes
to mitigate pupils' fixation and stimulate their creative thinking

Alice Schut

This research was part of the overarching research project '*Co-Design with Kids: Early Mastering of 21st Century Skills*', funded by NWO/NRO under the HC21 call (number 409-15-212). Ethical clearance from the Ethics Committee (HREC, TU Delft) has been obtained. Informed participant consent was obtained from the parents.

Cover and chapter illustrations by Joost van Kemenade

Layout by Liz Yau

Printed by Gildeprint

ISBN/EAN: 978-94-6419-686-3

A digital version of this dissertation is available via https://repository.tudelft.nl/

“But, it’s just a really good idea!”

Investigating the guidance of design feedback processes
to mitigate pupils' fixation and stimulate their creative thinking

Dissertation

for the purpose of obtaining the degree of doctor
at Delft University of Technology
by the authority of the Rector Magnificus, prof.dr.ir. T.H.J.J. van der Hagen,
chair of the Board for Doctorates
to be defended publicly on
Wednesday 25 January 2023 at 12:30 o’clock

by

Alice SCHUT

Master of Science in Media Technology,
Leiden University, the Netherlands
Born in Groningen, the Netherlands

This dissertation has been approved by the promotors.

Composition of the doctoral committee:

Rector Magnificus	chairperson
Prof. dr. M.J. de Vries	Delft University of Technology, promotor
Dr. ir. R.M. Klapwijk	Delft University of Technology, co-promotor

Independent members:

Prof. dr. P.J. Stappers	Delft University of Technology
Prof. dr. A.W. Lazonder	Radboud Universiteit Nijmegen
Prof. dr. M.M. Bekker	Eindhoven University of Technology
Prof. dr. K. Stables	Goldsmiths, University of London

Other member:

MSc. M.A. Gielen	Delft University of Technology

Table of Contents

Chapter 1

General introduction

1.1 INTRODUCTION

Not many aspects of human cognition are more intriguing or mystifying than creativity. It could be argued that it is the highest level of our cognitive abilities and that all of humanity's advances have been accomplished through it. Creativity is sought after and treasured in numerous domains. Also within the realm of primary education, creativity is progressively seen as a skill of great value. It is an integral part of the so-called 21st-century skills, identified as those skills future generations need to deal with the challenges of a world growing in complexity and interdependence (Van Graft et al., 2014). This defined set of skills takes a central position in various educational contexts, also within primary education (Thijs, Fisser, & van der Hoeven, 2014). Schools want to foster creativity in their classrooms, but often have difficulty implementing creativity in their curriculum and harnessing the creative talent of their pupils (McLellan & Nicholl, 2013). Luckily, design-related subjects can offer opportunities to encourage and develop pupils' creative abilities (Klapwijk, 2017; Lewis, 2005, 2009; Rutland & Barlex, 2008).

Designing is an inherently creative activity (Goldschmidt, 2014; Rutland & Barlex, 2008). Working on authentic design challenges confronts pupils with ill-structured open-ended problems for which no single 'right' answer or formula exists (Dorst, 2003; Lewis, 2005). Consequently, they will need to think and act creatively to design a valuable solution (Dorst & Cross, 2001; Lewis, 2009). One can think, for example, of the participation of primary schools in real-life co-design projects. In these types of projects, pupils often participate as experts by experience to help solve issues from clients and other stakeholders. Here, pupils generally work collaboratively in teams to explore the problem, generate ideas, and develop promising solution directions. Communication moments with the clients and other stakeholders are crucial and used to share their progress and receive feedback. Through these feedback moments, pupils are encouraged to evaluate the state of their design and generate avenues for further development. When implemented well, these types of projects can create a win-win situation in which the clients end up with valuable insights and ideas, while pupils are encouraged to develop a wide range of knowledge and skills (Hokanson, 2012).

Even though designing can bring many creative opportunities to the classroom, care needs to be put into its implementation and execution. There are various obstacles that can inhibit pupils from behaving creatively while designing. A key issue is the occurrence of a type of design fixation, which creates an (unconscious) adherence to the current state of their design (Jansson & Smith, 1991; McLellan & Nicholl, 2009; Nicholl & McLellan, 2007a; Purcell & Gero, 1996). This adherence is generally unfavourable, as it stagnates the pupils' creative processes and hampers the development of the design. In this dissertation, a start is made to tackle this issue of design fixation in the context of primary education. To further illustrate this issue, we give an example from one of the first studies of this research project. This study was done on a case encompassing a real-life co-design project in which primary school pupils helped design

'the gymnasium of the future'. During one of the design sessions, the following conversation took place between a design team of four pupils and a facilitator:

> *Pupil 1: What if we make it (the gym) dark?*
> *Pupil 2: That's impossible; the lights go on when you enter the gym.*
> *Facilitator: Well, I'm sure we could turn off the lights.*
> *Pupil 2: It is still too light because of the window.*
> *Facilitator: We could cover the windows.*
> *Pupil 1: Then it is too dark, children won't be able to see, that is dangerous.*

The dialogue starts with pupil 1 proposing an adjustment to the current design idea of the design team, with the intention of making it more interesting for the players. This proposal is swiftly turned down by pupil 2, who does not appear that open to making any alterations. Following this interaction, the facilitator tries to prompt further development of the design idea by proposing several alternative solutions. However, the design team did not recognise the same design possibilities as the facilitator. At the end of the dialogue, even pupil 1, who suggested the initial adjustment, rejects it altogether. The example illustrates how the pupils parry any proposed alterations, thereby maintaining the current state of their design idea. Through this behaviour, the pupils avoid critically evaluating their design, thereby hampering its creative development. Ideally, a designer intentionally works on discovering shortcomings to generate then solutions that lead to iterations of the design to end up with 'the best defensible compromise' (Keirl, 2017).

The type of design fixation illustrated by the example is common in various creative and educational contexts (Finke et al., 1992; Luo, 2015; McLellan & Nicholl, 2009; Nicholl & McLellan, 2007a). When putting time, effort, and attention into creating something, it can become challenging to remain objective towards its quality (Baer & Brown, 2012b). Although it can be useful to be persistent in creative processes and hold on to what you believe, it is essential also to be aware of the possibility of being misdirected and showcase openness to opposing and alternative views (Crilly, 2015; Csikszentmihalyi, 1999). Design education can provide opportunities for pupils to practice this type of openness, thereby supporting them in mitigating their fixation, for example, through the feedback exchanges with clients, other stakeholders, educators, or their peers. Although opportunities are present, *what* this support could be and *how* it could be implemented in practice needs to be explored. This dissertation aims to create understanding and practical know-how on nurturing pupils' creative skills through design.

1.2 LITERATURE REVIEW

1.2.1 Defining creativity

What do we mean by 'creativity' in this dissertation? Creativity is often defined as the ability to produce an output that is both novel and useful (Amabile, 1996; Cropley & Cropley, 2010; Guilford, 1967). In this definition, novel can be considered synonymous with original, and useful means that what is produced is relevant to the situation at hand. The combination of both elements is crucial for creative output. If something is novel and not useful, it is often merely viewed as weird. While if something is useful and not novel, it is generally considered generic and unremarkable. How creative something is thought to be, depends on many contextual factors. After all, what one person regards as creative, might not be considered as such by someone else.

Often a general distinction is made between big-C and little-C creativity (Craft, 2002; Richards, 2010; Simonton, 2010). Big-C creativity generates the type of output that is world-changing. It is rare and only reserved for a few special people among us. Think of the scientific breakthroughs of Einstein or the paintings by Van Gogh. Little-C creativity generates the type of output that enriches our lives on a regular basis. It is the everyday creativity we all get to create and experience. For example, thinking of small hacks that improve a daily routine or creating a wooden birdhouse for the garden. In this dissertation, the focus will lie on little-c creativity (henceforth creativity), as it is this type of creativity that primary school pupils come into contact with when starting to design. By generating and making things that, first of all, are original and purposeful in their eyes (and that of their teacher and perhaps client), pupils will steadily stimulate and develop their creative abilities.

1.2.2 Creativity in design processes

As stated in the introduction, designing is an inherently creative activity (Goldschmidt, 2014; Rutland & Barlex, 2008). A driving force behind a designer's creative actions can be considered their creative thinking processes. There appears to be a general consensus within the literature on creative cognition that creative thinking processes (in design) can be divided into two main modes of thought: divergent (DT) and convergent (CT) thinking (Finke et al., 1992; Goldschmidt, 2014, 2016; Howard-Jones, 2002). DT entails the generation of new thoughts and ideas, and is therefore generative in nature. CT entails the reflection and evaluation of these generated or previously existing thoughts and ideas, and is therefore evaluative in nature (Finke et al., 1992; Goldschmidt, 2014; Sowden et al., 2015).

According to the dual-process theories of creative cognition, continuous shifting between both modes of thinking is needed when working towards creative solutions (Finke et al., 1992; Howard et al., 2008; Sowden et al., 2015). When designing, this continuous alternation between DT and CT leads to the development of an initial design idea into a final design that

solves the problem at hand and adheres to any predefined criteria. During this development process, convergent thoughts help uncover strong points within the design, as well as various shortcomings and sub-problems. Divergent thoughts aid the generation of new additions and alterations, which are also needed to help solve the uncovered issues (Cardoso et al., 2014; Oh et al., 2013; Yilmaz & Daly, 2016).

Within a design process, this process of development takes place right after any brainstorming and idea selection activities, when the initial design idea is chosen, and the focus lies on perfecting promising option(s) to end up with the best design possible. Tassoul (2009) refers to this phase as the 'concept development stage'. This stage encapsulates physical developments such as testing of material or construction of mechanisms, as well as mental developments such as the conceptual development and creation and development of overarching processes. The term 'prototyping' might also be used for this stage of the design process. However, the conscious decision was made not to use that term in this dissertation, as the association with prototyping is generally more focused on the physical developments of a design. In this work, we want to pay explicit attention to the mental developments that take place.

1.2.3 Creativity meets fixation

Ideally, pupils engaging in design activities would display a continuous array of divergent and convergent actions. However, even though designing is a creative activity, this does not mean pupils will automatically behave creatively (contrary to popular belief). These difficulties in practice are acknowledged on various educational levels and can be attributed to a wide range of (interdependent) causes. This dissertation focuses on the occurrence of design fixation, a common factor hindering pupils' creative thinking processes while participating in design activities (McLellan & Nicholl, 2009; Nicholl & McLellan, 2007; Nicholl & McLellan, 2007, 2008).

Although fixation had been studied previously within the cognitive sciences, for example by Duncker (1945), it was not until 1991 that fixation generated attention in the context of design processes. Design fixation was first researched by Jansson and Smith (1991) and defined as "a blind, and sometimes counterproductive, adherence to a limited set of ideas in the design process". Purcell and Gero (1996) added the aspect of premature commitment to a particular problem solution to this definition. In their words: "…the designer appears trapped by the characteristics of a possible solution that has been developed or an existing precedent solution" (Purcell & Gero, 1996). In short, design fixation can be described as a sort of mental block (Finke et al., 1992), inhibiting a designer from successfully moving forward in their creative process.

Currently, we can roughly distinguish between two types of design fixation occurring at different moments in the design process. Firstly, there is the occurrence of design fixation within the ideation phase of the design process (Crilly & Cardoso, 2016). This type of fixation is researched most extensively and often focuses on the effect different types of external examples and stimuli can have on designers' idea generation (Jansson & Smith, 1991; Linsey et al., 2010; Vasconcelos & Crilly, 2016). It is commonly identified through the level of conformity the generated ideas have to the stimuli that were shown. In the classroom, this type of fixation becomes visible through stereotypical designs with strong likenesses to teacher examples or references from popular culture (McLellan & Nicholl, 2009, 2013; Nicholl & McLellan, 2007a).

Secondly, we distinguished another type of fixation within this research that occurs later in the design process during concept development. This type of fixation entails a designer's "…(unconscious) adherence to the current (possibly unfavourable) state of the design (idea)" (Schut, Klapwijk, Gielen, van Doorn, et al., 2019). Its occurrence hampers the development of a design (idea), as (sub)problems are easily overlooked, and requirements are sooner thought to be already embodied within the design. In the classroom, this becomes visible through pupils' fixation on one of their early generated ideas for which they already worked out how to proceed and their reluctance to change, modify, or develop this idea (McLellan & Nicholl, 2009; Nicholl & McLellan, 2007a). This fixation hampers pupils' creative thinking processes, as the constructed image of the final design - the exact image of how the design will look and function - prevents them from further developing their idea.

Even though concept fixation is a pervasive obstacle within design education, no real strategies are available for teachers to help pupils avoid or overcome this type of fixation while designing. This pervasiveness is partly due to the lack of research on this specific type of design fixation and, we argue, how it is generally identified. Currently, design fixation is identified by analysing and comparing the design ideas and produced artefacts at the end of a design process (Sio et al., 2015; Vasconcelos & Crilly, 2016). However, knowing that design fixation has occurred at the end of design projects is not directly helpful in supporting pupils during their design process. From a pedagogical viewpoint, there is a need to make design fixation visible while designing since this would allow pupils to avoid or overcome this hurdle during the project. Thus, teachers and pupils need to be able to collect evidence and diagnose whether there are any occurrences of design fixation as early as possible.

Following recent developments in (design) education literature, feedback exchanges that take place within the classroom can provide opportunities for the early identification of this type of design fixation (Cardoso et al., 2014; Fox-Turnbull, 2016, 2018; Yilmaz & Daly, 2016). Additionally, design feedback appears to be a promising avenue to explore ways of supporting pupils in mitigating this type of fixation (Cardoso et al., 2014, 2016; Yilmaz & Daly, 2016). After all, creative design processes do not happen in a vacuum. In an educational setting, the designing pupils generally have various exchanges with their peers, teachers, clients, users, and other

stakeholders. During these exchanges, questions and comments on the state of the design are shared, which influence the next steps pupils' take in their design process. In other words, the feedback shared with the pupils can influence the divergent and convergent directions they might take to develop their design. This potential influence on pupils' creative thinking provides opportunities for reducing design fixation.

Even though design feedback can provide opportunities, this is not a given. Within general education, it is well recognised that feedback exchanges can play an essential role in learning when guided in a constructive manner (Colfer, 2017; Mercer & Littleton, 2014). However, it is well known that design feedback is not always shared constructively and does not automatically benefit novice designers' creative thinking processes (Anthony, 1991; Cardoso et al., 2014; Yilmaz & Daly, 2016). This issue brings us to the question of what is needed to create a context in which design feedback could help overcome design fixation. And specifically, what is needed and how this could be implemented the context of primary education.

1.3 RESEARCH AIM AND QUESTION

In this dissertation, we aim to understand the interplay between design feedback and pupils' creative thinking processes to develop and test feedback interventions that stimulate these thinking processes and thereby help mitigate pupils' design fixation. In line with the aforementioned aim, the following main research question was formulated:

Which qualities of design feedback processes stimulate pupils' creative thinking and mitigate their design fixation in the concept development stage of the design process?

To answer the main research question, four sub-questions are formulated. Sub-question 1 and 2 are focussed on gaining an understanding of the occurrence of design fixation within unguided design feedback exchanges between the designing pupils, their peers, and the clients. The goal was to make a diagnosis of the unguided situation and uncover critical problems that hamper the pupils' creative thinking processes and could be tackled through the creation of an intervention. Building on this new information, the third and fourth sub-questions focus on developing a peer feedback intervention to encourage pupils' creative thinking processes and testing this in practice.

Sub-questions:

1. *What are early indicators of design fixation within pupils' design feedback exchanges, and how can they be identified?*
2. *What is the convergent and divergent nature of the design feedback given by the client and peers, and what are the pupils' direct responses in an unguided design feedback situation?*
3. *In what way does the peer feedback intervention influence the convergent and divergent nature of the design feedback given by the clients and peers and the concurrent direct responses of the pupils?*
4. *In what way does the peer feedback intervention enable pupils in their process of design feedback uptake?*

Sub-question 1 aims to uncover ways in which pupils' design fixation could be identified during their design process, instead of in hindsight. This early identification was done through the analysis of the unguided design feedback exchanges that take place within the classroom. Sub-question 2 aims to further understand the occurrence of pupils' design fixation by looking in more detail at unguided design feedback exchanges. To gain this understanding, the divergent or convergent nature of the design feedback given by the client and peers was identified and compared to the different types of concurrent responses of the pupils. The goal was to gain insight into the interplay between design feedback and direct responses to diagnose factors hindering pupils' creative thinking. Special attention was given to those exchanges in which design fixation is present. Sub-question 3 aims to understand how the intervention shaped the divergent or convergent nature of the design feedback given by the clients and peers, and the concurrent responses of the pupils. Again, the goal was to gain insight into the interplay between design feedback and direct responses to uncover possible successes and obstacles for pupils' creative thinking linked to the principles behind the intervention. Finally, sub-question 4 aims to understand how the intervention could support the pupils beyond their initial direct responses and enable their process of feedback uptake.

1.4 RESEARCH DESIGN

To answer the research questions, we implemented an educational design research approach consisting of a series of three cases and four studies over the course of three years (Bakker, 2018; Yin, 2014). Design research in education includes the design of interventions and materials for a specific educational context, testing these in a naturalistic setting, analysing the results, and creating new theoretical insights (Bakker, 2018). It generally has an iterative approach, in which the designed interventions and materials go through one or more development rounds based on the analysis results. Since the research topic is novel within the context of primary education, there is little pre-existing knowledge and experience to build upon. Therefore, qualitative methods were used, enabling us to 'look inside the black box' and understand how, why and

when things happened and worked (Bakker, 2018). Additionally, contrasting cases were created to provide robust analytical and theoretical generalizability (Robson & McCartan, 2015).

Lastly, it is relevant to add that this dissertation was part of a larger research project named *'Co-Design with Kids: Early mastering of 21st century skills'*. This project focussed on the successes and obstacles of developing three key 21st century skills – empathy, creativity, and communication – through design activities. As a result, the scientific, educational, and industry partners developed a toolbox together to support ways of conducting (co-)design sessions with primary school pupils.

1.4.1 Participants & Setting

The cases took place at three different primary schools in The Netherlands. The selection of schools was based on their general interest in design and technology education, specific interest in the research project, and offering favourable research environments. The participating schools all had an interest in improving their design and technology education and some experience with inquiry-based learning. In addition, they had a specific interest in the research project, which meant they supported the researchers where possible with the implementation of the interventions and gathering of research data. This interest and support from the schools created favourable conditions for the execution of the case studies, as it ensured support from the teachers within the classrooms and a dedication of resources. From each school, one class of pupils (ages 7-12) participated in a case. The pupils participated in authentic learning situations, where they became co-designers to help solve real-life design challenges introduced by real clients. Each case had its own design challenge and corresponding clients, who were also partners in the research project. The choice of clients and design challenges was predetermined due to their partnership within the overarching research project.

To complete each design challenge, the pupils were guided through the entire design cycle in a series of design sessions by researchers of the project. The design activities in the sessions were based on tools and methods from the CPS tradition (Isaksen et al., 2010; Tassoul, 2009) and design tools from the Delft Design Guide (Van Boeijen et al., 2013). Next to this, the newly developed research interventions were included, of which a peer feedback intervention is a focal point within this dissertation. Currently, the tools used and developed in the design sessions can be found on the following websites: www.tudelft.nl/codesignkids (English version) and www.tudelft.nl/yourturn (Dutch version)

1.4.2 Overview case-studies

Figure 1 gives a visual overview of the cases and studies. Table 1 provides more detailed information on the cases in terms of participants, clients, and design challenge. The first case served as a problem exploration, which corresponds with the first and second sub-question.

This case aimed to identify early indicators of design fixation within design feedback exchanges and gain insight into the interplay with the preceding feedback. Two studies were done on this first case, of which the results fed into the design of the first version of a peer feedback intervention. Next, this intervention (I1, see Figure 1) was implemented in the second and third cases, on which two overarching studies were done. These studies correspond with the third and fourth sub-question. A design iteration of the intervention was done based on an initial analysis of the second case to make grounded improvements for the third case (I2, see Figure 1). These two cases and studies aimed to develop, test, and improve a peer feedback intervention that can help mitigate pupils' design fixation and stimulate their creative thinking.

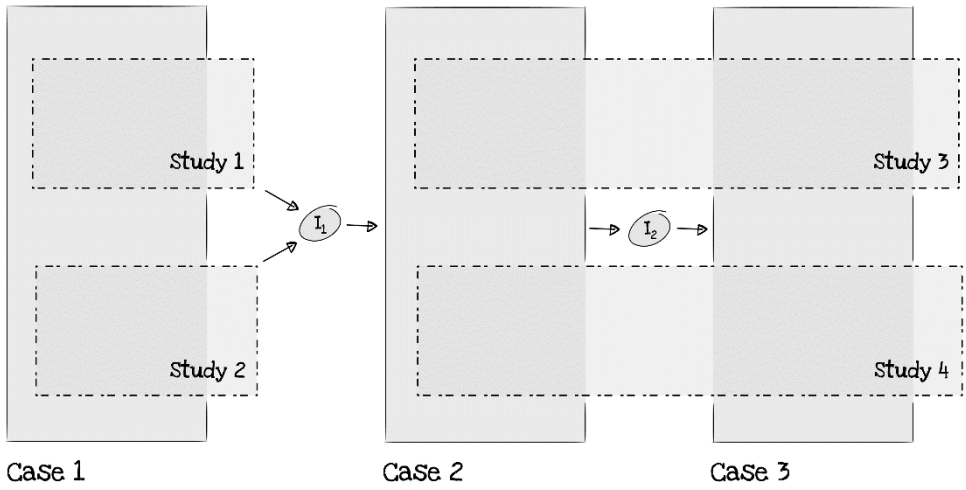


Figure 1: Overview of the cases and studies in this dissertation

Table 1 Overview of the participants, client, and design challenge per case

	Case 1	Case 2	Case 3
Education type	Theme-based education	Montessori	Dalton
Participants	School class of 24 pupils (age 9-11)	School class of 27 pupils (age 8-12)	School class of 27 pupils (age 7-11)
Client	HALO sports academy, The Hague University of Applied Sciences	Jantje Beton A Dutch NGO which promotes outdoor activities and play.	Wilhelmina Kinderziekenhuis A Dutch children's hospital.
Design challenge	Gymnasium of the future – Design a game, lesson, or sports equipment that enables pupils with different participation motives to be active together.	Outdoor education - Design something that enables regular indoor classes (calculus, language, geography, etc.) to be taught outdoors.	Wellbeing of long-term hospitalized children - Design something for the park of the hospital that enables hospitalized and non-hospitalized children to play and be active together.

1.5 Structure of the Dissertation

As described, this dissertation aims at understanding the interplay between design feedback and pupils' creative thinking processes to develop and test feedback interventions that stimulate these thinking processes and help mitigate pupils' design fixation. Through the execution of three cases and four studies (see Figure 1), the main research question - *Which qualities of design feedback processes stimulate pupils' creative thinking and mitigate their design fixation in the concept development stage of the design process?* - is answered.

The first two chapters focus on understanding the issue at hand. *Chapter 2* presents the results of the first study on the first case, which addresses the first sub-question: *What are early indicators of design fixation within pupils' design feedback exchanges, and how can they be identified?* This study dives into the occurrence of design fixation during the concept development stage of primary pupils' design processes. Although the occurrence of design fixation is commonplace, its identification mainly happens when a design project is finished. This late identification leaves a lot of teaching and learning opportunities unused. In this study, early means of identifying design fixation are uncovered through the responses of the designing pupils in the feedback exchanges with their client, peers, and facilitators.

Chapter 3 aims to further understand the occurrence of pupils' design fixation by looking in more detail at these unguided design feedback exchanges. It presents the results of the second study on the first case, which addresses the second sub-question: *What is the convergent and divergent nature of the design feedback given by the client and peers and what are the pupils' direct responses in an unguided design feedback situation?* The goal was to gain insight into the interplay between different types of design feedback and pupils' direct responses to diagnose factors hindering pupils' creative thinking. Special attention was given to those exchanges in which responses indicating design fixation were present.

The following two chapters report on the development of a peer feedback intervention and its testing in practice. The goal of the intervention was to guide the design feedback processes in a way that stimulates pupils' creative thinking and helps mitigate their fixation. *Chapter 4* presents the results of the third study on the second and third cases, which addresses the third sub-question: *In what way does the peer feedback intervention influence the convergent and divergent nature of the design feedback given by the clients and peers and the concurrent direct responses of the pupils?* It aims to understand how the intervention shaped the divergent or convergent nature of the design feedback given by the clients and peers, and the concurrent responses of the pupils. *Chapter 5* presents the results of the fourth study on the second and third case, which addresses the fourth sub-question: *In what way does the peer feedback intervention enable pupils in their process of design feedback uptake*. It aims to understand in what way the intervention was able to support the pupils beyond their initial direct responses and enable their process of feedback uptake.

Finally, *Chapter 6* summarises the main findings of *Chapters 2* to *5* and provides a general discussion about the results, limitations and future research opportunities, and practical implications of the results.

We want to notify the reader that there will be a certain level of overlap in the introductions, literature reviews, and research designs of Chapters 2 through 5. This overlap is due to the article-based nature of this dissertation and the wish to have the studies in these chapters be independently readable.

Chapter 2

Uncovering early indicators of design fixation during the concept development stage of pupils' design processes

This chapter is based on: Schut, A., Klapwijk, R., Gielen, M., Van Doorn, F., De Vries, M. J. Uncovering early indicators of fixation during the concept development stage of children's design processes. *Int J Technol Des Educ* 30, 951–972 (2020). https://doi.org/10.1007/s10798-019-09528-2

2.1 INTRODUCTION

In the world we live today, being able to behave creatively is progressively seen as a skill of great value. As introduced in the previous chapter, it is therefore no surprise that creativity is gaining more and more attention within all educational levels, and primary education is no exception. Although often believed that creativity is something a lucky few among us just inherently possess, it can be, to some extent, found in everyone (Guilford, 1987). Additionally, evidence suggests that it can be trained (Scott et al., 2004). Designing and is an undoubtedly creative activity (Barlex, 2007; Goldschmidt, 2014; Howard et al., 2007), and it therefore offers excellent opportunities for pupils to develop their creative abilities (Lewis, 2005, 2009; Rutland & Barlex, 2008). However, research has also shown that behaving creatively is not always easy for pupils. This is due to various external reasons, such as the available teaching methods, teacher beliefs (Cropley & Cropley, 2010; Thijs, Fisser, & Hoeven van der, 2014) and examination requirements (Greven & Letschert, 2006), as well as internal reasons, such as pupils' personality and their cognitive abilities (Atkinson, 2000; Lewis, 2005).

Another contributing factor is the occurrence of design fixation - a sort of block in creative thinking processes - in pupils participating in design classes (McLellan & Nicholl, 2009; Nicholl & McLellan, 2008; Nicholl & McLellan, 2007). It shows that behaving creatively doesn't always come naturally to children and that the context is of influence on the development of creative thinking (Cropley & Urban, 2000). There is a need for research that focuses on how pupils can develop their creative abilities through design-related subjects and how they can best be guided during this process. An essential part of this is to investigate the problem of design fixation in pupils, which will be the focus of this chapter.

When working towards a creative output, creative thinking processes play an essential role. Creative thinking involves the continuous shifting between two cognitive processes: divergent (DT) and convergent (CT) thinking (Finke et al., 1992; Goldschmidt, 2014, 2016). Ideation and evaluation will follow each other continuously. When designing, these two modes of thinking are needed throughout the whole process. Design fixation, commonly known as the blind adherence to a limited set of ideas (Jansson & Smith, 1991), may however occur and hamper the continuous cycles of divergent and convergent thinking. A great body of literature describes how designers often have great difficulty to avoid or overcome design fixation, and a few studies identified this problem also in secondary education (McLellan & Nicholl, 2009; Nicholl & McLellan, 2007). Ultimately, the occurrence of design fixation results in less creative

and less complete designs, e.g. not all the design criteria or needs of the user and context have been met.

Design fixation is commonly identified by analysing design ideas and produced artefacts (Sio et al., 2015; Vasconcelos & Crilly, 2016). In the classroom, design fixation has for example been identified by teachers at the end of a design project through 'stereotypical' designs that are made by the pupils (Nicholl & McLellan, 2008; Nicholl & McLellan, 2007). However, knowing that design fixation has occurred at the end of design projects is usually not helpful in moving novice designers forward. From a pedagogical viewpoint, there is a need to make design fixation visible during the design process. As this would give pupils an opportunity to overcome a creative hurdle in the specific design project at hand. In addition, the increased understanding of their own fixation will also help them to strengthen their creative thinking in the long run.

In this chapter we will therefore look for ways to identify fixation in the design process, through other methods than analysing the design outputs at the end of a design project. When designing in teams, talk is used as one of the main principles in constructing and developing design ideas. Through talk, a shared understanding of a design idea can be reached and agreements and compromises can be made (Fox-Turnbull, 2018). Therefore, the conversations held while designing may offer opportunities for the identification of design fixation. In the study presented here, we observed a group of primary school pupils (ages 9-11) carrying out a design project. We will take a closer look at the conversations that took place between the pupils, their peers, and the client to identify the fixation moments. We are especially interested in the occurrence of fixation when design ideas get developed during the later stages of their design processes.

2.2 Literature review

In this section, we elaborate on creative thinking in the context of the concept development stage and address problems that may arise. First, we discuss the role of DT and CT during the concept development stage of the design process. Subsequently, a common factor stagnating creative thinking when designing, design fixation, is explained in the context of concept development and D&T education.

2.2.1 Creative thinking during concept development

Throughout the whole design process there is a continuous shifting between divergent (DT) and convergent (CT) thinking, through which ideation and evaluation follow each other continuously (Finke et al., 1992; Goldschmidt, 2014, 2016; Isaksen et al., 2010; Tassoul, 2009). The terms 'DT' and 'CT' were first mentioned by Guilford in the 1950s (Guilford, 1956, 1962). DT

entails the generation of novelty, which is commonly thought to go hand in hand with the ability to see lots of possible answers and interpretations to a problem or issue. CT entails the evaluation of this novelty, which deals with analysing and selecting the 'best' answer to a problem or issue. As the ability to separate and alternate between DT and CT is considered extremely valuable when developing creative solutions (Guilford, 1967; Howard-Jones, 2002; Isaksen et al., 2010; Tassoul, 2009), it is important for pupils to practice this continuous alternation throughout the whole design process.

In the Creative Problem Solving (CPS) tradition idea development is explained as the stage in which an initial idea is selected and the focus lies on perfecting promising option(s) in order to end up with the best design possible (Isaksen et al., 2010; Tassoul, 2009). *Figure 2* shows Tassoul's adaptation of the CPS model in which this idea development is part of the last stage, named: 'Concept Development'. Usually, the idea that is initially selected does not have much detail yet, and not all criteria of the design problem at hand are covered. Further elaboration is needed. In addition, there can be unforeseen shortcomings within the idea that only come to light later in the design process. To identify these various sub-problems critical reflection and evaluation (CT) of the design idea is needed. When designers work on these sub-problems they need new input in the form of ideas (DT) and this, in turn, leads to the selection of one of these ideas (CT) to solve the sub-problem at hand. If too many unsolvable sub-problems arise, the decision can be made to reject the idea and start over, or merge elements of the idea with another idea.

Tassoul acknowledges the equal importance of DT and CT, and the necessity of the alternation between the two in order to fully develop ideas (Tassoul, 2009). The importance of these iterative processes are made visible by three spiralling lines in the model (see *Figure 2*). As the number of alternations of DT and CT increase, the design process becomes more sophisticated (Mioduser & Kipperman, 2002). Ideally, design ideas keep on developing and continuously improving in order to manifest into the ultimate design, which embodies all the desired design requirements. Here we focus on the concept development stage to gain insight into one of the hurdles in pupils' creative thinking when they develop their design ideas, namely design fixation.

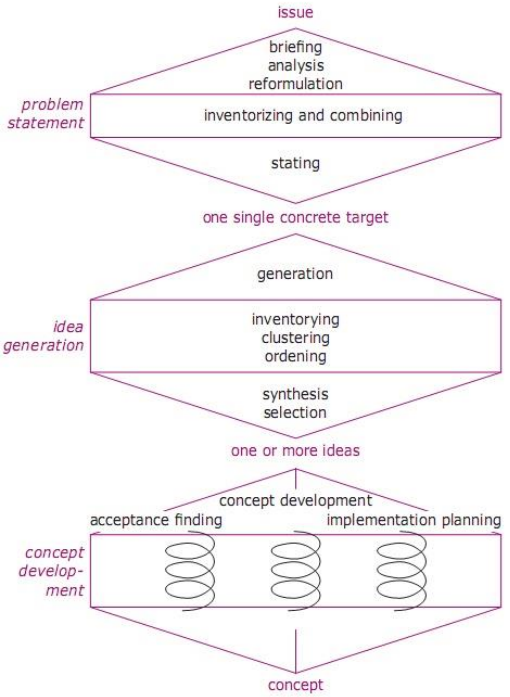


Figure 2 The Creative Problem Solving (CPS) model (Tassoul, 2009)

2.2.2 Design fixation

The repeated alternation of DT and CT during the concept development stage is not without effort and can be easily stagnated by many factors. One of the factors hampering this alternation in the creative thinking processes is the occurrence of 'fixation'. In its most broad definition fixation can be described as a sort of mental block (Finke et al., 1992). It is a very common phenomenon which is not only limited to creative processes, but can occur in a wide variety of cognitive domains (Finke et al., 1992). Its occurrence in creative processes has been, and still is, researched quite extensively. Predominantly in relation to creative idea generation (Crilly & Cardoso, 2016; Smith et al., 1993). One of the first well-known examples of fixation stems from research into creative problem-solving within the domain of psychology and is that of Duncker's candle problem (Duncker, 1945). In the candle problem, subjects are expected to attach a candle to a vertical surface and light it without letting wax drip on the table surface by making use of a box of tacks and a book of matches. Fixation, or here called functional fixedness, is then observed through the inability of the subjects to produce alternate functions for the given objects in order to solve the problem.

Jansson and Smith (1991) were the first to conduct research into the fixation in the domain of engineering and design, in which they tested the effects of examples on creative idea generation. Their results showed that the examples shown to the subjects induced conformity within their designs. The fixated mindset of the subjects constrained their creative idea generation. Even when they were specifically told to diverge as much from the examples as possible the fixation effect persisted. Additionally, one version of their experiment showed that even experienced designers fixate on attributes in the example designs, despite their clear undesirableness. Jansson and Smith refer to design fixation as "a blind, and sometimes counterproductive, adherence to a limited set of ideas in the design process" (Jansson & Smith, 1991). Purcell and Gero (1996) also note the aspect of premature commitment to a particular problem solution: "…the designer appears trapped by the characteristics of a possible solution that has been developed or an existing precedent solution". There are a number of causes that can contribute to the emerging of design fixation: example solutions, inspirational material, ill-defined problems, expertise or unfamiliarity with certain domain knowledge, previously generated ideas, feelings of ownership and it appears that even the will to be 'different' can cause design fixation (Jansson & Smith, 1991; Moreno et al., 2015; Purcell & Gero, 1996; Smith, 2003).

Most research on design fixation focuses on the idea generation phase in the early stages of the design process. Specifically, the influence of external stimuli on creative idea generation, like example solutions and inspirational material, has been researched rather extensively. A literature review focussing on this type of design fixation by Vasconcelos and Crilly (2016), in which they highlight the similarities and differences between the different studies and suggest several recommendations, gives a good overview of its current state of the field (Vasconcelos & Crilly, 2016). In a report summarizing the results from an international workshop focussed on the future of design fixation research, Crilly and Cardoso (2016) even propose a specific name for fixation on idea generation in the earlier phases, namely '*ideation fixation*'. Further, they suggest several opportunities for future research, one of which is the occurrence of design fixation during later stages of the design process (Crilly & Cardoso, 2016). Next section will introduce design fixation in relation to concept development.

2.2.3 Concept fixation

Design fixation can also occur during the concept development stage of a design process. To clarify the difference between this type of fixation in relation to fixation in the idea generation phase, we propose the term '*concept fixation*' to indicate this type of fixation. *Concept fixation* leaves the designer stuck in a certain train of thought, adhering to the current (possibly unfavourable) state of the design (idea). This adherence can range from small details to key features and components. Through it (sub)problems within the are idea easily overlooked and requirements are sooner thought to be already embodied within the design. Consequentially,

success in developing a design idea then depends on one's ability to abandon this train of thought and generate alternative ones (Smith, 1995). Only then the continuous alternation between DT and CT can continue through which an idea can be adjusted and elaborated on in order to embody all the design requirements and fully solve the problem at hand.

2.2.4 Fixation in young novice designers

In the context of design and technology education, design fixation is mainly researched in the design processes of university students. Yet there are examples of research into the occurrence of design fixation in secondary and primary education settings. Rather well-known is the work of Nicholl and McLellan, who researched the phenomenon of design fixation in secondary design and technology (D&T) students (ages 11-16). In their research, it was acknowledged by students and teachers alike that generating original ideas is difficult for the students. Many of the generated design ideas are derived from popular culture or examples shown by the teacher, since this is an easily accessible source of inspiration for them (McLellan & Nicholl, 2009; Nicholl & McLellan, 2007b). As a result, many of the designs became stereotypical in nature, showing the *ideation fixation*-effect and exemplifying how thinking along the 'path-of-least-resistance' can influence a design (Ward, 1994).

It also became apparent that students became fixated on the first idea that came to mind and that they were not motivated to think of multiple ideas. They did not understand the concept and the possibility of accepting or rejecting ideas. The students simply wanted to go with their first idea for which they had already worked out how to proceed. As one teacher stated in Nicholl and McLellan's research: "*They get a fixed image, that's what I want to make. It's very hard to make them see that you can change and modify this. They're fixed, they think now that's what I want and that's what I'll do*" (Nicholl & McLellan, 2007). Here we see how the occurrence of *concept fixation* hampers the student's creative thinking processes. The students' fixation on the constructed image of the final design prevents them from further developing their idea. Since they already have an exact image of how the design will look and function their creative thinking is set to a halt. Their CT is hampered because they see no need to critically reflect on the state of their already 'perfect' design. Consequently, they will also not explore alternative solutions for these sub-problems within the problem space (DT).

A case study by Luo (2015) found comparable results regarding design fixation during an engineering design project with primary school students aged 8 to 11. Similar to the results of Nicholl and McLellan, these younger students fixated on popular culture, common features, and their first design ideas (Luo, 2015). Although the distinction between ideation fixation and concept fixation is not made in these studies, the results show that both types of design fixation can occur from a young age.

2.2.5 Identification of design fixation

Currently, design fixation is mostly identified and studied indirectly by analysing design ideas, prototypes and artefacts when a design process has ended (Sio et al., 2015; Vasconcelos & Crilly, 2016). Also in the classroom, design fixation is only assessed at the end of a design project through 'stereotypical' designs that are made by the pupils (Luo, 2015; Nicholl & McLellan, 2007a, 2008). At that moment it is too late for the pupils avoid or overcome their fixation. Identifying fixation during the design process, instead of when the project has already ended, can transform the occurrence of design fixation into a learning process through which DT and CT can be practiced. For that reason, we want to find ways through which concept fixation can be identified during the concept development stage of a design process.

We expect that the analysis of conversations that take place about design ideas, prototypes and artefacts offers opportunities for the early detection of fixation during concept development. When designing in teams, talk is used as one of the main principles in constructing and developing design ideas. Through talk, a shared understanding of a design idea can be reached and agreements and compromises can be made (Fox-Turnbull, 2018). We expect concept fixation to become visible through friction in the conversations in which the young novice designers show resistance towards external comments, suggestions and questions regarding the development of their design idea. There are for instance examples of students reacting 'negatively' to design feedback from their instructors and clients to keep the imagined construct of their design intact. We will introduce this in the following section.

2.2.6 Design feedback sessions

Feedback interventions, or design reviews, are common educational practice in design disciplines at university level (Goldschmidt et al., 2010; Yilmaz & Daly, 2014) and can benefit the design process greatly (Crilly, 2015). During these design reviews, the students communicate their design ideas, goals and expected user interactions in words, sketches and early models to the instructor, their peers and other stakeholders. They, in turn, react with questions and comments in order to get clarification on aspects of the design and the choices made. This feedback can encourage the students to take convergent or divergent paths in their design process (Cardoso et al., 2014; Yilmaz & Daly, 2014, 2016), helping them with the development of their design idea.

When receiving feedback on their design there is always an inherent contradiction with which designers have to deal. As Crilly states, "Designers must remain open to the possibility that their ideas are limited or misdirected whilst also being persistent in developing their nascent ideas in the face of negative feedback" (Crilly, 2015). When a designer is too persistent in developing an idea, fixation can emerge. Alternately, when a designer is too open to the possibility that something might be wrong with their ideas, it might be that many valuable ideas never get developed (Csikszentmihalyi, 1999). So, in conversations a designer has to balance

between openness and persistence. We presume that the tension that occurs in this balancing process can offer an opportunity to observe the occurrence of concept fixation.

We expect this tension between openness and persistence to become visible through the manner in which the pupils react towards the design feedback that is posed. Research has for example shown that university students can react negatively towards feedback that asks for clarification of certain aspects of the design. As a result, they either end up being too descriptive (Cardoso et al., 2014) or become defensive and try even harder to convince everyone of the quality of their design (Cardella et al., 2014; Cummings et al., 2015). These types of interactions could inhibit a student's critical thinking processes, since they will not easily engage in reflective or evaluative thinking about the state of their idea when they feel they have to justify it.

2.3 RESEARCH DESIGN

As discussed in *Chapter 1,* an educational design research approach was implemented, comprising a series of case studies with in-depth analysis using qualitative research methods (Bakker, 2018; Yin, 2014). Here we present the first study of the first explorative case, which is focussed on identifying and understanding the problem. In this explorative case, we facilitated a class of primary school pupils through a series of design sessions in which they created solutions to a real-life design challenge. Our goal was to identify indicators of design fixation through the conversations that took place during the later stages of their design process. This was translated in the following explorative research question: *What are early indicators of design fixation within pupils' design feedback exchanges, and how can they be identified?*

2.3.1 Participants

The design sessions took place at a primary school in the Netherlands. The selection was based on the school's availability, their interest in design and technology education and a wish to experience a hands-on project giving new insights on how to implement design and technology within their curriculum. The participating school is, as they state, 'development-focused', meaning that umbrella themes are used to integrate different learning subjects over the course of a few weeks. The pupils are accustomed to collaborating in teams over a longer timeframe on a range of educational activities. In this study, one class participated over a period of seven weeks in March and April of 2016. The class consisted of 24 pupils, ranging between 9 to 11 years old. The class of pupils had not participated in any design project prior to this one. The class was divided into six gender-mixed teams of four pupils by the teacher. When dividing the pupils into teams, the teacher was instructed to provide in each team a mix of different 'types' of pupils to create heterogeneous teams. As Kolb's learning styles are generally known by the teachers in the Netherlands through a simplified categorization, namely: dreamer, doer, thinker

and decider, this was chosen as a guide to compose the teams. In addition to this, the teacher was asked specifically to pay attention to pupils' abilities to lead so that each team would, ideally, have one leader.

2.3.2 Design problem

The pupils worked on solving a real-life problem which was made available by the HALO sports academy, which is part of The Hague University of Applied Sciences in the Netherlands. The design assignment was presented as follows: "Design a game, lesson or sports equipment for the gymnasium of the future that enables pupils with different participation motives to be physically active together." An example of different 'participation motives' is a child who enjoys a competitive component during physical activities and plays to win versus a child who enjoys playing together, regardless of winning or losing the game. A problem owner from the HALO, who acted as a client, introduced the design assignment and was present during several of the design sessions to give feedback on the pupils' design ideas.

2.3.3 Design sessions

Over the course of seven weeks, the pupils participated in teams in weekly design sessions of 90 to 120 minutes in which the teams were led through different diverging and converging stages. *Table 2* presents an overview of the design sessions with the corresponding activities and how they related to each design phase. The connection to the design phases was based on a general representation of the design cycle that is used in primary schools in the Netherlands (*Figure 3*). The design activities were based on tools and methods from the CPS tradition (Tassoul, 2009) and design tools from the Delft Design Guide (Van Boeijen, Daalhuizen, Zijlstra, & Van der Schoor, 2013). These methods and tools were transformed for use at primary school level in collaboration with the Science Hub Delft (Wetenschapsknooppunt Zuid-Holland, n.d.), an organisation who develops educational material for primary schools to help develop research and design skills. The tools and methods were used during the design sessions to guide the teams through their design process. Examples of these tools and methods during the later stages of the design process, from session 4 onwards, were feedback interventions, prototyping and guidance from the facilitators through questions and suggestions. An overview of the design sessions can be found in *table 2*. Although we expected these tools and methods to help the teams engage in DT and CT and develop their idea further during the later stages of their design process, we did not try to intentionally counteract or evoke *concept fixation* within the teams.

Table 2 Overview of the design sessions, facilitation style, activities and corresponding relation to each design phase. The highlighted sessions were selected for in-depth data analysis

Session	Facilitation	Design phase	Activities
1	classroom facilitation	Exploring & Formulating design problem	- Introduction of the design assignment by the client. - Experiencing different sport preferences and participation motives within the class through group activities led by the client. - Timeline visualization of positive and negative physical education experiences. - Brainstorm to shed first ideas.
2	Separate team facilitation	Exploring & Formulating design problem	- Constructing interview questions. - Practice interview. - Homework: do interviews with other pupils.
3	Separate team facilitation	Generating & Selecting ideas	- Discussing the interviews. - 3 brainstorm techniques. - Categorization of all ideas. - Idea selection. - Top 4 selection.
4	Classroom facilitation	Generating & Selecting concepts	- Make a small model/first prototype of two ideas. - Feedback on ideas from the client and peers. - Selection of one idea.
5	Separate team facilitation	Building a prototype	- Make a building plan. - Build a prototype with provided materials. - Make a testing plan.
6	Classroom facilitation	Testing & Optimizing	- Build-up for the test. - Test with other pupils. - Get feedback from testers. - Think of implications for design.
7	Classroom facilitation	Presenting	- Present the design to the client and peers and receive feedback.

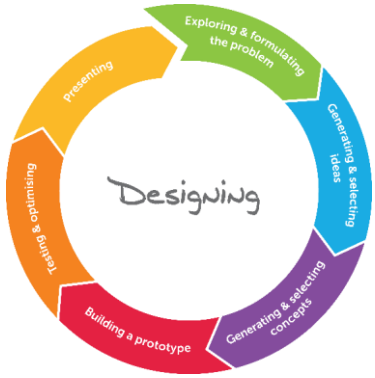


Figure 3 Representation of the Design Cycle by the Science Hub (Klapwijk, 2017)

2.3.4 Facilitation

Three facilitators were present during the design sessions to facilitate the teams. Each facilitator was assigned two teams. Two facilitators, the first and second author, had a double role as researcher within the project. The client was present during sessions 1, 4 and 7 in which he actively participated by explaining the design assignment (session 1) and giving feedback on the design ideas (session 4 and 7). During session 1, 4, 6 and 7, which were organised in a classroom setting, the teacher of the class was also present, yet did not guide the sessions.

2.3.5 Setting

During design session 2, 3 and 5, the teams were facilitated by their assigned facilitator in separate sessions in separate rooms. Session 1, 4, 6 and 7 took place in a classroom setting in which all teams participated simultaneously in one session.

2.3.6 Data collection

The seven design sessions were audio and video recorded and the materials that the pupils produced during the sessions were photographed.

2.3.7 Data analysis

To analyse this stagnation in the development of the design ideas, we focused on the conversations that took place between the design team, their peers, the client and the facilitator during session 4, 5 and 7. During these sessions, the teams had selected their initial design idea and were expected to develop their idea further. In session 4, the teams had

selected their initial design idea and received feedback on their idea from their peers and the client. In session 5, the teams worked on building a prototype of their idea and in session 7 the teams presented their final design idea to the client and their peers and, again, received feedback. Two researchers transcribed the audio and video data of all the sessions, focusing on the discussions between the team members, their peers, facilitators and the client.

The purpose of our analysis was to look for possible indicators of concept fixation within the design teams through the conversations held with the client, peers and facilitators. This means that we looked for moments during which the pupils show adherence to their design idea (too much persistence) and a lack of openness to consider the questions, comments and suggestions posed about the state of the design ideas. The explorative nature of this study and limited previous research on design fixation in pupils' design processes led us to conduct an inductive data-driven approach. This approach was similar to the work of Yilmaz & Dali (2016), who researched possible design feedback types and structures in the context of university students.

Firstly, the entire dataset was analysed through the constant comparative method (Glaser, 2008; Glaser & Strauss, 1967), to let recurring patterns indicating concept fixation emerge. This process of categorization was executed in three rounds by the same two researchers who also transcribed the audio and video data. During each categorization round, each researcher first individually selected sections of conversation indicating concept fixation. Afterwards, these individual selections were followed by sessions in which the researchers compared their individual categories. After three rounds, a consensus was reached on the final categorization and four categories were formed.

Secondly, we attempted to refine these categories by comparing them to the student response framework from Cummings et al. (2015) and Cardella et al. (2014). This framework was inductively constructed to analyse the responses of university design and engineering students towards design feedback they received. Although the framework does not aim to identify design fixation, we had strong suspicions that four codes from this framework could be an indication of concept fixation and therefore have similarities to the categories we found. These codes are: defend, ignore, denial and compensation. When comparing the codes to the categories, we noticed that the codes could be applied to the same sections of conversations as that of the categories found. Yet the codes grouped the types of concept fixation differently than the categories composed through the first analysis. For example, most of the sections could be coded with 'compensation', while the categories found by us distinguished more between the different manners in which concept fixation was expressed by the pupils. Therefore, the decision was made to keep the four categories found in the first analysis.

2.4 Findings

The preliminary findings of our analysis have been presented at the E&PDE conference in 2017 (Schut et al., 2017). Based on the received feedback, we expanded the description of the results and incorporated more detail. Here, we will discuss several moments during which the pupils' exhibited fixation on their design idea. This concept fixation was observed through the manner in which the teams responded during conversations with their peers, facilitators and the client in sessions 4, 5 and 7. The response behaviours from the teams, indicating concept fixation, could ultimately be grouped into four categories. We named these categories: *'band-aids', 'already-in-there', 'question-not-relevant'* and *'it's-not-possible'*.

The following sections introduce these four categories through examples of conversations that took place between the pupils, facilitators, and the client. Each section describes a category of response behaviour indicating concept fixation. The pupils that were part of the design team that the example focusses on are indicated as 'pupil' and, if necessary, a number. The pupils that were not part of the team are indicated as 'classmate' and, if necessary, a number. The client and facilitators are indicated as such.

2.4.1 Band-aids

The first category of response behaviour that we will present is what we named '*band-aids*'. There was a clear instance of the use of this type of response behaviour when the teams got feedback on their design idea during sessions 4 and 7. *Band-aids* are adjustments or additions to the design idea that leaves the core of the idea intact and do not present a possible valuable and relevant development. They are 'quick fixes' used to 'patch up' any flaws in the idea.

The 'everyone is different' example illustrates the *band-aids* response behaviour of one of the teams when they got feedback on their idea during the 7th session. In the example, the team had just presented their *maze-game* idea to their peers and the client. Their idea consisted of a maze in which different types of games can be played. the maze consisted of the equipment that is normally used during physical education classes. *Figure 4* showcases images of the maze that the team built. The client started the conversation by asking a question related to one of the criteria present in the design question, namely, different participation motives.

> Everyone is different
> Client: *Is it suitable for the different types of movers during physical education?*
> Pupil 1: *In a sense, yes. If for example something is wrong, so you can't run or walk or something. Yeah, then. Uh. Or you can be there as a referee or you stand behind the line with the pawns. As a referee, you can check if the players don't cheat when they hide.*
> Client: *Uh yes, ok. Uh. And what if I would like to stay very fit? If I would be a player and find that important.*
> Pupil 2: *Yes, well then you just have to run many laps.*

> Client: *Yes, so than I should make it more difficult for myself? Yes. Well, I guess that's possible. Ok.*

In a sense, the pupils showed DT as they generated a number of options to make the maze-game suitable for different types of movers. Nevertheless, something can be said about the quality of the options mentioned. The proposed 'referee' idea, as well as the 'run many laps' idea, did not transform the idea of the maze-game to be intrinsically suitable for different types of movers. Both ideas made use of external systems that compensate for possible problems in the game itself. The difference between *band-aids* and idea development is that *band-aids* do not solve the actual problem within the idea and often lead to new problems. For example, the 'referee' idea appeared to solve the problem of a player not being able to run or walk. However, what if there are more players with the same problem? What about the players that cannot really run that hard or long to begin with? In addition, the player that is a referee does not really participate in the game, which could be quite demotivating. When pupils engage in *band-aids* response behaviour, the possibility for critical evaluation of the idea is set to a halt because the problem appears to be solved. As a consequence, the openness and reason to keep exploring alternative solutions is lost.

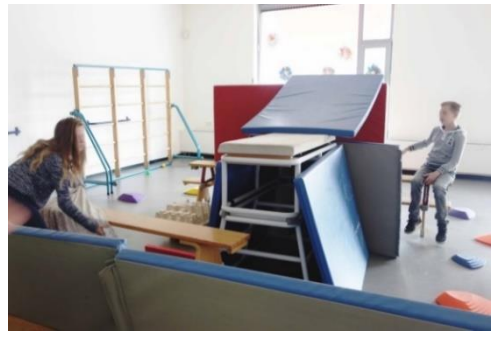



Figure 4 Images of the *maze-game* idea. Both pictures illustrate the equipment used to build it. In the image on the right, the maze is being used by players to hide from another player holding a big ball

2.4.2 Already in there

Another category is '*already-in-there*'. This type of response behaviour was detected during the 4th and 7th sessions during the moments when the teams got feedback from their peers and the client on their design idea. The *already-in-there* response entails that whatever others might detect as missing from the idea is, in fact, not missing since it was already present within the idea all along. However, that which is suddenly present within the idea according to the design team was never mentioned before the moment that others point it out as missing.

The 'it's all-in-one'-example is from the 4th session and illustrates a team engaging in *already-in-there* response behaviour. One of the teams presented their design idea about a device that combined a lot of sports in one object. *Figure 5* showcases images of this design idea. On the spot, more sports were added to the idea. The additions that were mentioned in the conversation were not mentioned or discussed before within the team.

> It's all-in-one
> Classmate 1: *What about if you want to do handball?*
> Pupil: *You can do that as well with it.*
> Classmate 1: *And if you like to play football?*
> Pupil: *You can do that as well.*
> Classmate 2: *So, it is all-in-one, and there is no korfball.*
> Pupil: *Yes, there is korfball in there!*

In a way, the conversation shows a development of the existing design idea through several elaborations. However, Pupil 2 is also deflecting the questions by stating that everything is already present within the design. The team does not seem to use the feedback from others to evaluate the quality of their design and to see if any further development is needed. Feedback appears to be something that needs to be contradicted. Instead of something from which they can learn and which can help them to critically evaluate their design idea.

Figure 5 Images of the *all-in-one* idea. The images illustrate a clay model that represents a new type of sport equipment with which many different types of sports can be played.

2.4.3 Question not relevant

'*Question-not-relevant'* is a type of response behaviour which, just like *band-aids*, peaked during the 4th and 7th sessions. Engaging in *question-not-relevant* response behaviour indicates that the feedback given is not relevant to the design idea. The following examples will illustrate this type of response behaviour. In both examples, the same team gets feedback on their idea, which they called *b-games*. Images of the idea are made visible in *figure 6*. The idea entails a sort of

virtual reality dome in which different sports can be played. In the 'no friends needed' example below, a classmate suggests thinking about playing the designed game together with other pupils.

> No friends needed
> Classmate: *How can you do this game with friends?*
> Pupil: *Well. You don't have to do it with two people, you can also do it alone*
> Classmate: *Okay…*

The classmate's question stems from the design question given by the client, which mentions pupils being active together. One of the pupils from the design team answered that the game could be played alone, implying that no other players are needed. This left the classmate a bit puzzled. Since the classmate did not connect the feedback back to the design problem, it appeared to be a personal preference instead of a reference to the design criterion that was still missing. This could, in turn, explain the response behaviour of the team.

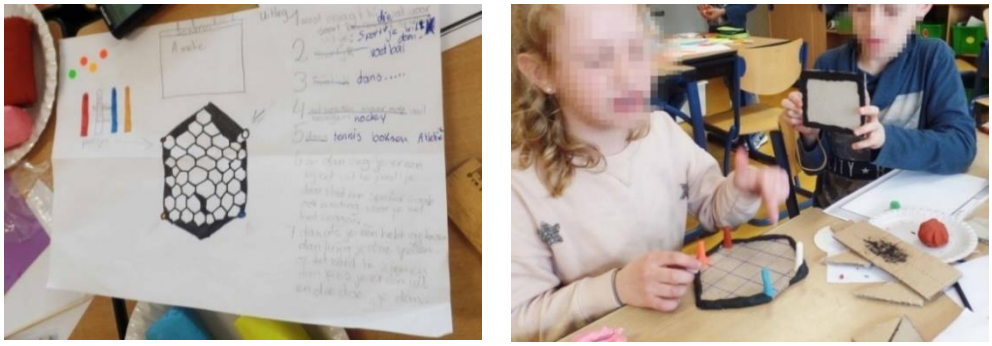


Figure 6 Images of the *b-games* idea. The left image shows a sketch of the idea. The right image shows a clay model of the idea and two of the team members who demonstrate the model. One team member points at the virtual reality dome and the other team member holds up a screen, which is part of the dome

A second example, 'no handball included', showcases a different manner in which the *question-not-relevant* response was observed during the sessions. After presenting their idea, a classmate then asked a question about a technical aspect of the idea.

> No handball included
> Classmate: *If you for example throw a ball during handball, then the computer can never know how fast you throw. Because he can also not…*
>
> Pupil: *But we don't offer handball.*

Here, the core of the question – how the speed of a ball thrown could be measured within the game – was ignored by the team. Instead, it was made clear that the sport used as a reference in the question was not part of their design idea. In both examples, engaging in *question-not-relevant* response behaviour enabled the team to ignore the core of the question and show that their idea still 'worked' by giving a deflecting answer.

2.4.4 It is not possible

The last category of response behaviour we will present in this paper is *it's-not-possible*. This response behaviour deems whatever is proposed or suggested as not feasible within the design idea. It was observed in session 5 and session 7. The following 'too light, too dark' example illustrates how a design team repeatedly engages in *it's-not-possible* response behaviour during the 5th session. In the example, the pupils of the team discussed a possible adjustment to their design idea, which was proposed by one of the team members, to make the design more interesting for the players.

> Too light, too dark
> Pupil 1: *What if we make it (the gym) dark?*
> Pupil 2: *That's impossible, the lights go on when you enter the gym.*
> Facilitator: *Well, I'm sure we could turn off the lights.*
> Pupil 2: *It is still too light because of the window.*
> Facilitator: *We could cover the windows.*
> Pupil 1: *Than it is too dark, pupils won't be able to see, that is dangerous.*

After Pupil 2 rejected the idea as not possible, the facilitator tried to prompt the idea development by proposing several alternative solutions yet the team did not see the same possibilities as the facilitator and, in the end, even Pupil 1, who suggested the idea, rejected the idea altogether.

The next example illustrates a team engaging in the *it's-not-possible* response behaviour during the 7th session.

> We can't do it
> Client: *I might have a tip. Maybe you already know this, but I'm always looking for how you can make something easier or more difficult. That you can customize it for all players. Is that possible?*
> Pupil: *Yeah, that was the idea you proposed, with the camera. That you think that someone is far away, but then they are very close. But we thought, we cannot really test that easily with the other pupils from our school.*
> Client: *No, I understand. Also, I think that will mostly make it more thrilling.*

The client appeared to try to get the team to think about possible solutions to meet, what was to him, an important design criterion: customizing the difficulty level for players. The team then referred back to an idea that the client had previously posed to them, which could be a solution to meet the design criteria, stating that they would not be able to execute an idea like this. Both examples show how the teams parried a DT process by stopping it before it even began, making it difficult for the facilitator and client to continue the line of questioning.

When evaluating all four types of response behaviour, we conclude that engaging in these response behaviours allowed the teams to keep the core characteristics of their idea intact and unchanged, therefore leaving the teams fixated on the current state of their design idea.

2.5 Discussion and conclusion

The presence of design fixation during the pupils' design process is not a new phenomenon (Luo, 2015; McLellan & Nicholl, 2009; Nicholl & McLellan, 2007). Yet where most work on design fixation analyses it by looking at the design ideas or produced artefacts, this research shows that it is also possible to signal design fixation through the conversations held in a classroom. Additionally, the focus lies on design fixation that occurs during concept development in the later stages of the design process, which we named: *concept fixation*. Four categories of response behaviours indicating concept fixation were uncovered during our analysis. Through several examples we aimed to illustrate these four behaviours. *Table 3* gives an overview of the response behaviours that we uncovered and the effect each type can have on the creative thinking processes and, as a result, on the development of a design idea.

All four types of response behaviours allow the design teams to keep the core characteristics of their idea intact and unchanged, therefore leaving the teams fixated on the current state of their design idea. In the 'band-aids' and 'It's not possible' categories, the sub-problems within the design idea, or the opportunity proposed, is acknowledged. However, this feedback is also directly parried by either proposing worthless and irrelevant adjustments or elaborations (*'band-aids'*) or completely dismissing what is proposed as not feasible *('it's not possible'*). In the other two categories, 'already in there' and 'question not relevant', the sub-problems within the design idea, or the opportunity proposed, is not acknowledged. The feedback that is given is either ignored by indicating it as irrelevant (*'question not relevant'*) or dismissed by stating that any uncovered shortcoming or missing element was already present and working within the design idea (*'already in there'*). As a result of engaging in any of the described response behaviours, the feedback given is not used to critically evaluate the state of the design. We speculate that the absence of this critical evaluation let the teams to believe their designs were already in a 'complete state' and no sub-problems were present. This hampered their creative thinking by bringing continuous alternation of DT and CT to a halt. Since critical evaluation (CT) was absent, possible sub-problems within the designs were not

uncovered. Consequently, there was no need to generate new ideas (DT) to elaborate or adjust the design.

Our results show that young novice designers (age 9-11) do not necessarily show to critically evaluate their own design in the concept development stage of the design process. Even though tools and methods were in place, like the feedback interventions, that are commonly thought to help idea development (Crilly, 2015). This lack of evaluation of young novice designers is also observed in the field of linkography by Blom and Bogaers (2018). The field of linkography studies design cognition by analysing small increments of divergent and convergent thoughts. Here, Blom and Bogaers (2018) obtained results suggesting young novice designers (age 13-14) engage in limited critical convergent thoughts while designing compared to older novice designers, like university students. They found that the young designers proposed many new thoughts and ideas, but did not necessarily develop, evaluate or summarise them (Blom & Bogaers, 2018). In their research no tools or methods were used to guide the young designers through their design process, giving insight in to their 'natural' thinking processes. Similar to ours, their results suggest that critical reflection does not happen 'naturally' in pupils.

In the context of D&T education critical thinking is progressively seen as an important skill (Williams & Stables, 2017). By practicing critical thinking and reflection within a design process the pupils will not only be able to better optimize the design they are working on, but it will also help them develop their personal critical view on design and technology in relation to this world. While designing they will uncover a wide range of questions: about ethics, economics, sustainability, usability, values, emotions and others, on what they plan to make and the impact it might have on its future users and surroundings. As Keirl puts it: "*Critiquing is an excellent tool for arriving at the best defensible compromise*" (Keirl, 2007). The ability to think critically about one's own design can prove valuable to eliminate or overcome concept fixation. In this study the focus is on the early identification of concept fixation. Therefore, we did not explore the reasons why the design teams might have experienced this type of fixation during their design processes.

The parrying of feedback by the design teams suggests that they might have felt too much attachment to their design ideas, creating strong feelings of ownership. Research by Baer and Brown shows that too much ownership can lead people to only selectively adopt given feedback (Baer & Brown, 2012a). Their findings suggest that the nature of the proposed change in combination with the feeling of loss and the negative effect the person might feel directly influences whether they remain open to or resist suggestions for change. This phenomenon is also known as 'kill your darlings', which is a phrase that in some creative processes is used by a facilitator or team member to remind one that sometimes you just need to let go of an idea (Tassoul, 2009). Following the research of Viswanathan and Linsey (Viswanathan & Linsey, 2011) we can speculate that the early first prototypes that the pupils made during the 4th design

session (see *table 2*) might have created or enhanced any feelings of attachment to their design idea. Yet feelings of attachment and ownership that a designer might have towards their design ideas do not necessarily have a negative impact on idea development. They can, for instance, help develop promising ideas of which the potential might be more hidden in the beginning of the design process.

Table 3 An overview of the four uncovered response behaviours with a description of the behaviour and the possible effect on the creative thinking processes and the development of a design idea.

Type of response behaviour	Description of the behaviour	Effect of the behaviour
Band-aids	Proposing adjustments or elaborations that don't present a valuable and relevant development and leave the flawed core of a design idea intact.	By proposing adjustments or elaborations, the uncovered sub-problem(s) appear to be immediately solved. Consequently, no critical evaluation takes place and the openness to generate alternative solutions to improve the design is lost.
Already in there	Dismissing uncovered shortcomings by stating (falsely) that they have been present within the design idea all along.	By stating that the uncovered shortcomings and missing elements were present within the idea all along, the design becomes an all-encompassing idea. The uncovered sub-problems are deemed as non-existent. Consequently, no critical evaluation takes place and the openness to generate alternative solutions to improve the design is lost.
Question not relevant	Indicating that the given feedback holds no relevance to the design idea.	By indicating that the feedback holds no relevance, the design idea is still proven to be correct and 'working'. The uncovered sub-problems are deemed as non-existent. Consequently, no critical evaluation takes place and the openness to generate alternative solutions to improve the design is lost.
It's not possible	Dismissing proposed adjustments or elaborations on feasibility without proper evaluation.	By immediately rejecting proposed adjustments or elaborations due to non-feasibility, the underlying sub-problems these might tackle do not get uncovered. Consequently, no critical evaluation takes place and the openness to generate alternative solutions to improve the design is lost.

Furthermore, we assume that the type of feedback given might have been unfitting in some instances, therefore pushing the teams even more into a fixated mindset. Interventions and methods that give feedback are regarded by experienced designers as a means to counteract fixation and help idea development (Crilly, 2015). Feedback has the ability to encourage a designer to take DT as well as CT paths during their design process (Cardoso et al., 2014; Yilmaz & Daly, 2014, 2016). A designer has to develop the skills to be able to balance between remaining open to possible flaws within the design ideas, yet also persistent in developing a promising idea despite receiving negative feedback (Crilly, 2015; Csikszentmihalyi, 1999). Nevertheless, our results show that feedback on (intermediate) design ideas does not necessarily help young novice designers (pupils age 9-11) to develop their ideas. Specifically, their lack of critical evaluation left sub-problems within their design hidden and discarded the need and openness for new generative processes. This stagnated their creative thinking processes by hampering the continuous alternation of DT and CT, which ultimately effected the development of their designs.

2.6 Implications & future research

The four response behaviours that we have uncovered and described are not meant to be a full overview of all possible types. We expect that there might be more response behaviours indicating concept fixation. Therefore, more research is needed on the conversations that take place during design processes, both inside and outside design teams. Not only to gain insight into response behaviours indicating concept fixation, but also those indicating success in balancing between openness and persistence. For now, we expect that the indicators we found - 'band-aids', 'already taken care of', 'question not relevant' and 'it's not possible' – will be helpful in identifying concept fixation during the design process, especially in an educational context. The process of identification of fixation, and reflecting on it, creates awareness. This is considered as an important step by professional designers towards guarding oneself from fixation episodes in future projects, and thus being more creative (Crilly, 2015).

For educators, this identification can lead to an adjustment in facilitation techniques in order to help pupils practice and enhance their CT and regain openness in the design process to start new DT processes. This aligns with suggestions from Nicholl and McLellan, who also believe that targeted intervention from the person facilitating is needed to prevent and/or overcome design fixation (Nicholl & McLellan, 2007). In our future cases, we will focus on creating interventions to help pupils to become aware of concept fixation and stimulate their divergent and convergent thinking processes to ultimately avoid or overcome their fixated mindset. We expect that the development of pupils' critical thinking skills will play a central role within these interventions.

Chapter 3

Pupils' responses to divergent and convergent design feedback

This chapter is based on: Schut, A., Klapwijk, R., Gielen, M., & De Vries, M. J. (2019a). Children's responses to divergent and convergent design feedback. *Design and Technology Education: An International Journal,24*(2), 67–89.

3.1 INTRODUCTION

The study in the previous chapter shows that feedback given to primary school pupils while designing does not always spark creative thinking and a set of response behaviours indicating design fixation were uncovered by analysing these feedback conversations (Schut, Klapwijk, Gielen, van Doorn, et al., 2019). It is commonly thought that receiving design feedback from others is one of the factors that can contribute to this and benefit the creative design process greatly (Crilly, 2015). Design feedback can help guide the creative thinking processes - divergent and convergent thinking - that are present in a design process. Design feedback can push towards convergence by suggesting evaluation, reflection and decision making. Or push towards divergence by suggesting the exploration of alternatives. Yet, one may ask if the divergent or convergent nature of the feedback always elicits the expected responses and therefore push towards the intended direction in one's creative process. Design feedback is expected to help novice learners gain insight in their creative processes and design decisions (Cardella et al., 2014; Cardoso et al., 2014; Cummings et al., 2015; Schut, Klapwijk, Gielen, van Doorn, et al., 2019), yet, as the previous chapter shows, it can also uncover or evoke resistance.

In this chapter, we will therefore look at the same case to analyse feedback conversations that take place between the pupils who are designing, their peers, and the client during the later stages of their design processes. Our goal is to identify the divergent and convergent nature of the design feedback present in the critiquing moments and the various responses of the pupils to this feedback. This is translated into the following explorative research question: What is the nature of the design feedback that is given by client and classmates and how do the design teams respond to these different types of feedback? We are especially interested in the moments in which the pupils show resistance to design feedback and hope to uncover how this might relate to the divergent or convergent nature of the feedback.

3.2 LITERATURE REVIEW

3.2.1 Divergent and convergent thinking

As previously touched on, two creative thinking processes play a central role while designing: divergent (DT) and convergent (CT) thinking (Finke et al., 1992; Goldschmidt, 2014, 2016; Guilford, 1956, 1962). Though the continuous alternation between DT and CT, creative solutions get generated and developed (Guilford, 1967; Howard-Jones, 2002; Isaksen et al., 2010; Isaksen & Treffinger, 2004; Mioduser & Kipperman, 2002; Tassoul, 2009). Yet understanding how and when to best shift between these cycles of thought is not easy, especially for novice designers. Many factors can hamper these creative thought processes, of which the occurrence of design fixation is a known obstacle in pupils designing (Luo, 2015; McLellan & Nicholl, 2013; Nicholl & McLellan, 2007a; Schut, Klapwijk, Gielen, van Doorn, et al., 2019).

Within design education, guidance in navigating this shifting and alternating process is therefore needed. Although this guidance can take different forms, like structured courses, tools and methods, assessment guidelines and coaching (Dannels, Gaffney, & Martin, 2008; McLellan & Nicholl, 2009; Nicholl, 2004; Nicholl & McLellan, 2007a; Tolbert & Daly, 2013), this chapter focuses on the role of design feedback.

3.2.2 Design feedback

Although little is known in relation to young novice learners, feedback interventions are common educational practice in design disciplines at university level to discuss the progress and status of a student's design projects (Dannels, 2005; Oh et al., 2013). Usually, there are several feedback interventions integrated in the design process at different stages. In those moments, students get the opportunity to update their instructors, their peers and other stakeholders, such as real or simulated clients and potential users, on their envisioned design and collect feedback. Oh et al. (2013) describe how these conversations are the predominant way through which students acquire expertise from their instructors and other stakeholders. Additionally, it adds the aspect of socializing students into the discipline, which prepares them for the 'real world' (Cummings et al., 2015; Dannels, 2005; Oak, 2000; Oh et al., 2013).

Commonly these feedback moments are known as 'design reviews' or 'design crits'. Although there are many similarities, and the terms are often used interchangeably, in this chapter the focus will specifically lie on design crits. Design critiquing is about improvement. This is attained by discussing how well the design addresses the goals and principles that were set beforehand. Within these discussions is not necessarily about getting everyone's approval, like design reviews tend to be (Sater-Black & Iversen, 1994), but about giving options and opinions on how to move forward within the design process. The active conversations can trigger students to reflect on, evaluate, and revise their designs (Oh et al., 2013), therefore impacting divergent or convergent paths they take in their creative process.

3.2.3 Divergent and convergent design feedback

Design feedback can steer creative thinking processes in divergent or convergent directions (Daly & Yilmaz, 2015; Goldschmidt et al., 2010). It can push towards convergence by suggesting evaluation, reflection and decision making, or encourage divergence by suggesting the exploration of alternatives. Although feedback can potentially benefit the creative design process (Crilly, 2015), literature shows that it can also evoke less than optimal reactions in novice designers. For example, Cardella et al. (2014) and Cummings et al. (2015) investigated the different directions design feedback can push towards and linked it to the processes of creating and reducing ambiguity between instructors and university students. They found that instructors who only work on eliminating ambiguity by giving feedback that pushes towards convergent actions through clarification, can provoke students to become defensive and try even harder to convince everyone of the quality of their design (Cardella et al., 2014; Cummings et al., 2015). These types of interactions could inhibit a student's creative thinking, since they will not easily engage in reflective or evaluative thinking about the state of their idea when they feel they have to justify it.

This focus on clarification through convergent feedback by instructors was also observed by others (Cardoso et al., 2014; Daly & Yilmaz, 2015; Yilmaz & Daly, 2014, 2016). In a study on question asking during design reviews, Cardoso et al. (2014) observed that due to this focus of the instructor, the students end up being too descriptive and do not engage in any reflective and evaluative thinking about the design decisions made. Yilmaz and Daly (2014, 2015, 2016) also observed this focus on clarification and decision making and found that instructors from different disciplines all primarily engage in convergent feedback. They note that although this type of convergence is necessary in working towards a design result, it should not be prioritized over the exploration of 'better' solutions or the pursuit of risky ideas. More balance between both types of feedback is therefore encouraged by the authors and the need for divergent feedback is brought forward (Daly & Yilmaz, 2015; Yilmaz & Daly, 2014, 2016).

From these studies, it appears that the, primarily convergent, design feedback from the instructors is not always met with the expected reactions from the students and does not necessarily facilitate DT or CT. Similarly, our previous study shows that feedback that is given to primary school pupils while designing does not always spark creative thinking (Schut, Klapwijk, Gielen, van Doorn, et al., 2019). Instead, it was found that the pupils often rejected or ignored the feedback in order to leave the core characteristics of their design ideas intact and unchanged. This fixation on their idea was observed through four uncovered types of response behaviours: 'band-aids', 'already in there', 'question not relevant' and 'it's not possible' (Schut, Klapwijk, Gielen, van Doorn, et al., 2019). Since unwanted reactions to feedback have been observed with university students, it is possible that responses of the pupils have been influenced the preceding feedback. It could therefore be worthwhile to explore the nature of the feedback preceding these uncovered response behaviours.

3.2.4 A design feedback model

One of ways in which the nature of design feedback can be uncovered, is through the use of Eris' question driven design model (Eris, 2004). Eris perceives design as a question driven process. He therefore created a model that encompasses the types of divergent and convergent questions asked when designing in teams, which is made visible in *Figure 7*. Use of this model has, for example, provided insight into the types and combinations of questions that can spark creative thinking within design processes (Cardoso et al., 2016). Although the model is intended to analyse the question behaviour of a design team while designing (Cardoso, Badke-Schaub, & Eris, 2016; Eris, 2004), it has also been used to analyse the feedback present in design crits (Cardoso, Eris, Badke-schaub, & Aurisicchio, 2014). It would therefore be interesting to explore the nature of the design feedback present in the first case and the insight this can give in relation to the pupils' creative thinking.

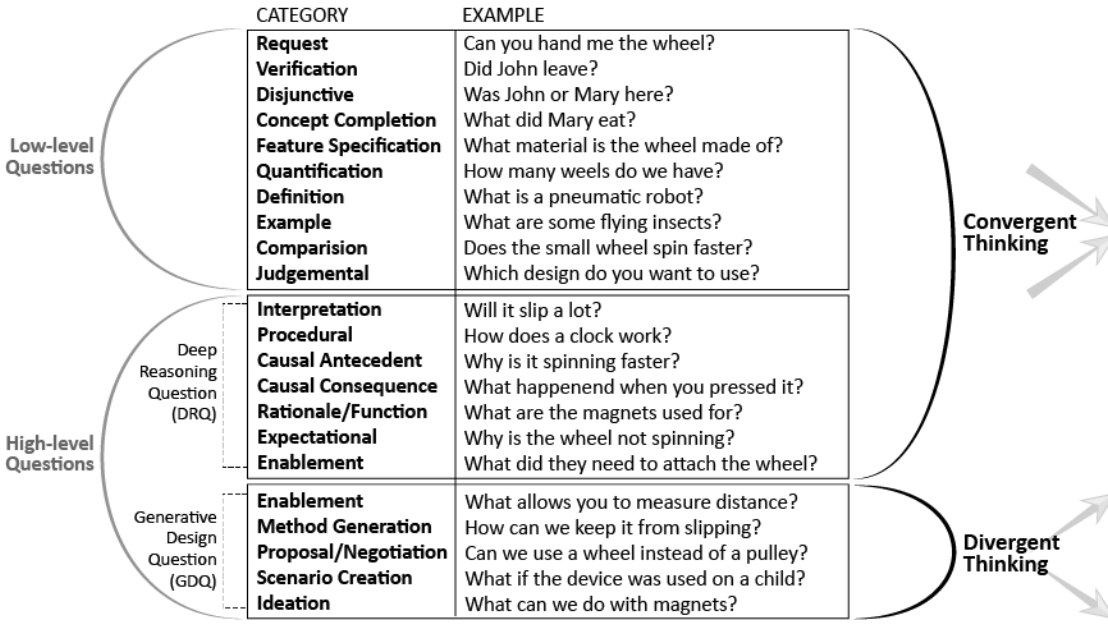


Figure 7: Eris' Question Driven Design Model (Eris, 2004)

3.3 RESEARCH DESIGN

Here we describe the results of a second analysis of the first case in which we facilitated a class of primary school pupils through a series of design sessions. The goal was to identify the nature (divergent or convergent) of feedback present in the critiquing moments and the reaction of the pupils to this feedback. This is translated into the following explorative research question: *What*

is the convergent and divergent nature of the design feedback given by the client and peers, and what are the pupils' direct responses in an unguided design feedback situation?

Since this second study was done on the same case as the first study described in *Chapter 2*, the description of the participants, design problem, and design session will be identical. Reference will be made to a table and figure presented in the previous chapter.

3.3.1 Participants

The design sessions took place at a primary school in the Netherlands. The selection was based on the school's interest in design and technology education and a wish to experience a guided hands-on design project. The participating school is 'development-focused', meaning that umbrella themes are used to integrate different learning subjects.

In this study, one class participated over a period of seven weeks in March and April 2016. The class consisted of 24 pupils, ranging between 9 and 11 years old. The class was divided into six gender-mixed heterogeneous design teams of four pupils by the teacher. Although the pupils had no experience with designing, the teacher stated that the pupils were used to giving feedback to each other during other subjects in the classroom.

3.3.2 Design problem

The pupils worked on solving a real-life open-ended design problem. This was made available by the HALO sports academy, which is part of The Hague University of Applied Sciences in the Netherlands. The assignment: "Design a game, lesson or sports equipment for the gymnasium of the future that enables pupils with different participation motives to be physically active together." An example of different 'participation motives' is a child who enjoys a competitive component during physical activities and plays to win versus a child who enjoys playing together, regardless of winning or losing the game. An experienced teacher of the HALO acted as a client. He introduced the design assignment and was present during several of the design sessions to give feedback on the pupils' design ideas. He had no specific experience in addressing or teaching primary school pupils.

3.3.3 Design sessions

Over the course of seven weeks the design teams took part in weekly design sessions of 90 to 120 minutes. *Table 2* presents an overview of the design sessions and their connection to the design cycle know by Dutch primary school teachers and pupils (*figure 3)*. The design activities were based on tools and methods from the CPS tradition (Isaksen et al., 2010; Tassoul, 2009) and design tools from the Delft Design Guide (Van Boeijen, et al., 2013). These methods and tools were transformed for use at primary school level in collaboration with the Science Hub

Delft (Wetenschapsknooppunt Zuid-Holland, n.d.), which is an organization who develops and researches educational design material for primary schools.

3.3.4 Facilitation

Three facilitators were present during the design sessions to facilitate the teams. Each facilitator was assigned two teams. Two facilitators, the first and second author, had a double role as researchers within the project.

3.3.5 Setting

During the design sessions 2, 3 and 5, the teams were facilitated by their assigned facilitator in separate rooms. Session 1, 4, 6 and 7 took place in a classroom setting during which all teams took part simultaneously.

3.3.6 Critiquing moments

During 4th and 7th session the design teams received feedback from their classmates and the client on the state of their design ideas during two design crits. For both critiquing moments the client and pupils received no specific instruction from the facilitators on how to give feedback. Yet the teacher noted that the pupils were used to giving and receiving feedback during other subjects.

The first critiquing moment took place during the 4th design session. At that moment in the design process all design teams had selected one or two initial ideas and constructed corresponding small ‘quick and dirty’ models. Through turn taking each design team had the opportunity to present their design idea, illustrated with the models. After presenting their design idea each team received feedback from the client, as well as from the other design teams (their peers). It was expected that the teams would use the feedback that was given to improve their design idea by adjusting and elaborating on its current state. This expectation was communicated to the teams by the client through a short presentation at the start of design session. In this presentation the importance of feedback in relation to idea development was pointed out through the phrase: “Feedback = OK!” and several examples. Additionally, the client pointed out that although sometimes you might feel hurt or attacked by the feedback that is given, it is always meant to help.

The second critiquing moment took place during the 7th design session. All design teams had prepared a short presentation in which they illustrated their final design with drawings or photos of their prototypes. Again, the design teams received feedback from the client and the other design teams (their peers). Since this was the final design session, the focus

was not so much on possible future improvements, but more on revealing the final state of the design. This expectation was also communicated to the pupils by the client.

3.3.7 Data collection

The seven design sessions were audio and video recorded and the materials that the pupils produced during the sessions were photographed.

3.3.8 Data analysis

Segments and pairs

To examine which type of feedback and responses occurred together, they were grouped before coding. Segments were created of consecutive feedback and responses based on the feedback content. Within these segments pairs of feedback and response were formed. When multiple questions and comments were posed in a row, or when multiple answers were given in a row, these would be grouped to form one pair consisting of multiple feedback and response codes. All pairs were coded with the corresponding feedback type codes and response type codes. Additionally, we coded who posed the feedback to the design teams, the client or peers. The qualitative analysis software Atlas.ti was used during the entire analysis process.

Feedback types

To determine the nature of the feedback, Eris's question-driven design model (see *Figure 7*) was used as our primary lens to analyse the feedback posed by the client and peers (Eris, 2004). The model makes a distinction between two levels of questions: Low-level Questions and High-level Questions. The High-level Questions are divided in Deep Reasoning Questions (DRQs) and Generative Design Questions (GDQs). Low-level questions are mainly information seeking questions and are posed when a questioner for example wants clarification or verification about certain aspects of the design. High-level questions ask for a higher level of reasoning and often entail reflection, evaluation and/or generation. In the model Low-level Questions and DRQs are classified as convergent. These types of questions are presumed to facilitate convergent thinking processes and share the share the common premise that a specific answer, or a specific set of answers, exists. GDQs are classified as divergent, since they are presumed to facilitate divergent thinking processes by proposing alternative answers and prompting their generation.

The first author initially coded all the transcribed data, after which consensus and consistency were promoted by routinely discussing the coded data with the second author. Since we were not solely interested in questions, not all instances of feedback could be coded with Eris' model. These particular segments of feedback were therefore coded inductively, which resulted in three new codes: 'Critique', 'Compliment' and 'Direct recommendation'. For the purpose of this study, we added these three codes to Eris' model and classified them as

Low-level Comments and part of the convergent category. This adapted model is visualized in *Figure 8.*

Types of responses

To determine the different types of responses of the design teams, all responses were labelled through open-coding, allowing codes to emerge from the data itself. Four of these response types were previously identified in this particular dataset through open coding, namely 'band-aids', 'already in there', 'question not relevant' and 'it's not possible' (Schut, Klapwijk, Gielen, van Doorn, et al., 2019). Afterwards we refined these codes by comparing them to a framework of student response codes created by Cardella et al. (2014) and Cummings et al. (2015). Due to the different context of their studies the conscious decision was made to not use their framework inductively. When comparing the codes uncovered through open coding to the framework of Cardella et al. (2014) and Cummings et al. (2015) we found that several codes overlapped, some could be adopted and a few could be dismissed due to irrelevance to our context. Overlapping codes were merged and the code name from the source that described the response type in most detail was adopted. From this process an improved framework for initial responses to design feedback in primary design projects emerged, which is made visible in *Table 4.* Again, the first author initially coded all the transcribed data, after which consensus and consistency were promoted by routinely discussing the coded data with the second author.

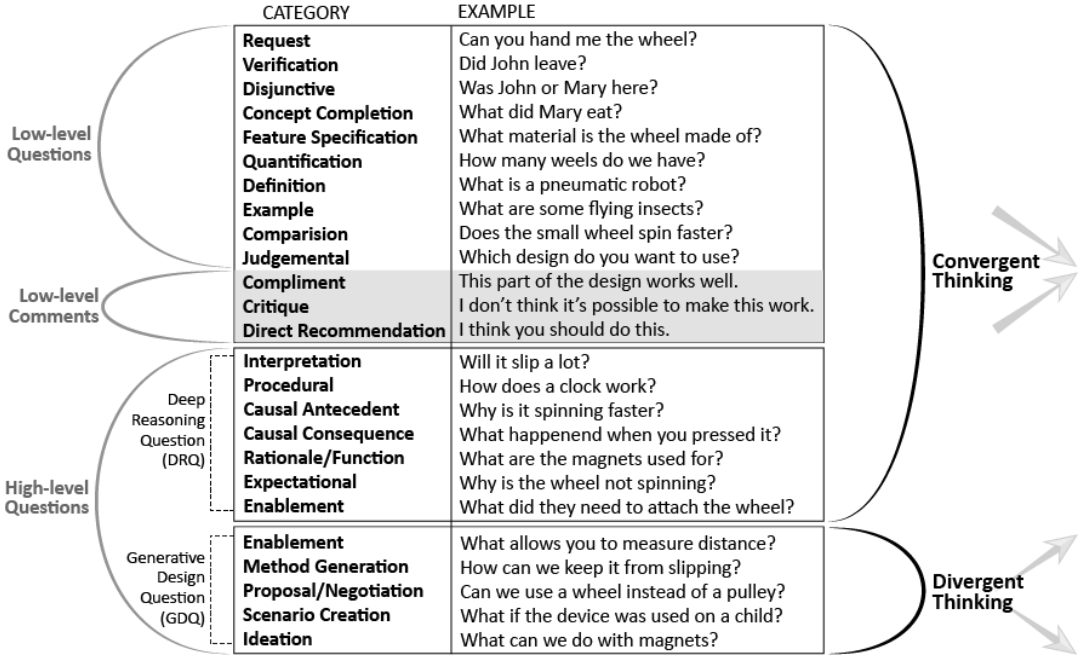


Figure 8: Adapted version of Eris' Question Driven Design Model. The Low-level Comments category was added for the purpose of this study.

Table 4 Pupils' initial responses to design feedback

Code	Description of the behaviour
Band-aids	Proposing adjustments or elaborations that don't present a valuable and relevant development and leave the flawed core of a design idea intact.
Already in there	Dismissing uncovered shortcomings by stating (falsely) that they have been present within the design idea all along.
Question not relevant	Indicating that the given feedback holds no relevance to the design idea.
It's not possible	Dismissing proposed adjustments or elaborations on feasibility without proper evaluation.
Ideation	Coming up with new ideas/exploring new possibilities
Confirming	Confirming that what someone states/assumes is correct
Insecure	Reaction indicating insecurity about what to answer
Show	Physically showing something (part of design/drawing/etc)
Ask	Clarifying questions
Restate	Student restates the information from the person providing the feedback
Acknowledge	Indication of active listening
Agree	"Ok", "I will do that"
Report	Explaining a feature or the design
Silence (non-verbal)	No reaction present
Nodding (non-verbal)	Physical response to any type of feedback

3.4 RESULTS

The following sections introduce the occurrence of the different types of feedback and responses throughout both critiquing moments. Specifically, we concentrate our efforts towards discussing the responses that indicate a form of resistance and towards design feedback and expose their relation to the nature of the feedback types and additional feedback properties.

3.4.1 Types of feedback

Figure 4 gives an overview of the occurrence of the different types of feedback during the first and second critiquing moment. In accordance with Eris' model, low-level questions, comments and DRQs are categorised as convergent and GDQs as divergent. In both critiquing moments convergent as well as divergent is posed by the client as well as the peers. Overall, the first critiquing moment contained more instances of feedback than in the second. In this first critiquing moment, the client posed more feedback than the peers, especially low-level questions, comments and GDQs. In the second critiquing moment the peers posed more feedback than the client. Remarkable is the relatively high amount of DRQs asked by the peers during this critiquing moment.

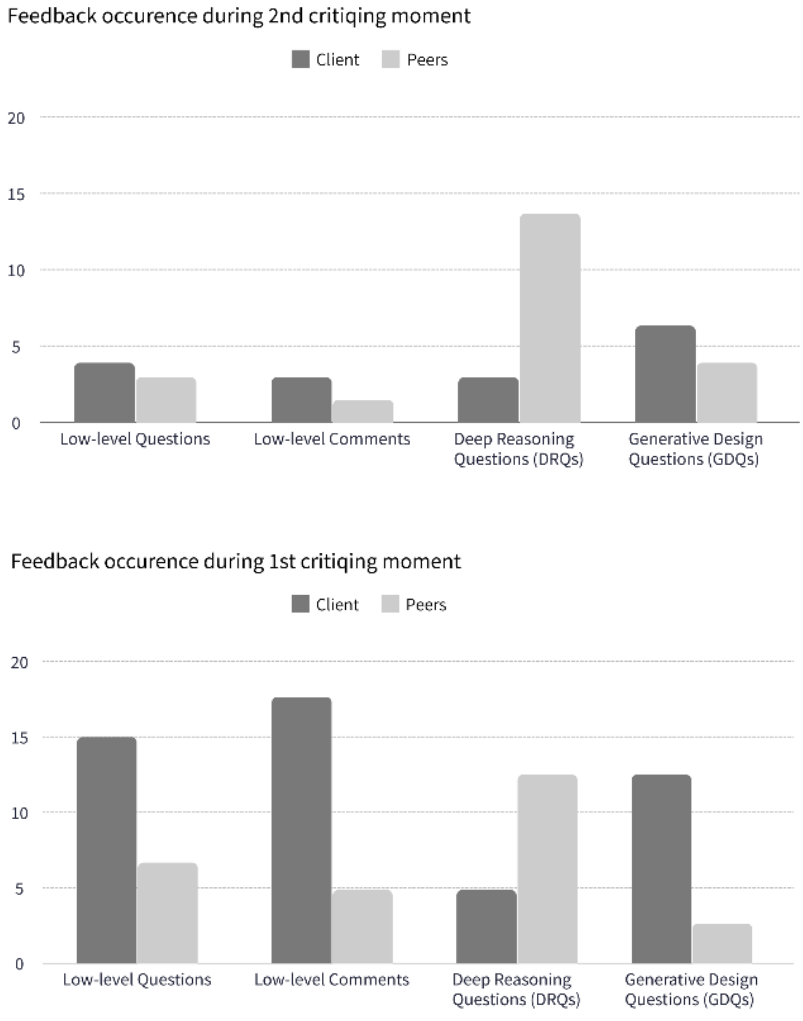


Figure 9: Occurrence of the different types of feedback posed by client and peers during the 1st and 2nd critiquing moments.

Convergent feedback

Overall *convergent* feedback was most prominent during both critiquing moments. When looking closer at the different types of *convergent* feedback, we see that the client mostly engaged in low-level questions and comments, while the peers took a leading role in posing Deep Reasoning Questions (DRQs).

Low-level questions were generally posed by the client to clarify or verify certain aspects of the design idea. For example:

> Client: *What are the game rules?*
>
> Client: *Ok, so if I understand correctly there is a video game attached to it?*
>
> Client: *So, you are moving in the game and on the screen?*

Since the client took a leading role in both critiquing moments and was generally the first to provide feedback to the design teams, this could explain why most low-level questions were posed by the client.

The low-level comments that were posed by the client mainly consisted of compliments. Often these compliments were interwoven with other types of feedback. For example:

> Client: *You did choose a really nice topic. Something that everybody will find cool. And that was also sort of my assignment right, creating something that everybody will find cool.* [compliment (low-level comment)] *Yet, what is really new about it?* [Causal Antecedent (DRQ)] *What makes this different?* [Rational (DRQ)]
>
> Client: *I think it's really cool!* [compliment (low-level comment)] *I envision the gym of the future maybe without all that equipment* [proposal (GDQ)]. *That there is nothing in the gym, only those beamers and a really cool game that we can project.* [ideation (GDQ)]

In both examples the client starts with a compliment, after which he directly continues with expressing a concern or posing a suggestion.

Even though the peers also posed a few low-level questions and comments, the great majority of their feedback consisted of DRQs. More than half of all feedback that was given by the peers consisted of this type of feedback. The high-level questions they posed were concerned with how the design came to be, how it exactly works and why it works that way. For example:

> Peer: *Well, how can you for example climb that tree?*
>
> Peer: *Most of the equipment is not very high, so how can you then hide well?*

Peer: *I don't think a player is able to slide on their knees the entire time. Right?*

In the DRQs above, several concerns are expressed about the designs. By posing these questions the peers ask the design teams to reflect and evaluate their design.

Divergent feedback

Divergent feedback, in the form of Generative Design Questions (GDQs), was present in both critiquing moments. Yet a clear spike in its occurrence was observed in the first critiquing moment, caused by the client. Through divergent feedback he appeared to persuade the design teams to explore alternative features or possible new additions to the design. For example:

> Client: *I am searching for a way to customize it for different players. How could we do that?*
>
> Client: *So maybe, when using a camera, you* [a player] *could think 'well, I'm not someone that is able to run fast, so I stay far from the catcher'. And someone who is very good (in running fast), they maybe need something to provoke the catcher a bit?*

3.4.2 Types of responses

The type of responses that followed the different instances of feedback varied throughout the critiquing moments. The occurrence of many of the responses appears incidental, making it difficult to discover distinct patterns. However, there was a group of responses that took a prominent position in both critiquing moments. Together, the 'band-aids', 'already in there', 'question not relevant' and 'it's not possible' made up about half of the responses in both critiquing moments. Through these responses the design teams showed resistance towards the design feedback posed to them. In the next section we discuss the observed feedback and an overarching pattern preceding these four types of responses. From now on we will refer to these four types of responses as 'resistance responses'.

3.4.3 Feedback preceding the four resistance response behaviours

Convergent feedback

The resistance responses were predominantly preceded by convergent feedback, especially by DRQs posed by classmates. Through these DRQs the classmates often revealed to the design team how they expected certain mechanisms in the design idea to function incorrectly. The following 'no handball included'-example illustrates this. In all examples 'pupil' plus a number refers to members of a design team.

No handball included

Peer: *If you for example throw a ball during handball, then the computer can never know how fast you throw. Because he can also not…*
Pupil 1: *But we don't offer handball.*
Peer: *Okay. Then soccer, if you then kick the ball then you don't know how fast you will kick?*
Client: *Well, the computer would be able to measures that. You can make that happen.*
Pupil 2: *Yes, there are machines that can measure how fast it goes.*

Here the expectation of the classmate is that the computer will never be able to measure the speed of a ball thrown within the game. First the design team tries to parry the question by focussing on the sport used in the example, which they state is not part of their idea. This behaviour enables the team to ignore the question and show that their idea still 'works'. The peer then repeats the expectation, prompting the client to step in and contradict the expectation of the classmate. This help is quickly embraced by the team. DRQs generally ask for reflection and evaluation of the design idea, which can ultimately help to develop and improve it. Yet this behaviour was not observed here. The first reaction of the team to feedback of the peer was to parry it, showing little intention to evaluate the feedback and possibly using it to improve their idea. This behaviour could have been promoted by the peer sharing expectations about the idea without any explanation towards the team as to what these assumptions are based on.

A second example showcases another instance in which a peer poses a DRQ, yet does not communicate the expectations and assumptions about the design idea clearly and directly.

No friends needed

Peer: *How can you do this game with friends?*
Pupil: *Well. You don't have to do it with two people, you can also do it alone*
Peer: *Okay…*

The peer's question stems from the design question given by the client, which focusses on pupils being active together. One of the pupils from the design team answered that the game can be played alone, implying that no other players are needed. This left the peer a bit puzzled. Here, the peer expects the design idea to not fulfil a certain wish of the client, namely: stimulating playing together. Yet this expectation is not communicated directly by referring to the design problem and the unfulfilled design criterion. Again, the first reaction of the design team is to parry the question, instead of taking it as an opportunity to reflect and evaluate.

Divergent feedback

There were also instances in which the four resistance responses were preceded by *divergent* feedback in the form of GDQs, which were mainly posed by the client. In those cases, the client often proposed multiple new alternatives for certain features or completely new additions to the design idea. The following example dialogue showcases how one of the design teams reacts to the *divergent* feedback of the client.

> New proposals
> Client: *What might be nice is something you can see in some playgrounds.*
> *That you get points if you hit something. You know?*
> Pupil: *Yes, this game is that you can shoot and then you get points.*
> Client: *Yes. And that could be from two sides this way. Right?*
> *Maybe the computer can control and move this, or that you move it yourself.*
> Pupil: *If you stand there the sticks will fall and then you can get them really fast.*
> Client: *Yes, nice. Or maybe this goal can turn around and*
> *that you think of a game in which the goal moves around all the time.*
> *That will keep making the game more difficult.*
> Pupil: [silence...] *Maybe…* [end conversation]

The client starts with proposing a new addition to the game. The design team reacts by stating that his proposed addition is already present in the idea. The client then continues with a stream of several new additions, showcasing different directions in which his proposal could be manifested in the game. The dialogue then ends with the team showing little enthusiasm towards the proposed additions of the client.

Although the feedback of the client can be classified as *divergent*, it does not appear to spark any new DT processes with the design team. This could be due to the stream of additions the client proposes, which he thinks will make their idea better, without checking with the team how they view these additions in relation to their idea. All the proposed additions appear to stem from the client's expectation that the game needs to get more difficult over time, but this is not mentioned explicitly. Furthermore, the client assumes that the current state of the design idea does not yet fulfil this assumption. Yet this is not communicated clearly, therefore keeping the team in the dark about the client's true intentions for the majority of the dialogue. Although other reasons may exist, this lack in transparency may to have caused that the design team was less open to the new additions.

3.5 DISCUSSION

3.5.1 Divergent & convergent design feedback

Our results show that with no guidance on how to give design feedback, the client and peers (age 9 – 11) both pose divergent as well as convergent feedback to the design teams. Yet overall convergent feedback was considerately more prominent in both critiquing moments. This result has similarities to previous studies which also found convergent feedback to occur more frequently (Cardella et al., 2014; Cardoso et al., 2014; Cummings et al., 2015; Yilmaz & Daly, 2014, 2016). We observed that the client posed the majority of convergent feedback through low-level comments and questions, concerned mainly with clarifying the designs of the teams. This focus on clarification by the client has similarities to previous studies, in which instructors were observed to also have this tendency (Cardella et al., 2014; Cardoso et al., 2014; Cummings et al., 2015).

Although few instances of high-level convergent feedback were found with the client, more than half of the feedback posed by the peers consisted of high-level convergent DRQs. By posing these questions the peers ask the design teams to reflect and evaluate their past, present and future design decisions. This is quite remarkable and suggest that more research on this phenomenon is needed. One explanation could be that because they were participating in the same design sessions as the design teams presenting, certain design choices made by the teams were more striking to the peers than to the client. Additionally, the teacher noted that the pupils were used to giving feedback during other subjects, although we have no information on the nature of this feedback. Next to this, we speculate that the client might not have known how to pose these types of reflective and evaluative questions to that age group, therefore abstaining from it. Cardoso et al. (2014) found the instructor in their study to also abstain from DRQs in a university context, which could point to a more general difficulty in posing these types of questions.

Even though overall convergent feedback was more prominent, divergent feedback was also present in both critiquing moments. The client was the one primarily engaging in divergent feedback in the form of GDQs. Additionally, there was a spike of divergent feedback during the first critiquing moment. We speculate that this could be due to the unfinished state of the design ideas during the first critiquing moment and assume that the client tried to encourage the teams in developing their ideas by posing GDQs.

3.5.2 Reactions to the design feedback

The results on the occurrence of the different type of responses showcase how the convergent or divergent nature of the feedback does not necessary guarantee the start of the corresponding thinking processes within the design teams. Around half of all responses consisted of one of the four resistance responses, which stagnated the divergent and

convergent thinking processes of the design teams. In those instances, the convergent feedback, especially DRQs, did not lead the design teams to reflect or evaluate their design. Instead, the design teams appeared to become defensive and tried to prove the quality of their design, which is similar to results found by others in the context of higher education (Cardella et al., 2014; Cardoso et al., 2014; Cummings et al., 2015). Additionally, the occurrence of resistance responses also pointed out how divergent feedback did not always spark new ideation processes. It appears that only the convergent or divergent nature of the feedback is not enough to guarantee the start of new divergent or convergent processes with the pupils.

3.5.3 Possible contributing factors

The resistance the design teams exhibited to the design feedback given by the client and peers hampered their creative thinking processes. We believe there are several factors that could have contributed to this high occurrence of resistance responses of the teams. Firstly, we speculate that the high occurrence of convergent feedback might have limited the start of creative thinking processes within the design teams. High occurrence of convergent feedback is thought to hamper exploratory thinking and risk taking, which are both essential within creative processes (Tolbert & Daly, 2013; Yilmaz & Daly, 2016). Although convergent thinking is essential in working towards a final design, more balance between divergent and convergent feedback could prove promising in creating better and more creative designs.

Besides this, we presume that (implicit) expectations and assumptions about the design ideas, that we found present within the convergent and divergent feedback, hindered the start of both DT and CT thinking processes. Interpretive challenges in feedback are known to cause communication problems for students and instructors (Sadler, 2010). Due to the implicit nature of the expectations and assumptions, there was an absence of mutual understanding between the design teams, the client, and peers about the (sub)problems present in the designs. Since the teams did in general not use the feedback to subject their design to any critical evaluation (CT) in order to detect these (sub)problems, there was no need to generate new ideas (DT) to elaborate or adjust the design. Critical evaluation appears to not come ‘naturally’ to the pupils, a notion that is supported by research done by Blom and Bogaers (2018) in the field of Linkography with young novice designers (age 13-14).

Furthermore, the parrying of feedback by the design teams suggests that they might have felt a high level of attachment to their design ideas. This could have made it difficult for them to decide to accept or reject the feedback, since their abilities to objectively consider the feedback might have been impaired. Literature shows that high levels of ownership can create feelings of loss when confronted with suggestions for change, making people less likely to fully adopt the given feedback (Baer & Brown, 2012a). Yet, we must note that feelings of ownership can also have a positive impact on developing promising ideas of which their potential is not immediately recognized. A designer has to develop the skills to be able to balance between

remaining open to possible flaws within the design ideas, yet also persistent in developing a promising idea despite receiving negative feedback (Crilly, 2015; Csikszentmihalyi, 1999).

Ultimately, it appears that there is a need for guidance on deciding what to do with each piece of feedback; (partly) accept or (partly) reject. The development of critical thinking skills are needed in order to objectively explore the feedback before accepting or rejecting it. Novice designers must learn to suppress the tendency to immediately reject criticism, and 'temporarily accept' it to explore its merit.

3.6 CONCLUSION

Earlier research emphasizes that feedback can encourage a designer to take DT as well as CT paths during their design process (Cardoso et al., 2014; Yilmaz & Daly, 2014, 2016). Nevertheless, our results show that feedback on design ideas does not necessarily help young novice designers (pupils aged 9-11) to engage in divergent and convergent thinking processes. Our study shows that divergent feedback will not necessarily promote divergent thinking processes, whereas convergent feedback will not necessarily promote convergent thinking. Resistance responses were widespread. The novice designers frequently rejected feedback immediately instead of accepting it temporarily to explore its merit. This led to stagnation of divergent and convergent thinking processes within the teams, resulting in a lack of critical reflection and a loss of openness which hampered the creative process. We point to the assumptions and expectations of clients and peers that were only implicitly present in the feedback on the design ideas as one of the factors sparking this resistance in design teams. We therefore suggest (1) the use of concrete convergent feedback followed by (2) divergent feedback to regain openness and spark new creative thinking processes.

3.7 Limitations

This study has some limitations due to the focus on the responses directly after the feedback was given. It is possible that in some instances, the feedback may have instigated the concurrent divergent or convergent thought processes at a later stage within the teams.

3.8 Recommendations & Future research

We believe that feedback from clients and peers can still be a fruitful strategy in learning to be creative and to apply DT and CT thinking. However, all parties involved – teachers, clients and pupils - need to learn to give and receive sound feedback. Feedback conversations should be constructed carefully, as they are sensitive and filled with fragile egos, sensitive identities and

insecure learning processes (Dannels, 2011; Goldschmidt, Hochman, & Dafni, 2010; Wiliam, 2017). What is being said by who and the reactions that follow create a complex minefield in which all participants need to learn to navigate. We suggest that design feedback needs to be concrete and should clearly explain any expectations and assumptions the feedback giver might have about the design in order to reach a mutual understanding. When a mutual understanding is reached about the (sub)problems within the designs, there is room to regain openness and use divergent feedback questions to spark new DT processes. Additionally, the development of critical thinking skills could help young novice designers to objectively explore the feedback before accepting or rejecting it

Further research on feedback that forwards the design process is needed in all levels of education. Ideally, both the feedback and the responses are be studied to be able to develop guidelines for DT and CT feedback. Our results show that Eris' Question Driven Design Model can be utilized as a framework to analyse design feedback of a real-life client and peers in the context of primary education design projects. A new category of low-level comments was added to the framework to account for the instances of design feedback which could not be coded. Due to our limited data-set, we believe additional research that utilizes this framework to analyse design feedback could prove valuable. Furthermore, the framework we constructed to analyse the responses could also benefit from additional research, since we believe other types of responses might still occur in different data-sets and contexts.

Chapter 4

Towards constructive design feedback dialogues: guiding peer and client feedback to stimulate pupils' creative thinking

This chapter is based on: Schut, A., van Mechelen, M., Klapwijk, R., Gielen, M., De Vries., M. J. Towards constructive design feedback dialogues: guiding peer and client feedback to stimulate children's creative thinking. *Int J Technol Des Educ* (2020). https://doi.org/10.1007/s10798-020-09612-y

4.1 INTRODUCTION

The previous chapters demonstrate that behaving creatively does not always come naturally to the designing pupils. Their creative thinking processes can easily be stagnated by several different factors. We have observed these instances of stagnation first-handed in the previous two chapters, where they became visible through the non-constructive design feedback dialogues the primary school pupils had with their clients and peers (Schut, Klapwijk, Gielen, & De Vries, 2019; Schut, Klapwijk, Gielen, van Doorn, & de Vries, 2019).

Design feedback is generally assumed to be beneficial to the creative design process (Crilly, 2015). It is often utilized as a tool to guide creative thinking and, therefore, the development of a design. However, *Chapter 2* shows that pupils' creative thinking is not necessarily stimulated or enhanced by the feedback conversations. In various cases, it was observed that the students (pupils) showed resistance towards the feedback and a lack of evaluative and generative thinking processes (Schut, Klapwijk, Gielen, van Doorn, et al., 2019). When analysing the feedback dialogues, we observed problems with receiving, as well as constructing design feedback. Therefore, we believe that guiding how design feedback is given and received can create new opportunities to stimulate and enhance the pupils' creative thinking while designing.

In this chapter, we report on the construction and use of a peer feedback intervention meant to stimulate constructive feedback dialogues between design teams of primary school pupils, their peers and the clients, while participating in a real-life design project. The overall goal of this study is aimed at gaining insight in the possible ways of guiding a design feedback dialogue to stimulate young novice designers' creative thinking. This study takes an educational design research approach, in which the peer feedback intervention is developed and optimized over two cases (Bakker, 2018; Van den Akker et al., 2006). We will uncover the success and obstacles of the peer feedback intervention and from this form recommendations.

4.2 LITERATURE REVIEW

4.2.1 Creative thinking in design

Creative thinking processes are central to designing and can be seen as the key driver of the creation and development of a design. Central to creative thinking is the utilization of both divergent (DT) and convergent (CT) thinking processes (Goldschmidt, 2014, 2016; J. P. Guilford, 1967; Howard-Jones, 2002). DT is generative in nature and entails the generation of new thoughts and ideas, and CT is evaluative in nature and entails reflection and evaluation of these (or existing) thoughts and ideas (Sowden et al., 2015). Following the dual-process theory of creative cognition, there is a continuous shifting between both modes of thinking when working towards a creative solution (Finke et al., 1992; Howard et al., 2008; Sowden et al., 2015).

These continuous shifts are not only essential for the generation of initial ideas, but also for the development of these initial ideas into complete final designs (Isaksen et al., 2010; Tassoul, 2009). Through critical reflection and evaluation (CT), various shortcomings and sub-problems within the designs can be identified, which, in turn, can lead to the generation (DT) of new additions and alterations. Navigating these creative thinking processes is not an easy endeavour, especially for young novice designers. Therefore, design feedback is commonly utilized within design education as one of the types of guidance (Dannels et al., 2008; Nicholl, 2004; Tolbert & Daly, 2013).

4.2.2 Feedback in Design Education

Thus far, little is known about design feedback in the context of primary education (Schut, Klapwijk, Gielen, & De Vries, 2019). However, feedback interventions are a common educational practice within the context of design disciplines at a university level and are known as design critiques (crits) or design reviews (Anthony, 1991; Dannels & Martin, 2008; Healy, 2016). Students get the opportunity to update their instructors, peers and other stakeholders - such as real or simulated clients and potential users - on their process and the status of their design and collect feedback (Dannels & Martin, 2008; Oh et al., 2013). These critiquing moments can be considered as central to design education and practice (Gray, 2013a, 2013b). It prepares the novice designers for the ‘real world’ by socializing them into the discipline (Oh et al., 2013) and it is seen as a primary form through which they acquire expertise from their instructors and other stakeholders (Dannels, 2005; McDonnell, 2016; Oak, 2000) and develop their design skills (Hokanson, 2012; McDonnell, 2016).

Design feedback dialogues are often about improvement and development of a design and can directly impact the divergent or convergent paths a novice designer might take (Cardoso et al., 2014; Oh et al., 2013; Yilmaz & Daly, 2016). Questioning can spark novice designers to think more deeply and broadly and help them to improve and develop their design (Stables et al., 2016). Within general education, it is well recognized that dialogues can play an

essential role in learning when guided in a constructive manner (Colfer, 2017; Mercer & Littleton, 2014). However, it is well known that design feedback is not always shared through constructive dialogue and therefore, does not always benefit the creative thinking processes (Anthony, 1991).

4.2.3 Non-constructive feedback dialogues

At a primary school level, it has also been observed that feedback dialogues easily become non-constructive (Schut, Klapwijk, Gielen, & De Vries, 2019; Schut, Klapwijk, Gielen, van Doorn, et al., 2019). Specifically, Schut et al. (2019) observed that the convergent or divergent design feedback does not automatically guide young novice designers towards the concurrent creative thinking processes. The discrepancy between the direction the design feedback drives towards and the actual thinking processes that take place thus occurs at all educational levels.

At university level, several studies indicate how instructors appear to mainly utilize convergent feedback, through which they tend to focus on the clarification and reasoning behind certain design decisions (Cardella et al., 2014; Cardoso et al., 2014; Cummings et al., 2015; Daly & Yilmaz, 2015; Yilmaz & Daly, 2014, 2016). As a result, the instructors expected a level of reflection and evaluation of the students. However, the students were often found to become too descriptive (Cardoso et al., 2014) or even defensive, trying even harder to convince everyone of the quality of their design (Cardella et al., 2014; Cummings et al., 2015). Although favouring convergent feedback is an understandable strategy when wanting to eliminate ambiguity and encourage reflection and evaluation, these results show that students' convergent thinking processes are not always that easily triggered.

At a primary school level, Schut et al. (2019b) also observed that the high level of convergent design feedback did not always promote constructive dialogue. Similar to the studies at a university level, it was observed that the convergent feedback did not automatically trigger reflection and evaluation with the young novice designers. Instead, they showed resistance to the feedback of their peers and the client by rejecting or ignoring it. Especially the convergent feedback of the peers, which actively asked the young novice designers to reflect and evaluate their past, present, and future design decisions, was often met with resistance (Schut, Klapwijk, Gielen, & De Vries, 2019).

Overall, divergent feedback appears to occur rather infrequently in the studies at a university level (Cardella et al., 2014; Cardoso et al., 2014; Cummings et al., 2015; Yilmaz & Daly, 2016) as well as a primary level (Schut, Klapwijk, Gielen, & De Vries, 2019). Therefore, there is not as much known about novice designers' responses to this type of feedback, as with convergent feedback. Although divergent feedback would ideally stimulate a form of ideation, *Chapter 3* that it was again often met with resistance similar to the convergent feedback.

Based on this review, we conclude that there is often a discrepancy between the goals of educators and other feedback givers and the actual thinking processes that are triggered. This brings us to the questions of whether and how guidance in giving and receiving convergent and divergent design feedback can help overcome unconstructive feedback dialogues. We want to address this gap in knowledge by proposing, implementing, and analysing a design feedback procedure that focusses on evoking desired concurrent creative thinking processes with young novice designers.

4.2.4 Resistance towards design feedback

The reactions of the novice designers in the previously discussed studies display that they are not always open to feedback, which could hinder their creative thinking and, therefore, the development of their design. To be able to behave creatively while designing, it is essential to keep a balance between persistence and openness (Crilly, 2015; Csikszentmihalyi, 1999). On the one hand, a designer needs to be persistent in pursuing valuable ideas in the face of negative feedback (Crilly, 2015), especially since creative ideas are often not recognized in its early stages (Tassoul, 2009). However, on the other hand, one must also be open to the possibility of being misdirected (Crilly, 2015).

The study presented in *Chapter 2* uncovers how the young novice designers' resistance and lack of openness when developing their designs can be explained through the occurrence of *concept fixation* (Schut, Klapwijk, Gielen, van Doorn, et al., 2019). This type of fixation appears to have been observed in multiple studies with young novice learners (Luo, 2015; B Nicholl & McLellan, 2007; Bill Nicholl & McLellan, 2007), although the difference of this type of fixation from fixation in the ideation phase is often not made clear. Concept fixation is a type of design fixation – see (Jansson & Smith, 1991; Purcell & Gero, 1996) – that can occur during the concept development stage of a design process and "*leaves the designer stuck in a certain train of thought, adhering to the current (possibly unfavourable) state of the design (idea)*" (Schut, Klapwijk, Gielen, van Doorn, et al., 2019). A creative design process is full of insecurities, and part of the process is to become comfortable with that (Lawson, 2006). It is, therefore, understandable that novice designers tend to hold onto their ideas. Additionally, research by (Baer & Brown, 2012a) suggests that too much ownership can lead people to have feelings of negative effect and loss towards proposed changes, which directly influences their openness to change.

Overall, too much persistence and adherence leads to a lack of critical reflection and evaluation, which already appears to be limited with young novice designers compared to experienced designers (Blom & Bogaers, 2018; Goldschmidt, 2016). This lack leaves possible shortcomings in the design undiscovered and, in return, dismisses any need for new divergent thinking processes to generate new solutions and elaborations. Therefore, guiding convergent

design feedback constructively could help young novice designers to uncover shortcomings in a manner that does not evoke as much resistance.

4.2.5 Stimulating convergent and divergent thoughts

Studies by Eris (2004) and Cardoso et al. (2016) utilizing Eris' Question Driven Design Model showcase that high-level questioning can facilitate moments of critical reflection and evaluation within design teams of university students, which helps them realize previously unthought-of obstacles or concepts (Eris, 2004) and makes them consider alternatives to their current design trajectory (Cardoso et al., 2016). Additionally, the results of both studies show that although high-level convergent feedback can facilitate moments of reflection and evaluation, the combination with high-level divergent feedback is needed to move the creative design process forward (Cardoso et al., 2016; Eris, 2004). This necessity for providing a way forward is also affirmed by research into effective feedback for learning within a general educational context (Black & Wiliam, 1998; Hattie & Timperley, 2007). Additionally, a lack of divergence can hamper exploratory thinking and risk-taking, which are essential within creative processes (Daly & Yilmaz, 2015; Tolbert & Daly, 2013; Yilmaz & Daly, 2016).

However, *Chapter 3* shows that just posing high-level convergent and divergent feedback is not enough to ensure constructive dialogue and can still evoke resistance (Schut, Klapwijk, Gielen, & De Vries, 2019). In that study, it was uncovered that (implicit) expectation and assumptions the peers and clients had about the design ideas lead to a lack of mutual understanding about possible shortcomings present in the designs. Interpretive challenges are known to cause communication problems during feedback dialogues (Higgins et al., 2001; Sadler, 2010). Hence, before posing high-level feedback, a shared understanding of the design needs to be reached (Schut, Klapwijk, Gielen, & De Vries, 2019; Stables, Kimbell, Wheeler, Derrick, et al., 2016). Therefore, questions that ask for verification and clarification still appear to be a critical first step.

In conclusion, for design feedback to be effective in stimulating young novice designers' creative thinking it needs to: (1) guide towards a shared understanding of the design through low-level convergent feedback, (2) stimulate critical reflection and evaluation of the design to help identify and internalize possible shortcomings through high-level convergent feedback, and (3) provide a way to move forward by guiding new generative thoughts through high-level divergent feedback. These conclusions will form the key principles for the design of the new peer feedback intervention.

We are interested in the influence of the peer feedback intervention on the divergent and convergent nature of the design feedback and the concurrent creative thinking processes of the young novice designers. This led to the following research question: *In what way does the peer feedback intervention influence the convergent and divergent nature of the design feedback*

given by the clients and peers and the concurrent direct responses of the pupils? Our main contribution entails a detailed understanding of the successes and obstacles within the feedback dialogues within a primary school context as guided by the new feedback procedure; and possible future improvements.

4.3 RESEARCH DESIGN

To answer the RQ we utilized an educational design research approach, comprising of two cases over one year (Bakker, 2018; Van den Akker et al., 2006; Yin, 2014). These two cases followed the initial explorative case of the studies discussed in *Chapters 2* and *3*, therefore these two cases will from now be named Case 2 and 3 (see *Figure 1, Chapter 1*). During these two cases, two groups of primary school pupils (ages 7-12) from two different schools were guided to design solutions for real-life design challenges. Part of this guidance consisted of the developed peer feedback intervention. The intervention was slightly adapted after Case 2. The adaptation will be discussed in section 4.3.3.

4.3.1 Participants

The two cases took place at two different primary schools in the Netherlands. The selection of schools was based on their interest in design and technology education and a wish to experience a guided hands-on design project. From each school, one classroom of pupils participated in the study. *Table 5* gives a more detailed overview of the two cases. In both school classes the pupils (aged 7-12) had no previous hands-on experience with designing, apart from 8 pupils of Case 2 who participated in a short pilot case-study a few weeks prior (Van Mechelen et al., 2018). Before the start of the design project, the pupils were divided into gender-mixed heterogeneous design teams of four pupils by the teacher. In Case 2, the pupils who participated in the pilot case-study were divided over the teams. From each school class, four design teams were selected for in-depth data collection and analysis. The selection was made by the teacher and based on our request to select four teams that could represent the class as a whole concerning academic achievement and collaboration.

Table 5: Overview of Cases 2 and 3

	Case 2	Case 3
Education type	Montessori	Dalton
Participants	School class of 27 pupils (age 8-12), 7 design teams total, of which 4 selected for in-depth analysis	School class of 27 pupils (age 7-11), 7 design teams total, of which 4 selected for in-depth analysis
Design theme	Outdoor education: Design something that enables regular indoor classes (calculus, language, geography, etc.) to be taught outdoors.	Long-term hospitalized children's wellbeing: Designing something for the park of the hospital that enables hospitalized and non-hospitalized children to play and be active together.
Design sessions	6 sessions of 90-120 minutes Spread over 3 weeks (1 session a day)	6 sessions of 90-120 minutes Spread over 2 weeks (2 sessions a day)
Client(s)	1 adult representative of the Dutch NGO: Jantje Beton, which is an organisation that promotes outdoor play and activities.	1 adult representative and 4 child representatives of a Dutch children's hospital.
Client(s) background	Responsible for the creation of several of Jantje Beton's nationally promoted outdoor play events and activities for primary school pupils.	*Adult representative:* Head of the education department and manages the hospital's children's council. *Child representatives:* Part of the children's council and are experts through experience. They are either chronically ill or previously long-term hospitalized children. The council helps the hospital with improving any aspect of care.

4.3.2 Design Sessions

During the two cases, the design teams worked on solving real-life design challenges presented to them by real clients. For two to three weeks, they were guided through the entire design cycle in design sessions of 90 to 120 minutes. The different phases of the design sessions were structured as follows: introduction & sensitizing, exploring the design theme, defining a point of view, ideation, selection & detailing, feedback on the design ideas, concept development & prototyping, and feedback on the final designs. The design activities were based on tools and methods from the CPS tradition (Isaksen et al., 2010; Tassoul, 2009), design tools from the Delft Design Guide (Van Boeijen et al., 2013) and lessons learned from previous studies conducted by the researchers connected to this study. These lessons learned included, but are not limited to, the following topics: design fixation (Schut, Klapwijk, Gielen, van Doorn, et al., 2019), design feedback (Schut, Klapwijk, Gielen, & De Vries, 2019), group dynamics ((Van Mechelen et al., 2015), co-design processes (Van Mechelen, 2016; Van Mechelen, Laenen, et al., 2019), and pupils' design skills (Van Mechelen et al., 2018; Van Mechelen, Schut, et al., 2019). *Table 6* gives a concise overview of the content of each of the design sessions. Furthermore, the tools used in the design sessions can be found on the following websites: www.tudelft.nl/codesignkids (English version) and www.tudelft.nl/yourturn (Dutch version)

The design sessions took place in a classroom setting, and all design teams took part simultaneously. The first and second authors facilitated the sessions. The teacher of the class was present during all of the design sessions to assist with any classroom management or behavioural issues. The researchers facilitated the design sessions instead of the teachers, to ensure that the content of the sessions was implemented as envisioned.

4.3.3 Peer Feedback Intervention

Overall, the goal of the peer feedback intervention was to support a constructive feedback dialogue that would stimulate the design teams' creative thinking and help prevent and/or overcome resistance. The intervention was based on the conclusions from the literature review and the pilot case-study (Van Mechelen et al., 2018) and was implemented in the 4th, 5th, and 6th design sessions. Furthermore, a few changes were made to the procedure in Case 3 based on the observations in Case 2. Since these changes primarily affected aspects of the procedure during the 5th design session, they are disregarded in this particular study.

In the 4th and 6th session, a design critique took place, during which the design teams took turns to present their design and receive feedback from their peers (the other design teams) and the clients. In the 4th session, the focus of the critique was on improving and elaborating on the designs. In the 6th session, the focus was firstly on communicating the final designs in detail to the client and secondly on exploring future improvements and elaborations. During the 5th session, the design teams selected the feedback which they wanted to utilize to improve their design. Since the focus of this study is on the feedback dialogues, the focus will lie

on the implementation of the intervention during the 4th and 6th design sessions. *Table 7* gives a concise overview of the procedure of the intervention during these two sessions.

Table 6: Overview of the content of the design sessions

Design Session	Content
0. Introduction & Sensitizing	• Pre-session one week prior to the start of the design project • Announce the start of the project and give a short introduction. • Pupils received sensitizing assignments that they had to complete before the start of the first design session. These assignments were meant to trigger reflection about the design theme.
1. Exploring the design theme	• Introduction of the design cycle and design skills • The client (s) introduced the design theme. • Exploring design theme through stories
2. Defining a point of view	• Introduction to problem defining • Defining an ideal situation, design question, and design criteria
3. Ideation, selection & detailing	• Ideation guided by brainstorming tools • Idea selection guided by selection tools • Detailing selected idea with an elaboration tool
4. Feedback design ideas	• Each design team presents their design idea and receives feedback from the clients and their peers • Focus on improvement and elaboration of the design idea
5. Concept development & elaboration	• Each design team selects design feedback to improve and elaborate on their design • Building models or prototypes to develop the design idea
6. Feedback final designs	• Each design team presents their final design and receives feedback from the clients and their peers

Table 7: Overview of the procedure of the peer feedback intervention in the 4th and 6th design sessions of Cases 2 and 3. The quotations are copied from the feedback forms.

Part	4th design session	6th design session
Preparation	Modelling exercise by facilitators to teach the intention and procedure of the peer feedback intervention.	A reminder of the intention and procedure of the peer feedback intervention.
Next parts form one turn per design team.		
Part 1.	Design team presents design idea.	Design team presents design prototype.
	Peers and clients are prompted to pose clarification questions to work towards a shared understanding of the design.	Peers and clients are prompted to pose clarification questions to work towards a shared understanding of the design.
	Peers and clients receive scaffolding guidance by feedback forms	*Peers and clients receive verbal prompts as a reminder*
Part 2.	Peers and clients are guided to construct specific compliments. "*What do you not yet understand about the design?"*	Peers and clients are prompted to pose specific compliments. "*What do you not yet understand about the design?"*
	Peers and clients are guided to construct high-level convergent feedback. "*We think this could be better about the design… because …"*	Peers and clients are prompted to pose high-level convergent feedback.
Part 3.	Peers and clients are guided to construct a high-level divergent how-question. *"How can you …"*	Peers and clients are prompted to pose high-level divergent feedback.
	Peers and clients are guided to construct possible solutions to their how-question. *"We think this could maybe be a solution …"*	
	The clients and a few peers share their feedback with the design team by reading the feedback forms out-loud.	

Preparation

Before the start of the feedback procedure, the pupils and the clients participated in several modelling exercises to teach them how to construct the design feedback. During these exercises, the facilitators demonstrated the different steps of the feedback procedure and allowed the pupils and clients to practice each step through several examples. All participants were made aware that the goal of giving and receiving design feedback was to *'help each other make their design better'*. The two researchers facilitated entire the peer feedback intervention and acted as gate-keepers in order to guide the procedure as planned.

Additionally, a feedback form was utilized during the 4th design session as a scaffolding tool to help the peers and clients with the construction of their design feedback (*part 2 & part 3*). An example of this feedback form can be found in the *Appendix*. These feedback forms were filled in collaboratively by the peers in their design teams. When more than one client was present, they also collaborated on one form. After constructing the feedback forms, the clients and some of the peers could share their feedback by reading it out loud to the design teams. During the 6th design session, the feedback form was not utilized again. Instead, the facilitators utilized verbal prompts to remind to the peers and clients of the structure of the feedback form and the order in which they should pose their feedback.

Part 1: Guide towards a shared understanding of the design.

To start, each design team took their turn to present their design to their peers and the clients, utilizing sketches and prototypes or models to clarify their idea. Directly after each presentation, their peers and the clients were invited by the facilitator to pose questions low-level convergent questions to help them verify and clarify their understanding of the design. As guidance, the facilitator posed the following question: "*What do you not yet fully understand about their design?".* These questions should not directly contain a form of judgement or stimulate a higher level of reasoning. When a shared understanding of the presented design was reached, the procedure continued with guiding the construction of high-level convergent (*part 2*) and divergent (*part 3*) feedback.

Part 2: Stimulate critical reflection and evaluation of the design.

This part involved the peers and clients in constructing high-level convergent feedback to help the design team identify and internalize possible shortcomings in their design through critical reflection and evaluation. Before giving high-level convergent feedback, the peers and clients were asked to mention one or more specific and particular positive aspects of the design, which they could write on the feedback form (4th session) or directly share with the design team (6th session). Afterwards, specific and concrete high-level convergent feedback was constructed. In the 4th session, this was guided by the feedback form by finishing the following sentence: "*We think this could be better about the design… because …".* The *'because'* implemented to guide the construction and communication of an adequate argumentation for the uncovered critique.

Previous studies have highlighted this type of argumentation is often absent in a more unguided setting, while this type of transparency was found of importance for the design teams (Schut, Klapwijk, Gielen, & De Vries, 2019; Van Mechelen et al., 2018). *During* the 6th session, the peers and clients could directly give high-level convergent feedback to the design team. They were reminded of the feedback form via prompts, yet were also free to pose other types of high-level convergent feedback. This was done intentionally to gain insight into the types of questions they would pose in a more unguided setting.

Part 3: Provide a way to move forward by guiding new generative thoughts.

After the high-level convergent feedback, the peers and clients were invited to construct high-level divergent feedback to provide the design team a way to move forward by guiding new generative thoughts. In the 4th design session, this was again guided by the feedback form. First, they were guided to transform their high-level convergent feedback into a high-level divergent question: "*How can you …".* Then, they were asked to construct possible solutions to this question, which could serve as an inspiration to the design teams: *"We think this could maybe be a solution …".* In the 6th session, the peers and clients could directly pose the high-level divergent feedback to the design team. They were reminded of the feedback form via prompts, yet were again free to pose other types of divergent high-level questions. This was again done intentionally to gain insight into the types of questions they would pose in a more unguided setting.

4.3.4 Data collection

During both cases, all design sessions were audio and video recorded. Due to the focus of this study on the verbal feedback interactions, only the recordings of the 4th and 6th design sessions were selected for data analysis.

4.3.5 Data analysis

To analyse the data, we followed the Verbal Analysis approach (Chi, 1997), which consisted of the following steps: segmenting the transcripts in units of analysis, selecting and developing the coding frameworks, applying the coding frameworks in a coding process, and pattern identification & interpretation. The transcriptions of the audio-video recordings of the interactions of the selected design teams during 4th and 6th design sessions during Cases 2 and 3 were used as the primary data source.

Units of analysis: Design feedback & direct responses:

Units of analysis were created of consecutive feedback and direct responses based on the conversation content. Only the feedback and responses focussing on the design in question were considered. Within the units, pairs of feedback and response were formed. When multiple

questions and comments were given in a row, or when multiple answers were given in a row, these would be grouped to form one pair consisting of multiple feedback and response codes.

Coding framework: Types of feedback

To determine the nature of the feedback of the clients and the peers, Schut et al. (2019)'s *Design Feedback Model* was used, which is displayed in *Figure 10*. The current model has evolved from the initial version presented in *Chapter 3* and was originally based on Eris' question-driven design model (Eris, 2004). When instances of feedback could not be coded with the model, additional codes were formed through inductive coding and added to the model. The Design Feedback Model makes, identical to Eris' model, a distinction between two levels of feedback: low and high. However, in this model, *low-level feedback* is divided into *low-level questions* and *low-level comments*. Low-level questions are mainly information-seeking questions and are posed when one giving feedback, for example, wants clarification or verification about certain aspects of the design. Low-level comments are expressions that do not directly ask for a direct response and are mainly posed to express a positive or negative judgement or give a direct suggestion. *High-level feedback* is, similarly to Eris' model, divided into *deep reasoning questions* (DRQs) and *generative design questions* (GDQs). High-level feedback asks for a higher level of reasoning and often entails reflection, evaluation, and/or generation. In the model, low-level feedback and DRQs are classified as convergent. This type of feedback is presumed to facilitate convergent thinking processes and share the common premise that a specific answer, or a specific set of answers, exists. GDQs are classified as divergent since they are presumed to facilitate divergent thinking processes by proposing alternative answers and prompting idea generation.

Coding framework: Types of direct responses

To determine the different types of direct responses of the design teams Schut's *Direct Responses Model* was used, which is displayed in *Figure 11*. The current model has evolved from the authors' initial version presented in *Chapter 3* and was originally constructed through open coding and comparison to the framework of Cardella et al. (2014) and Cummings et al. (2015). When instances of feedback could not be coded with the model, additional codes were formed through inductive coding and added to the model. The Direct Responses Model makes a distinction between different groups of direct responses, namely: resistance responses, report type responses, agreement type responses, deep reasoning response.

Coding process

All of the created the pairs were coded with feedback and direct response codes from the models. Additionally, we classified who posed the feedback to the design teams: the client(s) or their peers. Initially, the first author coded all of the feedback and response pairs of the entire dataset. Subsequently, the third author was trained by the first author in the use of the coding frameworks and also independently coded all of the feedback and response pairs of the entire dataset. Consistency was promoted by routinely comparing and discussing the coded data per

design team until a consensus was reached. All coding decisions were documented, and code descriptions were adjusted accordingly.

Pattern identification & interpretation

To be able to analyse coded data tables were constructed with the code occurrences and code co-occurrences of Cases 2 and 3. These tables, together with the coded transcripts, were used as a means to interpret the data and look for patterns.

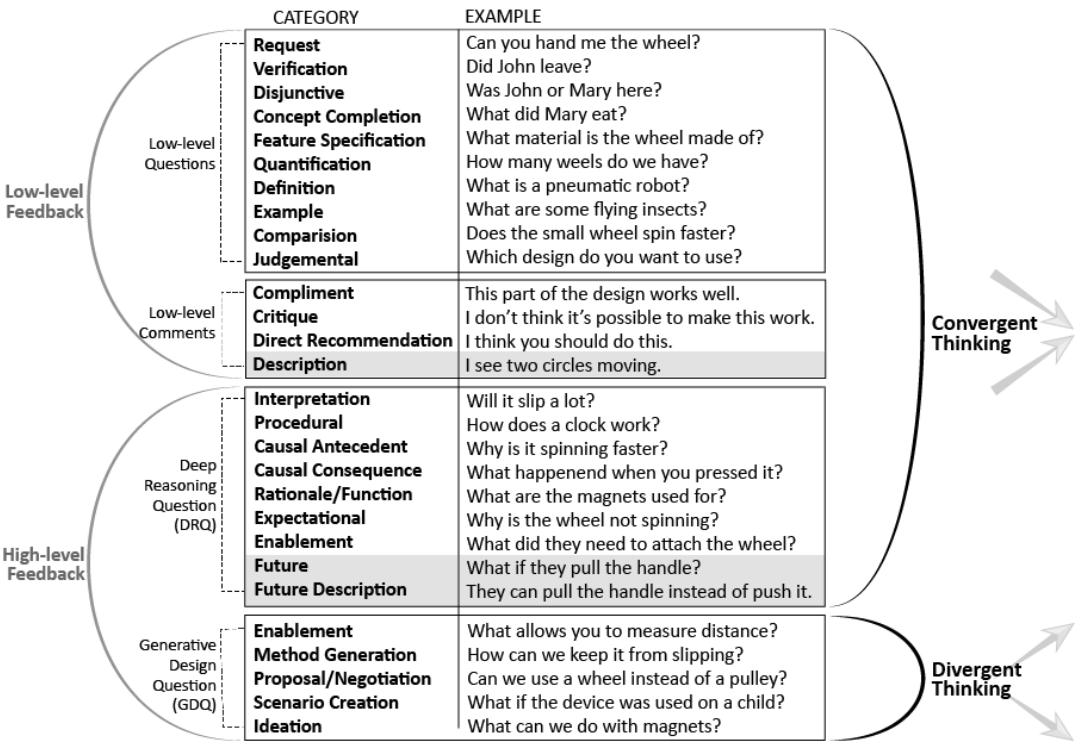


Figure 10: Design Feedback Model. The responses highlighted in grey emerged in the current study.

	CATEGORY	DESCRIPTION
Resistance responses	**Band-aids**	Adjustments or elaborations that don't present a valuable and relevant development and leave the flawed core of the design idea intact.
	Already in there	Uncovered shortcomings are dismissed by stating (falsely) that they have been present within the idea all along.
	Question not relevant	Feedback is indicated as not relevant to the design idea.
	It's not possible	Proposed adjustments or elaborations are immediatly deemed as not feasible without proper evaluation.
	It's you	Uncovered shortcomings are dismissed by making the future users responsible.
Report type responses	**Report Justify**	Explaining (features of) the design with a level of justification.
	Report Uncertain	Explaining (features of) the design with a level of uncertainty.
	Report	Explaining (features of) the design.
	Show	Physically showing something or acting it out.
Agreement type responses	**Disagree**	Being not on similar terms.
	Insecure	Showing uncertainty in a response.
	Silence	No reaction present.
	Ask	Question to clarify something.
	Restate	Rephrasing the received feedback.
	Nodding	Physical response indicating acknowledgement or agreement.
	Acknowledge	Indication of active listening.
	Confirming	Validation of a statements/assumptions.
	Agree	Being on similar terms.
Deep reasoning responses	**Don't know yet**	Admitting to incompleteness of the design.
	Reflection	Reflecting on previous actions.
	Evaluation	Evaluation previous actions an make judgement.
	Ideation	Generation of new ideas and exploring new possibilities.

Figure 11: Direct Responses Model. The responses highlighted in grey emerged in the current study.

4.4 FINDINGS

The following sections introduce the results of the qualitative analyses. Each section will start with the objective of the feedback procedure during that part of the design session and the expected design feedback (DF) and direct responses (DR). Subsequently, we will present actual occurrence and co-occurrence of the different types of DF and DR in Cases 2 and 3. Translated excerpts of the transcripts of the feedback dialogues are given to illustrate the results. In these examples, the pupils that were part of the design team are indicated as 'pupil' and, if necessary, a number. The peers and clients are indicated as such and, if necessary, a number.

4.4.1 Fourth Design Session: Feedback Procedure 'Part 1'

During each feedback round of a design team, the first part of the feedback procedure is meant to guide towards a shared understanding of the design by allowing the peer and clients to pose clarification type questions. Therefore, the expected DF from the clients and peers are primarily

low-level convergent questions. The expected DRs from the design teams are those facilitating clarification and explanation.

Clarifying the design through low-level convergent feedback

As expected, the majority of the DF posed in both cases consisted of low-level convergent questions. With these questions, the clients and peers predominantly checked their understanding of the design through *verification* questions; and asked for additional information about the design through *feature specification* and *concept completion* questions. The DR of the design teams to these low-level questions in both cases consisted mainly of *report*.

> Peer: *So, you have to solve a math problem and the answer… Uhm… What did you have to do with the answer again?* [Concept completion]
> Pupil: *The answer, that number is how often you have to score (in the goal).* [Report]

> Client: *Does the (hospitalized) child have to pull it (the cable of the cable cart) themselves or someone else?* [Feature specification]
> Pupil: *No, someone else who is there.* [Report]

There were also a few instances of *report uncertain*, which shows that the design teams are not always fully confident when explaining their design in its infant state. Below is an example of this type of DR.

> Peer: *Where should you position yourself to score?* [Feature specification]
> Pupil: *I think the player can decide themselves.* [Report uncertain]

Beside *report* type responses, the low-level convergent questions in Case 2 were also met with the DR *confirm*. This difference can be attributed to the higher occurrence of *verification* questions in this case.

> Peer: *So, you have to run as fast as you can to the right spot (on the playground)?* [Verification]
> Pupil: *Yes.* [Confirm]

The majority of the DRs during the first part could be considered as responses that enable a constructive feedback dialogue. However, there were also a few *resistance responses* present in both cases. Since low-level convergent questions ask for information and do not directly ask for any evaluative or generative thinking processes, these DRs were unexpected. Nonetheless, the example below illustrates how questions asking for additional information about certain aspects or mechanisms of a design can trigger design teams to parry the feedback.

Peer: *How many times do you have to score?* [Feature Specification]
Pupil 1: *You should decide for yourself.* [It's you] *You should use a sort of timer, and then you can…, and then as fast as you can.* [Band-aid]
Pupil 2: *How often you can score in a minute or something.* [Band-aid]

Unexpected DRQ's and GDRs

Aside from the expected low-level convergent questions, there were also instances of Deep Reasoning Questions (DRQs) and Generative Design Questions (GDQs). Especially in Case 3 the peers posed several DRQs to the design team, consisting mainly of *Future* and *Future description* questions. Through these types of questions, the peers asked the design teams to reflect and evaluate possible future states of the design. The DRs to these high-level convergent questions varied between *report type responses* and responses indicating disagreement (*disagree)* or resistance (e.g., *band-aids, already in there*).

Peer: *Yet at a certain moment, then all the (drawn) chalk boxes (on the schoolyard) are full (with numbers), and then you cannot continue anymore.* [Future description]
Pupil: *Yes, but you can just make it (the chalk drawings on the schoolyard) wet, then it's gone. Then it's vanished, gone (hand movement) (laughing).* [Band-aid]

The example above illustrates the occurrence of resistance towards high-level convergent feedback. Since the clients and peers were prompted to not yet pose these types of questions at this part of the process, the facilitators tried to postpone the dialogue as much as possible. This can be seen in the example below.

Peer: *I can imagine that some kids do not always have someone accompanying them. So what if that happens and they still want to go in the cable cart?* [Future]
Facilitator: *Is that a clarification question, or do you think this might be a critique? Is this something you could put on the feedback form?*
Peer: Maybe yes.

4.4.2 Fourth Design Session: Feedback Procedure 'Part 2 & 3'

The second part of each feedback round corresponds with the 2nd and 3rd part of the feedback procedure, during which the constructed high-level convergent and divergent feedback were meant to stimulate the design teams' reflective, evaluative, and generative thinking processes.

In the 4th design session, the peers and the clients utilized the feedback forms to construct written feedback. From these forms, a few were shared with the design teams on the spot by reading them out-load, to which the teams could respond. Other forms were shared with the design teams in session five, but this part of the process is not analysed in this chapter.

Beforehand, we found it difficult to predict which type of DRs might occur as all feedback is shared consecutively due to the read out-load format.

Direct responses to the feedback forms

As expected, the DF of the clients and peers in both cases was generally in accordance with the structure of the feedback form. This means that the feedback read out-loud by the client or by a design team usually started with a low-level comment (*compliment*), followed by high-level convergent feedback (DRQ) and followed with high-level divergent feedback (GDQ).

Almost all of the DRQs consisted of *future description*, which is one of the new feedback codes added to the model during analysis. Through this type of feedback, a person uncovers possible future strengths and shortcomings in the design by describing a scenario in which the design is used. As this type of feedback did not occur in any of the feedback sessions in our earlier studies presented in *Chapters 2* and *3* without the peer feedback intervention, we are quite certain that the occurrence of this new type of DRQ can be attributed to the formulation on feedback form *("We think this could be better about the design … because …")*. The form stimulated to mentally model and describe how a design might function in practice.

Below is an example of a feedback form that is red out-loud during Case 2. The peers give feedback on a design idea that combines math and sports. In the game, a player first solves a math problem and then scores in a goal to match the number of the answer.

> Peer 1: *We think the idea is a lot of fun.* [Compliment] *Uhm (…) 'What could be better' (…) Yeah, well, having to score that often is a lot. And that can be quite tiring. So, imagine you have 121 times, that is then the answer. If you then have to score 121 times you lose all your time trying to score. Then you can maybe only solve one problem.* [Future description] *Our 'how-question' is: How could you change it (the game) so you don't have to score that often*? [Method generation] *And 'this could maybe be a solution': that you can divide it. The answer.* [Proposal/Negotiation]
>
> Peer 2: *Yeah, so that you divide the answer again. That you again make a math problem with the answer to divide it.* [….]

In this example, the GDQs consists of method generation followed by a proposal. As intended, almost all of the GDQs on the feedback forms consisted of *method generation* and *proposal/negotiation*.

In the analysis, we looked at the DR of the design teams towards the reading out-loud of the feedback forms. In both cases, low-level comments (*compliments*) were mainly met with a DR in the form of *silence*. In Case 3, a few instances of *nodding* and *agree* also occurred when the clients shared their low-level comments.

The DRQs of the clients co-occurred with the DR *silence* in both cases. However, DRQs from the peers were also met with a few instances of resistance. This could be explained through the expert position the clients take. Design teams might see them as more knowledgeable as their peers and are therefore more willing to accept their questions.

The DRs to the GDQs were more varied than to the DRQs, although again *silence* took up a substantial part. Other types of responses were mainly observed towards the GDQs of the peers in Case 2 and the clients in Case 3. In Case 2, the GDQs of the peers were met with a few DRs indicating resistance, yet there were also DRs present indicating more openness, namely, *acknowledge* and *ideation*. In Case 3, DRs in the form of *nodding, reflection,* and *ideation* to the DF of the clients were present. This shows that the design teams were able to receive the feedback in a positive way.

4.4.3 Sixth Design Session: Feedback Procedure 'Part 1, 2 & 3'

In this design session the feedback procedure again makes a distinction between the different parts of the feedback procedure. However, since this time only verbal prompts were used, all of the feedback parts follow each other directly during each feedback conversation. The focus in this 6th session lies predominantly on revealing the final design to the clients and peers and less on possible further improvement. Therefore, we expected the clients and peers to work more towards understanding the design fully through low-level and high-level convergent feedback. Nonetheless, we expected all types of DF to be present in this session.

The peers' focus on convergence

Overall, convergent DF was most prominent, yet all types of DF were present in this 6th session in both cases. In both cases the peers posed around the same amount and types of DF. Low-level convergent questions, low-level convergent comments, and high-level convergent questions all took up around a small third of the total DF of the peers. Additionally, there were a few instances of high-level divergent questions.

As expected, due to the guidance in the feedback procedure, the peers posed most of the low-level convergent questions right after the presentation of each design team at the start of the feedback dialogue. Similar to the results of the 4th session, the peers utilized this first part of the feedback procedure to check their understanding of the design through *verification* questions; and ask for additional information about the design through *feature specification* and *concept completion* questions. Especially in Case 2 the peers predominantly posed *verification* questions, while in Case 3 the questions were more varied. In both cases, the low-level convergent questions were often met with a *report* DR. In Case 2 the *confirming* response also occurred often, which can be related to the higher occurrence of *verification* questions. Other DRs that stood out was the occurrence of a few instances of *deep reasoning responses.*

Since these DRs indicate a form of higher-order thinking, we did not expect them to occur after any of the low-level convergent questions directly. Below is an example in which a low-level question evokes reflection and ideation.

> Peer: *What is actually the height of the cart (of the cable cart)?* [Feature Specification]
> Pupil 1: *We did not really think about that...* [Don't know yet]
> Pupil 2: *Not too high I guess.* [Reflection]
> Pupil 3: *Maybe a meter?* [Ideation]

The peers did not adhere to the order of the feedback form when posing high-level feedback in this session. Instead of starting with convergent feedback and following with divergent feedback, the high-level feedback appeared to be mainly convergent with only a few instances of divergent feedback. The high-level convergent feedback (DRQs) of the peers was varied in Case 2, while in Case 3 the majority consisted of *future* and *future description*. These two types of feedback are somewhat similar, in the sense that they uncover possible future functioning and often shortcomings in the design. Since in the 4th design session the high occurrence of the feedback type *future description* is presumed to be linked to the phrasing of the feedback form, the high occurrence of *future* and *future description* may be a lingering effect of the peers' previous practice with filling in these forms.

In both cases, the DRs of the design teams to the DRQs were fairly similar in their distribution. Around half of the DRs consisted of report type responses, of which around half was *report justify*. Especially in Case 3 *report justify* took a more prominent role. *Report justify* is a type of report that (re)explains the design with a certain level of justification from the designer.

> Peer: *I don't always go sitting face forward down the slide. I also go on my back or belly or face backward. I don't know if it's nice to land on such a pillow if you do that.* [Future description]
> Pupil: *Well, we think it is nice to land on such a pillow. Because it's not really smart to go down the slide facing backward. That's true.* [Report justify]

Besides this, the DRQs of the peers were also met with resistance responses, especially *band-aids* and *question not relevant*.

> *Peer: Why does someone have to pull on the cable and is it not electric?* [Expectational]
> *Pupil: We didn't think an electric cable was needed.* [Question not relevant]

Together the occurrence of *report justify* and *resistance responses* implies that the design teams were not as open to the DRQs posed by the peers as to the DRQs by the clients.

Opposite to this, there were a few instances of deep reasoning responses, in the form of *don't know yet, reflection, evaluation,* and *ideation*. Although only a few of these DRs occurred, they do indicate that the DRQs have the potential to stimulate a higher level of reasoning. The examples below illustrate how DRQs can trigger reflection.

> Peer: *Imagine that the answer (to the math problem) is 64. You said that the side poles (of the goal) are 50 (points), and the top bar is a 100 (points). But there is not exactly 64 on any of them.* [Future description]
> Pupil 1: *Well, you also have pons, and there are also numbers on there.* [Report]
> Pupil 2: *Oh, yeah. Those (the pons) are not an uneven number.* [Reflection]

> Peer: *How does it exactly work with the iv pole (on the slide)?* [Procedural]
> (team members whisper to each other)
> Pupil: *We don't have a solution for that yet.* [We don't know yet]

Our data shows that these types of DRs predominately occurred when a design team already displayed a certain level of openness in the feedback dialogue preceding the DRQs.

Although the peers predominantly posed convergent feedback, instances of divergent feedback were also present. The high-level divergent feedback (GDQs) of the peers were varied in both cases, yet in Case 2 *proposals* did take up a significant part of the DF. In both of the cases around half of the DRs to the GDQs consisted of *resistance responses*, with *already in there* being quite prominent. Through this response, the design teams dismiss that what is proposed by stating that it is already present within their design. Although also a few other DRs were present, the relatively high occurrence of resistance responses indicates that the design teams were not very open to the GDQs posed by the peers. Below are two examples that display how the design teams dismiss the GDQs of their peers.

> Peer: *Maybe it could be fun to do something with points? For example, who collects the points? Or maybe play in teams?* [Proposal/negotiation]
> Pupil: *The player with the most points who wins, that's it.* [Already in there]

> Peer: *Maybe you can think a bit more about how it will work with the wheelchair?* [Method generation] *Because there is not always someone else present.* [Future description]
> Pupil: *No, there is always someone else present.* [Question not relevant]

The clients' focus on verification and generation

Since the client of Case 2 was not present during this final design session, we only discuss the DF posed by the clients of Case 3. Around half of the DF of the clients consisted of low-level convergent questions, focussing mainly on verification. This distribution of DF indicates that the

clients' focus lies predominantly on gaining a good understanding of the designs. This is to be expected, since the focus of the design session was revealing the final designs to the clients. Around half of the DRs to the low-level convergent questions consisted of *confirming* and a third of *report.* These responses indicate a neutral posture from the teams, with an apparent willingness to elaborate on the explanations of their designs.

Furthermore, around a third of the DF consisted of low-level convergent comments, mainly *compliments*. The many compliments could indicate a positive attitude from the clients towards the designs. These comments were mainly met with DRs in the form of *nodding*. Additionally, there were some instances of *acknowledge* and *agree*; and even some *reflection* responses. The DRs indicate that the reception of this DF by the design teams was rather positive, which could explain the level of openness of the design teams towards the rest of the DF.

There were only a few instances of high-level convergent feedback (DRQs) in the form of *future descriptions.* The rest of the DF was classified as high-level divergent feedback (GDQs), predominantly consisting of *proposals*. These *proposals* showcased how the clients focussed on possible future adaptations and elaborations of the designs. Around half of the GDQs of the clients were met with agreement type DRs in the form of *nodding, acknowledge* or *agree.* Additionally, a bit less than half of the GDQs co-occurred with deep reasoning responses, in the form of *ideation, reflection*, and *don't know yet.* Together, these DVRs of the design teams indicate openness towards the high-level divergent questions of the clients.

The key to openness: verification & compliments

Compared to the DRs towards the DF of the peers, the DF of the clients was met with more openness from the design teams. Below is an example of such a constructive feedback dialogue between one of the clients and a design team. The design that is discussed was rather unusual and received some critical feedback from the peers at an earlier point in the feedback dialogue. The team reacted to this DF of their peers with several *resistance responses*, trying to prove the quality of their design. However, the manner in which the team reacts to the DF of the client is very different.

Client: *So the idea is that you will build an ice-ring?* [Verification]
Pupil 1: *Yes, I guess so.* [Confirm] [Insecure]
Client: *And this means that the ice-ring is there all year round?* [Verification]
Pupil 1: *Yes.* [Confirm]
Pupil 2: *It depends on if you want to ice-skate in the summer.* [Reflection]
(…)
Client: *So the ice-ring will be there permanently?* [Verification]
Pupil 1: *Yes.* [Confirm]

Client: *And what else could you maybe do with the ice-ring?* [Ideation] *If it's a hot summer, will there then also be ice on it?* [Feature specification]
Pupil 1: *Maybe you can then also use it as a pool.* [Ideation]
Client: *Yes. And maybe you can make this thing float so they can swim with it.* [Proposal/negotiation]
(team members nod)
Pupil 1: *Yes.*

The example illustrates how the client first puts their effort towards gaining a shared understanding of the aspect of the design they want to direct their high-level feedback to. After, the client proceeds to pose their high-level feedback, which then evokes a concurrent convergent or divergent response from the design team. As described earlier, the design teams reacted more positively and open to the high-level feedback from clients than their peers. The manner in which the client poses the high-level feedback might have added to this openness.

4.5 DISCUSSION & CONCLUSION

The peer feedback intervention was developed with the intention to guide constructive feedback dialogues and stimulate young novice designers' creative thinking. In our previous studies on design feedback in an unguided setting, feedback of clients and peers was frequently met with resistance (Schut, Klapwijk, Gielen, & De Vries, 2019; Schut, Klapwijk, Gielen, van Doorn, et al., 2019). The results of the current study demonstrate how different types of guidance supports young novice designers, their peers and clients in engaging in constructive feedback dialogues. Several successes were uncovered during the analysis, showing how the intervention was able to (1) guide towards a shared understanding about the design, (2) stimulate cognitive modelling, (3) encourage an initial calmness towards high-level feedback, and (4) evoke deep reasoning responses.

4.5.1 Realizing a shared understanding

The intervention aimed at establishing a shared understanding of the developed design at the start of a design feedback dialogue through low-level convergent feedback. In general, this led to a constructive start of the feedback dialogues, in which the design teams displayed openness towards the questions and comments of their peers and the clients by confirming certain understandings or providing additional information about their design. The problem of undiscussed expectations and assumptions about the designs, that we observed in unguided settings (Schut, Klapwijk, Gielen, & De Vries, 2019; Schut, Klapwijk, Gielen, van Doorn, et al., 2019) was therefore no longer as prevalent. Several studies confirm the importance of clear communication and a shared understanding about the design between all parties for a

feedback dialogue to become valuable (Sadler, 2010; Schut, Klapwijk, Gielen, & De Vries, 2019; Stables, Kimbell, Wheeler, & Derrick, 2016), which the intervention can successfully guide towards.

4.5.2 Stimulating cognitive modelling

In all the sessions –whether the feedback form was used or verbal prompts to adhere to the feedback structure - we observed the repeated occurrence of the high-level convergent feedback types *future* and *future description*, especially from peers. Since these types of feedback did not occur during our previous study on design feedback of young novice designers in an unguided setting (Schut, Klapwijk, Gielen, & De Vries, 2019), we are rather confident that they can be attributed to the guiding sentences of the feedback form. *Future* and *future description* showcase the peers' ability to engage in high-level convergent thoughts. By imagining how the designs would be used throughout time they construct mental models of the design mechanics and user interactions. This ability of cognitive modelling is argued to be the core of designerly thinking and fundamental to one's creative abilities (Baynes, 2010). The intervention supports young designers in practicing and expressing this type of modelling.

4.5.3 Initial calmness towards the feedback form

All feedback given in the fourth session highlighted where there was room for improvement and explained why this was thought of as a problem. Then this feedback was concluded with a divergent question, usually in the form of *method generation* or *proposal/negotiation*. The primary direct response of the design teams to this high-level feedback of their peers and the clients was *silence*, which shows a level of calmness. Although this does not directly give a clear insight into their thinking processes, a positive impact of the intervention is clear when we compare it to the feedback sessions in an unguided session, where high-level feedback was often met with resistance (Schut, Klapwijk, Gielen, & De Vries, 2019; Schut, Klapwijk, Gielen, van Doorn, et al., 2019). In the guided setting, the design teams appear to not immediately reject the feedback. In *Chapter 5* we will focus our efforts on analysing the feedback uptake of the design teams when building their prototypes in the fifth design session.

4.5.4 Deep reasoning responses

On several occasions the design feedback of the clients and the peers was able to evoke deep reasoning responses from the design teams. Through these reflective, evaluative, and generative responses, the teams showcased their willingness to further elaborate on and improve their design. As our previous study on design feedback in an unguided setting indicates that these types of responses, especially reflection and evaluation, are not widespread (Schut,

Klapwijk, Gielen, & De Vries, 2019), the peer feedback intervention is thought to encourage reflective and evaluative thinking.

Unexpectedly, the high-level convergent feedback, especially that of the peers did not provoke the majority of the *reflection* and *evaluation* responses with the design teams. Instead, these responses were often preceded by high-level divergent feedback of the clients of Case 3 during the sixth design session. Also, the other deep reasoning responses, *ideation* and *don't know yet*, co-occurred often with this type of feedback. As described, verbal prompts were used during the sixth session as a form of guidance. With more freedom in constructing their high-level feedback, the clients deviated from the format of the feedback form, while still utilizing the core principles of the peer feedback intervention. We speculate that these modifications contributed to the stimulation of these desired deep reasoning responses with the design teams. The following modifications were identified:

Firstly, the clients repeatedly checked the shared understanding of the designs. They did this primarily by posing several verification questions to the design teams right before sharing any high-level feedback. By raising these questions and getting responses, the clients' assumptions and expectations of the designs are confirmed, and a shared understanding of the design arises. The difference with the feedback form on paper is that this form only guided towards creating a shared understanding of the design at the start of the feedback dialogue. Since clear communication and having a shared understanding is important in these feedback dialogues (Sadler, 2010; Schut, Klapwijk, Gielen, & De Vries, 2019; Stables, Kimbell, Wheeler, & Derrick, 2016), the clients' modification to check this understanding throughout the feedback dialogue repeatedly is an effective way to encourage a constructive feedback dialogue.

Secondly, the clients almost solely constructed high-level divergent feedback, while only a few instances of high-level convergent feedback were observed. As described, divergent feedback plays a crucial role in helping the receiver of the feedback 'move forward' (Black & Wiliam, 1998; Hattie & Timperley, 2007) and stimulating their creative thinking (Daly & Yilmaz, 2015; Tolbert & Daly, 2013; Yilmaz & Daly, 2016). We speculate that by focussing primarily on the additional opportunities and possibilities of the designs, combined with the clear shared understanding, the clients were able to create an open, positive atmosphere.

Lastly, another possible contributor to this open atmosphere is the many compliments the clients shared when compared to their peers. While sharing their feedback, the clients often added several positive remarks about the designs. Although the peer feedback intervention does give guidance in constructing positive remarks before sharing high-level feedback, this is often shared separately and not in such a high volume. Although the opinions on praise as an effective form of feedback for learners appear to vary (Hattie & Timperley, 2007; Voerman et al., 2014), our results show that in the context of design feedback dialogues it could encourage more openness with young novice designers. We speculate that all the modifications of the

clients together contributed to the open atmosphere, which has been vital in encouraging the design teams' deep reasoning responses.

4.5.5 Occurrence of resistance

Although constructive feedback dialogues were observed, the design teams also showcased instances of resistance towards the questions and comments of the clients and their peers. This is not entirely unexpected since novice designers of all educational levels have been observed to engage in responses indicating resistance, like parrying feedback and becoming defensive (Cardella et al., 2014; Cardoso et al., 2014; Cummings et al., 2015; Schut, Klapwijk, Gielen, & De Vries, 2019; Schut, Klapwijk, Gielen, van Doorn, et al., 2019). Additionally, the goal of the peer feedback intervention was not to eliminate all resistance. It can be argued that some resistance can be seen as positive since it shows signs of persistence, a quality that is needed when engaging in creative processes (Crilly, 2015; Csikszentmihalyi, 1999). One of the key learning processes of novice designers is figuring out how to balance between persistence and openness. Since this is not an easy task, it is understandable that the young novice designers, on occasion, lost this balance.

Several factors might have evoked or enhanced the design teams' resistance. As the data collection focused on the design feedback and the direct responses, it is not possible to discuss all possible factors that might have contributed to the occurrence of this resistance, such as the occurrence of concept fixation (Luo, 2015; Bill Nicholl & McLellan, 2007; Schut, Klapwijk, Gielen, van Doorn, et al., 2019), high levels of ownership (Baer & Brown, 2012a) or a lack of design skills (Blom & Bogaers, 2018; Van Mechelen, Schut, et al., 2019). We can, however, discuss how certain design feedback might have influenced the occurrence of this resistance. Most instances of resistance of the design teams co-occurred with high-level convergent feedback of their peers during the sixth design session. The design teams thus lacked openness towards the high-level feedback of the peers. We presume that there might be several causes that have contributed to this resistance.

To start, the peers primary shared high-level convergent feedback with the design teams during this session. Although convergence is needed when wanting to understand a design, an excessive focus is known to contribute to unconstructive dialogues (Cardella et al., 2014; Cardoso et al., 2014; Cummings et al., 2015; Schut, Klapwijk, Gielen, & de Vries, 2019). As described before, the lack of divergent feedback can leave the young novice designers without a clear ‘way to move forward’ (Black & Wiliam, 1998; Hattie & Timperley, 2007) and can hamper their exploratory thinking and risk-taking processes (Daly & Yilmaz, 2015; Tolbert & Daly, 2013; Yilmaz & Daly, 2016). The verbal prompts during the sixth session might not have sufficed in stimulating the peers in constructing high-level divergent feedback. Since the strict and specific guidance of feedback forms did showcase their ability to formulate this type of feedback, a different type of guidance during the sixth session might be more successful.

Furthermore, the literature suggests that the design teams could have perceived their peers, rightly or wrongly, as incompetent or lacking the expertise to give them feedback (Panadero, 2016). This could explain why the design teams showcased more resistance towards the feedback of their peers and not towards the clients, who were introduced as experts by profession or experience. Although the peers might not be perceived as knowledgeable as the clients, they could take on the role of an extension of the design team. By highlighting the ability of the peers to help adjust and elaborate on the designs, thereby focussing on the common goal of improvement, the design teams might be more open to the suggestions of their peers. Besides this, the peers need to be guided in creating a more open atmosphere when sharing feedback. Possibly, the clients' modifications can provide insight and inspiration for new ways of guiding peers in achieving more openness.

Additionally, the young novice designers might just not have agreed with some of the shortcomings that the peers uncovered. Their disagreement does, however, not necessarily justify their resistance. Reflective and evaluative thinking are thinking skills that are still in the process of developing with this age group. Studies show that engaging in convergent thoughts when designing does not always come easy to young novice designers (Blom & Bogaers, 2018; Schut & Blom, 2019). Although the construction of high-level convergent feedback does showcase their ability to engage high-level convergent thoughts, this does not mean they are able to reflect and evaluate their own designs critically. A study by (van Loon & van de Pol, 2019) suggests that elementary school pupils are more prone to detect errors in others' work than in their own. Therefore, it might have been easier for the young novice designers to reflect and evaluate the designs of their classmates, instead of discovering shortcomings in their own work. Future adjustments of the peer feedback intervention could therefore focus on finding ways to guide the design teams in first reflecting and evaluating their own design.

4.5.6 Updated design principles

To be effective in stimulating young novice designers creative thinking through design feedback dialogues, the peer feedback intervention was based on three main design principles: (1) guide towards a shared understanding of the design through low-level convergent feedback, (2) stimulate critical reflection and evaluation of the design to help identify and internalise possible shortcomings through high-level convergent feedback, and (3) provide a way to move forward by guiding new generative thoughts through high-level divergent feedback. Although the results indicate that the peer feedback intervention based on these design principles has shown to be effective in eliciting responses indicating divergent and convergent thinking, opportunities for improvement were also uncovered.

The first guiding principle, (1) guiding towards a shared understanding, was implemented at the start of a feedback dialogue by directing the clients and peers towards low-level convergent feedback. Generally, this led to a constructive start of the feedback dialogues

and could, therefore, be considered as a successful design principle. However, the constructive feedback dialogues between the clients and the design teams during the 6th design session, and the modifications to this guiding principle made by clients, could still provide inspiration for improvement. One of the modifications was the constant checking of the feedback givers of their shared understanding right before posing high-level feedback. We speculate that due to this clear understanding, the design teams feel that their design is well understood and feel acknowledged in their decisions. This might improve openness and reduce resistance towards the following high-level feedback, leading to more openness. Therefore, we propose that the first guiding principle should emphasise the need to continuously work towards a shared understanding throughout the dialogue, especially before posing high-level feedback.

The second and third guiding principle were meant to directly guide the young novice designers towards (2) reflective, evaluative and (3) generative thinking processes by means of high-level convergent and divergent feedback. However, the results showcase that, similar to previous studies (Cardella et al., 2014; Cardoso et al., 2014; Cummings et al., 2015; Schut, Klapwijk, Gielen, & de Vries, 2019; Schut, Klapwijk, Gielen, van Doorn, et al., 2019), the divergent or convergent nature of the feedback does not necessarily elicit the expected concurrent creative thinking processes. It could be argued that we need to let go of the idea that convergent or divergent feedback would direct the novice designers exactly into that concurrent thinking process. The intention of the feedback giver, either pushing towards convergence or divergence, could therefore be attained by either type of high-level feedback. Hence, there might be more merit in consciously and carefully alternating and iterating both types of feedback until the set intention is reached.

However, we do argue that more focus needs to be directed to the use of high-level divergent feedback within design feedback dialogues. The results show that the peers engage little in this type of feedback, creating an imbalance which could have contributed to the resistance of the design teams. Opposite to that, the clients engaged almost primarily in high-level divergent feedback during the 6th session. The dialogues that followed this feedback of the clients were observed to be generally constructive. We presume that this repeated use of high-level divergent feedback contributed to a positive and open atmosphere and directed the designers' attention towards 'moving forward' and improving their design. Additionally, we want to put specific emphasis on the many concrete compliments shared by the clients, which we believe to be another main factor contributing to the openness that was present in these specific dialogues. This approach of the client may have clarified to pupils that, besides judging the current state of a design, feedback is also meant to encourage current iteration rounds.

Based on our findings, we propose a set of revised principles for constructive design feedback dialogues among young novice designers, which stimulates their creative thinking: (1) continuously guide towards a shared understanding through low-level questions, especially before posing high-level feedback, (2) emphasise positive aspects of the design through specific

and concrete compliments, (3) stimulate reflective, evaluative and generative thoughts through alternating and iterating high-level divergent and convergent feedback, and (4) repeatedly provide a way forward, thereby fostering improvement, by posing high-level divergent feedback.

4.6 FUTURE WORK

Our results show that the developed and implemented peer feedback intervention can guide young learners and clients in sharing low- and high-level, as well as, convergent- and divergent feedback. Furthermore, it was observed how this design feedback and the concurrent direct responses from the young novice design teams were able to develop into constructive feedback dialogues. Even though, we see opportunities for optimizing these conversations further, thereby offering the young designers an even more optimal guidance on their creative journey. The constructive feedback dialogues between the clients and the peers could provide inspiration for future adjustments of the intervention, by utilizing the modifications of the intervention by clients. It could give insight into how the current resistance of the teams towards the high-level, primarily convergent, feedback of their peers could be transformed by guiding these dialogues in a different manner. Furthermore, clearly distinguishing the role of the peers from that of the clients by introducing them as helpers and extensions of the design teams, could create more openness towards the high-level feedback of their peers.

Although the young novice designers might have shown a level of resistance to high-level convergent feedback, we do not believe that this feedback should be avoided. In the data we have observed instances in which this type of feedback did evoke the desired concurred reflective and evaluative responses. However, the current intervention could benefit from future adjustments and research focussed on sharing and receiving high-level convergent feedback. Perhaps by focussing first on guiding the young novice designers to critically reflect and evaluate their own design and helping them understand the importance of this skill. Reflective and evaluative thinking form, together with generative thinking, the core of the creative design process (Goldschmidt, 2016; Howard et al., 2008). Future research on these thinking processes in the context of feedback dialogues between, and with, young novice designers could provide valuable insights on the development of their creative thinking skills. Therefore, we will expand the current results by analysing additional data to uncover how the design teams selected, discussed and utilized the feedback while elaborating and adjusting their design. Together, these studies will give an in-dept view of influence design feedback can have on young novice designers' creative thinking.

Chapter 5

Encouraging pupils' feedback uptake while designing

5.1 INTRODUCTION

Feedback is commonly used within a wide range of educational environments and can be a powerful tool for learning (Hattie & Timperley, 2007). The use of feedback in an educational context has been researched extensively, and it is widely accepted that even the youngest learners benefit from good feedback practices. (Wiliam, 2017). Design education is a specific creative context in which there is a longstanding tradition involving feedback interventions (Anthony, 1991; Oh et al., 2013). However, giving feedback on creative processes and the concurrent outcomes is often not so clear-cut (Csikszentmihalyi, 1999) and it is well known that the process of giving and receiving design feedback is not without obstacles (Anthony, 1991).

Chapter 2 and 3 showcase how primary school pupils often exhibit resistance to the feedback they receive from peers and clients, which hinders their creative design processes. Besides problems with receiving feedback, it was observed that the feedback was often (unintentionally) unconstructive in nature, creating a mismatch between the underlying objective and the actual effect. Due to these issues, much of the feedback these children received was left unused, while it could have benefitted their creative design processes greatly (Crilly, 2015).

To decrease resistance to design feedback, measures can be taken that improve the quality of the feedback given (Schut et al., 2020). For example, this could be by improving the balance between convergent and divergent feedback (Cardoso et al., 2016; Eris, 2004). However, measures that help pupils to process and make sense of feedback are equally important. Being able to process and utilise peer feedback is an essential competence in the context of design. Therefore, novice designers must have the opportunity to learn how to construct and receive feedback from an early age, which then needs explicit practise within the classroom. A meta-study on inquiry-based learning shows that it is necessary to guide the open-ended processes when aiming for valuable learning results (Lazonder & Harmsen, 2016). Due to the similarities, it is highly likely that well-constructed guidance is also essential for design-based learning, but this is often not put into practice. Therefore, a feedback procedure and tools were constructed as part of this dissertation to support primary school pupils in formulating and receiving peer feedback.

The general aim of this guided peer feedback intervention was to encourage young novice designers' feedback uptake, thereby stimulating their creative thinking processes leading to the development of their design outputs. To work towards this goal, the intervention was focused on encouraging constructive and valuable feedback exchanges by guiding the processes of giving and receiving peer and client feedback during real-life design projects. In *Chapter 4*, we evaluated the effect of this intervention on the formulation of feedback and the initial verbal responses (Schut et al., 2020). There we uncovered various constructive and valuable feedback exchanges between the young novice designers, their peers and the clients. To achieve this, a

series of key characteristics were implemented, namely: having attention for clarification and shared understanding of the design ideas, balancing convergent and divergent feedback, and using written and postponed feedback.

This chapter focuses on the processes of receiving and utilising design feedback. Receiving feedback requires active processes like managing emotions, sense-making, and deciding how to act upon the given feedback. *Chapter 2* and *3* on unguided design feedback processes show how primary school pupils struggle to take an active role and keep their emotions in check. Therefore, the guided peer feedback approach we developed was also meant to support the complex processes of receiving and stimulating the primary school pupils' feedback uptake. Here, we aim to understand the successes of the intervention and uncover points that can still be improved in future iterations. The following section provides a theoretical framework on feedback uptake in the context of design processes and possible ways to guide and encourage young pupils to take an active role as feedback receivers. This discussion results in three key principles to encourage constructive processing, sense-making and use of design feedback, which are implemented in the peer feedback intervention. How this implementation was done, and the resulting findings, are described throughout the rest of the chapter.

5.2 LITERATURE REVIEW

5.2.1 Feedback in design education

In general, design feedback forms an integral part of the studio practice of several university design disciplines. During these critiquing moments, the students update their instructors, peers and other stakeholders - such as real or simulated clients and potential users - on their process and the status of their design. While their work gets criticised, and its plusses and minuses are debated, the students have the opportunity to collect feedback (Dannels & Martin, 2008; Hokanson, 2012; Oh et al., 2013). These critiquing moments are considered imperative to design education and practice (Gray, 2013a, 2013b). Furthermore, they are regarded as a primary method through which novice designers develop their design skills (Hokanson, 2012; McDonnell, 2016) and gain expertise from their instructors and other stakeholders (Dannels, 2005; McDonnell, 2016; Oak, 2000).

Through questions and comments, novice designers can be sparked to think more deeply and broadly about their design (Stables, Kimbell, Wheeler, Door, et al., 2016), directly impacting their creative thinking processes. To solve ill-structured open-ended problems inherent to design (Dorst, 2003), designers must resort to these creative thinking processes to generate and develop solutions (Dorst & Cross, 2001a; Lewis, 2009). Design feedback is commonly used to help guide novice designers' creative design processes (Dannels et al., 2008; Nicholl, 2004; Tolbert & Daly, 2013). The feedback moments are primarily about improvement and development of a design (Van Dooren et al., 2020). By criticising the design output, the

design moves and decisions a novice designer took or will take are addressed (Cardoso et al., 2014; Oh et al., 2013; Yilmaz & Daly, 2016). Throughout a series of feedback interventions, the instructors commonly expect the novice designers to showcase the utilisation of the feedback they received through the developed and improved versions of their design.

However, this ideal of feedback utilisation often does not take place. Issues linked to a lack of openness by design students towards the feedback they receive have been observed at several educational levels. For example, university students were found to parry critical feedback by becoming too descriptive or even defensive (Cardella et al., 2014; Cardoso et al., 2014; Cummings et al., 2015). *Chapters 2* and *3* showcase how primary school pupils often rejected or ignored the feedback they received (Schut, Klapwijk, Gielen, & de Vries, 2019; Schut, Klapwijk, Gielen, van Doorn, et al., 2019). A state of defensiveness was also observed as pupils tried to protect the current state of their design (Schut, Klapwijk, Gielen, van Doorn, et al., 2019). Although designers should be critical of the feedback they receive and remain true to (parts of) ideas they believe to have value, the authors argued that the pupils' process of receiving, evaluating and utilising feedback could be improved on several facets.

5.2.2 Feedback uptake

As described in the previous section, the utilisation of feedback to evaluate, adjust and improve designs is a crucial goal of design feedback. In the context of non-design-oriented higher education, the utilisation of feedback by the learner is known as feedback uptake (Carless & Boud, 2018). It highlights the centrality of sense-making of the feedback information by the learners to be able to utilise it to improve their work (Boud & Molloy, 2013; Carless, 2015). Furthermore, it goes beyond the premise that feedback is predominantly a source – e.g. peers, teachers, professionals or computer-based systems - informing receivers -e.g. learners or students – about strong points, weak points and how to improve (Carless & Boud, 2018). Rather, it emphasises the pro-active stance learners need to take to process feedback to progress. In other words, learners need to take an active role in the feedback process.

To be active receivers and adequately make use of feedback, learners require specific competences and dispositions, which are known as feedback literacy (Carless & Boud, 2018; Sutton, 2012). Carless and Boud (2018) define feedback literacy as "… *the understandings, capacities and dispositions needed to make sense of information and use it to enhance work or learning strategies*". They describe a set of key capacities and dispositions feedback literate learners have or need to acquire (Carless & Boud, 2018), being: (1) appreciating the role of feedback in improving their work and understanding the active role they need to take, (2) being able to maintain an emotional balance when receiving feedback and are proactive in eliciting additional suggestions, and (3) continuously develop their evaluative capacities to be able to make sound judgements about their own work and that of others. Together, these three

competences maximise the potential for learners to utilise the feedback they received in order to (4) take action (Carless & Boud, 2018), ultimately resulting in feedback uptake.

To better understand design feedback processes and the emotions involved, we will build on a model from Carless and Boud (2018) that highlights the features of student feedback literacy (see *Figure 12*). The decision for this particular model was twofold. Firstly, this is the only model, to our knowledge, that explains feedback uptake through the capacities and disposition that are needed by the receiver, thereby emphasising their active role in the process. Secondly, we were able to adapt this model for this study while keeping its main features intact. The following sections introduce this adapted model and discuss it in the context of design education.

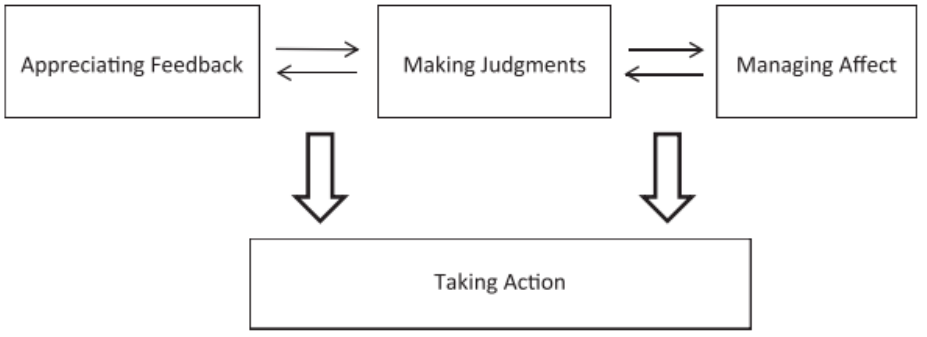


Figure 12: Features of feedback literacy (Carless & Boud, 2018)

5.2.3 Feedback uptake in the context of design

To shed light on the active role of the receiver within design feedback processes and generate novel insights, we will translate Carless and Boud's model of feedback literacy to the context of design education. The feedback literacy model differs from the dominant approach in design feedback literature, which either focuses on the role of the feedback givers - e.g. instructors, clients or peers -, the context in which the feedback is delivered, or the manner in which feedback is passively perceived or understood by receivers (Cardoso et al., 2014; Dannels et al., 2011; Goldschmidt et al., 2010, 2015; McDonald et al., 2019; McDonald & Michela, 2019; Yilmaz & Daly, 2016). Although these studies have led to insights and advice related to feedback giving, which can have a positive influence on feedback uptake, the suggested improvements often indirectly underline a passive role for the receivers. For example, the recommendations for education given by Yilmaz & Daly (2016) are mainly focused on changes the instructor could make in posing feedback, which are then consequently expected to change the actions of the students. Some studies touched on the active role of novice designers as feedback receivers

and their responsibility in utilising this feedback to their advantage (Dannels et al., 2008; Gray, 2013b). Yet, as far as we know, explicit measures that could support novice designers in receiving feedback have not been studied in the context of design education.

Building upon Carless and Boud's description of feedback uptake, we define design feedback uptake as 'novice designers taking an active role in utilising the received feedback to inform their future design moves, ultimately leading to the development and improvement of their design'. Furthermore, we build upon their model of the features of feedback literacy by transforming it into a process-based model for design. Although not stated, the components in their model implicitly point towards process steps as they are actions that a receiver continuously goes through during a feedback process. Practising these actions will then ultimately develop into capacities and dispositions. When taking this process perspective, the features in Carless and Boud's model overlap with actual process steps designers take during feedback processes. In *Figure 13,* we visualised a process model of design feedback uptake to illustrate how these process elements work together.

Our model utilises the four features described by Carless & Boud (2018) and highlights the active role of the receiver in the design feedback process. When feedback is given, receivers must balance their emotions and make evaluative judgements. In other words, they must remain open to the feedback, try to make sense of it, and evaluate if it is relevant and valuable for their creative design process. If the feedback is taken on board, this decision is followed by them taking action, e.g. a redesign activity. Differently from Carless and Boud (2018), we placed the element of 'appreciating feedback' in an overarching position. This decision was made because we perceive this element on a different level than the other three elements of the model. To illustrate, unconstructive feedback can directly affect the emotional balance of the receiver, and non-valuable feedback can directly affect the receiver's evaluative judgement and ability to take action. In contrast, a receiver's appreciation of feedback and their understanding of its value is generally not directly affected by a singular piece of 'bad' feedback. In the following sections, we will discuss each elements of the process model of design feedback uptake. Although the process of actions will be described in a relatively linear matter, we want to note that the actual process in real life is, of course, not linear.

Emotional balance

After presenting, displaying or explaining the current state of their design, the start of a feedback process is the moment when the novice designers receive a variety of feedback. One of the first actions needed during these initial moments in the feedback process is maintaining an emotional balance, as illustrated in *Figure 13*. When feedback is given, receivers would ideally be able to control their negative emotions and keep an open mind, even in the face of critical questions and comments. Refraining from negative emotions and maintaining an

emotional balance when receiving feedback is not easy, especially in the context of creative processes like design.

Novice designers from various educational levels have shown difficulty maintaining an emotional balance when receiving design feedback. In the studio context, it is observed how design students responding to critical feedback can ignore the questions and comments, become defensive, or resort to convincing the present parties of the quality of their design (Cardella et al., 2014; Cummings et al., 2015; Goldschmidt et al., 2010). Studies in higher education show that the manner in which students can control their emotional balance impacts how they deal with feedback (To, 2016). When students' negative emotions gain the upper hand, it could easily lead to defensive responses (Robinson et al., 2013). These negative emotions make it more challenging to evaluate and utilise the received feedback accordingly and recognise its potential. Similar results have been observed by Schut et al. (2019a; 2019b) in primary education, where the pupils often showed resistance to the questions and comments that were posed during unguided feedback dialogues, leading to an adherence to the current state of their design.

Most novice designers have a strong sense of ownership towards the design they are working on. This ownership can persist into the occurrence of concept fixation (Luo, 2015; Nicholl & McLellan, 2007b, 2007a; Schut, Klapwijk, Gielen, van Doorn, et al., 2019), which is a specific type of design fixation (Jansson & Smith, 1991; Purcell & Gero, 1996). When concept fixation occurs, negative emotions toward critical feedback can gain the upper hand and a strong attachment to the current state of the design develops (Schut, Klapwijk, Gielen, van Doorn, et al., 2019). Attachment can have positive and negative consequences for creativity. On the one side, a designer needs persistence when pursuing their ideas, especially since the quality of creative ideas is often not recognised in the early stages of a design process (Tassoul, 2009). While on the other side, they must also be open to the possibility of being misdirected (Crilly, 2015). The process of maintaining an emotional balance when receiving design feedback is, therefore, directly linked to the balance between openness and persistence (Crilly, 2015; Csikszentmihalyi, 1999).

So, what are responses that indicate openness from novice designers? In other words, what types of responses would educators like to see from their pupils within the design and technology classroom? In *Chapter 2* and *3*, a closer look was taken into the responses given by pupils in various unguided and guided feedback exchanges (Schut et al., 2020; Schut, Klapwijk, Gielen, & de Vries, 2019). Schut's *Design Feedback Model* and *Direct Responses Model* (see Schut et al., 2020) that were used as coding frameworks in the analysis gave a detailed insight into exchanges indicating openness or resistance. Two categories of response from the *Direct Responses Model* indicate degrees of openness to design feedback: so-called *report type responses* and *deep reasoning responses*. Through *report type responses,* pupils explain (features of) the design with different levels of certainty and justification. Generally, these types

of responses are relatively neutral and enable constructive dialogue. *Deep reasoning responses* showcase higher levels of thinking like reflection, evaluation, and ideation. These types of responses indicate an understanding of the feedback and initial use, as new divergent and convergent trains of thought are initiated. The studies showed that feedback exchanges are delicate, and feedback type and timing can enable or discourage openness in the responses.

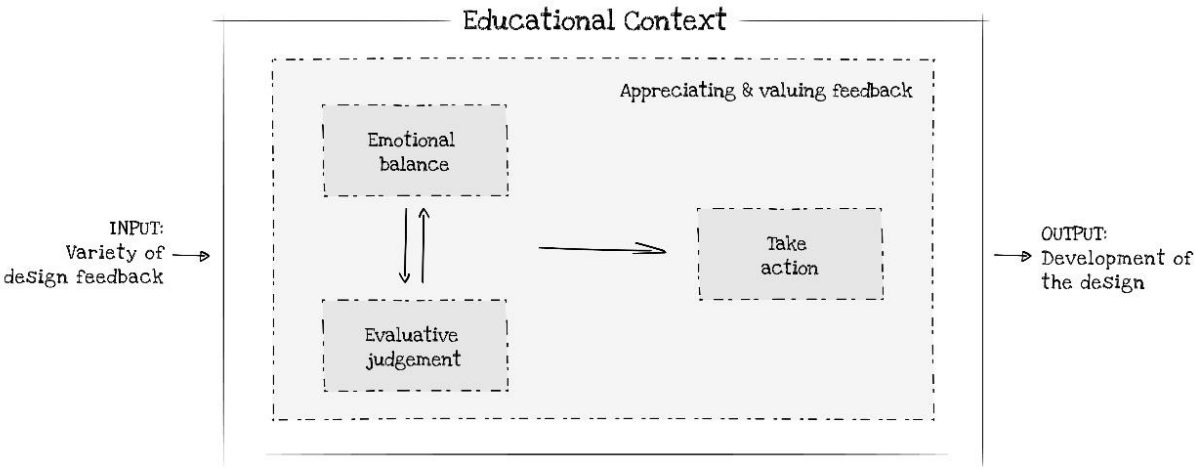


Figure 13, Process model of design feedback uptake - the active role of the receiver (based on Carless & Boud, 2018)

Evaluative judgement

After the feedback is initially received, the questions and comments need to be made sense off and evaluated by the young novice designers to enable successful feedback uptake (Carless & Boud, 2018). In feedback literature from higher education, evaluative judgement is described as the ability to make decisions about the quality of one's own work and that of others by identifying and utilising the appropriate, although often ambiguous, criteria (Tai et al., 2017). To evaluate something, learners need to have an understanding of what comprises quality within their current learning environment and apply these criteria to the work in question (Tai et al., 2017; Tai et al., 2016). When they understand this quality, they will be able to judge if the received feedback is relevant and can help them to make improvements. On top of that, learners need to be able to make sense of the feedback and the work before engaging in any form of evaluation.

Within design education, information on quality is linked to the parameters of a design assignment, which is generally accompanied by a set of explicit and implicit design criteria. The

explicit criteria are generally directly linked to the context of the assignment, available resources, and outspoken wishes from the client(s). The implicit criteria are often more ambiguous and come, for the most part, from a place of personal preference. Novice designers receive design feedback on their work from their instructors, peers and clients within these parameters and criteria. After making sense of and understanding the feedback on a content level, novice designers would ideally evaluate the feedback and their work based on the parameters of the assignment, the design criteria, and (if applicable) their previous knowledge and experience. This evaluation would then lead them to either accept or reject the received feedback. Either can be a valid decision, as long as it is done consciously. After all, not all feedback is valuable, and concerns can be refuted. When accepted, the novice designers arrive at the next stage within the process of feedback uptake, 'taking action'. When rejected, non-action or a different type of action can take place, which is outside the scope of the topic of feedback uptake.

Chapter 2 and *3* showed that young novice designers in primary education are not always able to adequately make sense of and evaluate the feedback and work in question (Schut, Klapwijk, Gielen, & de Vries, 2019; Schut, Klapwijk, Gielen, van Doorn, et al., 2019). We know from higher education that even for older and more advanced learners, sense-making and evaluative judgement are capacities that are difficult to master (Carless & Boud, 2018; Pitt, 2019; Tai et al., 2017; Tai et al., 2016). Even if the feedback is complete, of good quality and shared constructively, learners can still experience difficulty decoding statements properly (Sadler, 2010; Sutton, 2012). Concurrently, this can lead to a lack of skill in evaluating feedback and determining its value. This difficulty can be attributed to the level of ambiguity present within design. Due to its creative nature, there is no single right solution to a design problem, and there is no correct way to go about a design process (Dorst, 2003; Dorst & Cross, 2001a; Lewis, 2005). Although explicit design criteria can provide several concrete guidelines, many ambiguous criteria are often present within a design assignment. Due to this ambiguity, evaluation standards are subjected to varied interpretations and enactments (O'Donovan et al., 2004).

However, young novice designers' proneness to emotional imbalance when initially receiving feedback is also likely to interfere with their evaluative capabilities. Their resistance can lead to a lack of critical reflection and evaluation and instantly steer them towards rejection of the received feedback, regardless of the feedback's content and quality (Schut, Klapwijk, Gielen, van Doorn, et al., 2019). On top of that, young novice designers' evaluative thinking is already limited compared to experienced designers (Blom & Bogaers, 2018; Goldschmidt, 2016; Schut & Blom, 2019). These studies thus show that evaluative actions are not easy to conduct and hint towards the need of supporting pupils during these activities.

Take action

When the evaluation of the feedback has resulted in agreement with and acceptance of this feedback, this would ideally lead the young novice designers to 'take action', which requires receivers to act upon the feedback given to them (Sutton, 2012). In feedback for learning, this means that pupils need to actively close the feedback loop by using the feedback they receive to inform their future work and learning processes (Black & Wiliam, 1998; Boud & Molloy, 2013; Hattie & Timperley, 2007). In the context of design education, 'taking action' relates to the novice designers utilising the feedback to conceptually and physically adjust and improve their design. The driving forces behind these design developments are designers' creative thinking processes (Barlex, 2007; Goldschmidt, 2014; Howard et al., 2007).

It is commonly accepted that creative thinking can be divided into divergent (DT) and convergent (CT) thoughts (Goldschmidt, 2014, 2016; J. P. Guilford, 1967; Howard-Jones, 2002). DT is generative in nature and entails the generation of new thoughts and ideas, whereas CT is evaluative in nature and entails reflection and evaluation of these generated or already existing thoughts and ideas (Sowden et al., 2015). According to the dual-process theories of creative cognition, continuous shifting between both modes of thinking is needed when working towards creative solutions (Finke et al., 1992; Howardet al., 2008; Sowden et al., 2015). Ideally, design feedback supports novice designers in the process of taking action by encouraging critical reflection and evaluation (CT) to identify various shortcomings and sub-problems within their designs and, in turn, aid the generation (DT) of new additions and alterations to solve these uncovered issues (Cardoso et al., 2014; Oh et al., 2013; Yilmaz & Daly, 2016).

Ideally, young novice designers would display a continuous array of divergent and convergent actions. However, *Chapters 2* and *3* showed that design feedback often does not encourage the expected divergent or convergent thinking in primary school pupils (Schut, Klapwijk, Gielen, & de Vries, 2019; Schut, Klapwijk, Gielen, van Doorn, et al., 2019). Instead, their resistance to the feedback and concurrent rejection hampered their convergent and divergent thinking. This led to a lack of action and an adherence to the current state of the design (Schut, Klapwijk, Gielen, & de Vries, 2019; Schut, Klapwijk, Gielen, van Doorn, et al., 2019). These results again illustrate that design feedback processes should not be left unguided when aiming for feedback uptake.

Appreciating feedback

As illustrated in *Figure 13*, there is another essential overarching element that young novice designers need to acquire or develop for successful feedback uptake, namely appreciating feedback and understanding its value. As Carless and Boud (2018) describe it, learners need to *"recognise the value of feedback and understand their active role in its processes"*. In the context of design, this means that young novice designers understand that the value of feedback lies in the help it can offer in informing their future design moves and decisions to ultimately develop

their design skills and thereby improve their designs (Dannels, 2005; Hokanson, 2012; McDonnell, 2016; Oak, 2000). Furthermore, they would be aware of the active role they need to take to utilise this feedback to their advantage within their creative design processes.

Studies in general higher education show that students' appreciation of feedback and understanding their active role in the feedback process is often lacking. There is an indication that students tend to perceive their role in the feedback process mainly as that of consumers, passively receiving what is told to them (Bunce et al., 2017; McLean et al., 2015a). This consumerist mindset inhibits students from taking responsibility and ownership over the feedback process and, thereby, their own learning (Bunce et al., 2017). It may lead to passive learner reactions and can feed into the narrative that it would be solely the teacher's role to tell them how to succeed. This narrative, in which learners could sit back and just listen, will not work to their benefit, as they often lack the skills to properly decode and utilise feedback questions and comments (Sadler, 2010).

Within design education, novice designers in higher education appear to be aware of the value feedback can have concerning the improvement of their design process and design, especially when it provides a way to move forward (Dannels et al., 2011; Oh et al., 2013). They appear to understand that they need to take ownership of their design process and learning and that feedback can help with that. However, design crits are known for their highly critical and stress-inducing atmosphere (Anthony, 1991), filled with inconsistent feedback and a lack of peer engagement (Smith, 2011). Although little research is present, these negative aspects of the design feedback context likely affect novice designers' appreciation of the feedback and willingness to take an active role in the feedback process. Similar to general education, this can create an environment in which novice designers behave in a passive manner.

5.2.4 Guiding design feedback processes

In the previous sections, it became clear that several obstacles still impede young novice designers' feedback uptake. These issues are to be expected, since engaging in feedback processes is a skill that requires development. Therefore, primary school pupils need to receive guidance when engaging in design feedback processes. That way, the four highlighted capacities and dispositions for successful feedback uptake can be developed and will encourage pupils to take an active role. In the following sections, we will introduce three key principles based on literature that will form the core of the peer feedback intervention constructed for this study. A detailed description of the intervention and its guidance can be found in the 'research design'.

Implementing high-quality peer feedback

The implementation of peer feedback is a promising way to improve feedback uptake. Peer feedback entails pupils evaluating the work of their peers and communicating the judgements they have formed accordingly. When giving feedback to their peers, pupils must apply criteria, diagnose problems and suggest solutions. This is a very cognitively-engaging process, which is often more beneficial than merely receiving feedback (Nicol et al., 2014). It contributes to the development of pupils' evaluative judgement, as they establish a sense of quality by making comparisons with the work of others and increase self-reflection on their own work (McConlogue, 2015; Wood & Kurzel, 2008). Critical self-reflection does appear to need some extra encouragement, as evaluating and detecting errors in the work of others may be easier for primary school pupils than applying these to their own work and performance (Leenknecht & Prins, 2018). Another benefit is that peer feedback has a different power balance than teacher feedback, and can reduce negative emotional reactions (Yang & Carless, 2013). This can have a positive influence on the receiver's emotional balance.

Engaging in peer feedback practices can help develop young novice designers' capacities and dispositions to become active feedback receivers (Carless & Boud, 2018). By learning how to give appropriate feedback, an opportunity for increasing their abilities to receive feedback is created. Additionally, by training how to construct appropriate feedback, in other words, valuable and constructive feedback, the peer feedback will be of better quality and, therefore, easier to handle when it is received. However, without the proper training and support, these benefits of peer feedback will likely not take place (Tai et al., 2016). Therefore, the designed peer feedback intervention for this study that does not only supports young novice designers in the process of receiving (peer) feedback, but also guides them in composing valuable and constructive peer feedback.

Within the context of design, several obstacles can impede the formation of constructive and valuable feedback. Some of these obstacles are: interpretive challenges with regard to the design and the feedback, leading to a lack of shared understanding between giver and receiver (Higgins et al., 2001; Sadler, 2010; Schut, Klapwijk, Gielen, & de Vries, 2019; Stables, Kimbell, Wheeler, Door, et al., 2016); feedback givers having a strong focus on feedback pushing in convergent directions (Cardella et al., 2014; Cardoso et al., 2014; Cummings et al., 2015; Daly & Yilmaz, 2015; Schut, Klapwijk, Gielen, & de Vries, 2019; Yilmaz & Daly, 2014, 2016), even though this often does not evoke the expected moments of critical reflection and evaluation with the receivers to help them realise previously unthought-of obstacles and concepts (Eris, 2004) or consider alternatives to their current design trajectory (Cardoso et al., 2016); a lack of divergent feedback, leading to a lack of prospective orientation, e.g. the feedforward component (Black & Wiliam, 1998; Hattie & Timperley, 2007; Sadler, 2010). These obstacles undermine essential creative processes such as divergence, which are a driving force behind exploratory thinking and risk-taking (Daly & Yilmaz, 2015; Tolbert & Daly, 2013; Yilmaz & Daly, 2016).

To help overcome these obstacles as mentioned above, young novice designers need support. *Chapter 4* describes a set of guiding design principles for supporting the construction of high-quality feedback. The results demonstrate a level of openness from the pupils towards the feedback that was not observed in previous unguided feedback exchanges (Schut, Klapwijk, Gielen, & de Vries, 2019; Schut, Klapwijk, Gielen, van Doorn, et al., 2019). Furthermore, initial responses to the received feedback indicated several instances of divergent and convergent thinking through the so-called *deep reasoning responses*. The updated set of design principles for high-quality peer feedback exchanges are: (1) continuously guide towards a shared understanding of the design idea through low-level questions, especially before posing high-level feedback, (2) emphasise positive aspects of the design through specific and concrete compliments, (3) stimulate reflective, evaluative and generative thoughts through alternating and iterating high-level divergent and convergent feedback, and (4) repeatedly provide a way forward, thereby fostering improvement, by posing high-level divergent feedback.

Supporting and scaffolding giving peer feedback are expected to have two main effects. Firstly, feedback input from peers will change and become more constructive and of higher quality. Secondly, engaging in peer feedback is expected to positively influence the capacities and dispositions needed for successfully receiving feedback, leading to feedback uptake and ultimately enhancing feedback literacy.

Provide explicit guidance while enabling autonomy

As discussed above, learning how to give appropriate feedback is expected to help develop pupils with receiving feedback. Additional guidance is needed to ultimately ensure successful feedback uptake, as initial openness towards the received feedback does not automatically mean that the upcoming steps of the chain will be followed. Similar to when other subjects offer new learning content or procedures, pupils will need to receive explicit guidance to set them up for success. This explicit guidance will take the feedback receiver by the hand and lead them through the process of feedback uptake, while simultaneously helping them develop the aforementioned elements.

When taking pupils by the hand, it is relevant to start with creating an understanding of the need for design feedback. Creating this understanding can, for example, be done through meta-dialogues between the teachers and pupils. These dialogues should help pupils gain insight into the role of design feedback, outline effective feedback strategies, and highlight common pitfalls (Carless & Boud, 2018). Actions like sense-making, evaluating, and utilising feedback should be made explicit to signal the importance of taking action from the feedback. Supporting these actions can, for example, be done through the use of specific and well-timed verbal prompts. In inquiry-based education, the use of explicit guidance such as prompts has been fruitful; likewise, it is expected that making actions related to the uptake of feedback

explicit can greatly benefit pupils' evaluative judgement. Furthermore, clarifying that they can make a (well-considered) choice in which feedback to accept or reject helps create autonomy.

Besides that, explicit guidance can help create calmness in receiving feedback. Creating calmness can help pupils maintain their emotional balance and capture key information. Encouraging calmness can, for example, be done by delaying the receiving of feedback by offering it (again) at a later time in written form. Oral feedback is currently the standard when providing critique within design education (Anthony, 1991; Oh et al., 2013). Although it has advantages, such as flexibility, interactivity, and high volume in a short amount of time, the fleeting and often unstructured nature of oral feedback can make it difficult for the receiver to capture what is essential. Therefore, a combination of oral and written feedback can provide a solution. Written feedback can assist the receivers with capturing what is important. Furthermore, it gives the opportunity to provide delayed feedback. Even though it was long thought that immediate feedback was better for learning, Black and Wiliam (2018) discuss how feedback is often more effective for learning when delayed. This is because the delay asks for a greater retrieval strength of the memory for the receiver, which has a greater impact on long-term learning. Additionally, the delay creates a situation that does not require an immediate response. This lack of urgency enables the receivers to take their time when reflecting and evaluating the feedback in relation to their design, which can benefit their ability to maintain an emotional balance.

Design of the learning environment

A learning environment which allows for and caters to feedback utilisation is an important enabler for feedback uptake. Feedback has no effect in a vacuum and will not initiate further action by itself (Carless & Boud, 2018; Hattie & Timperley, 2007). Preferably, a learning assignment creates the conditions for active feedback utilisation during the assignment, especially for novice learners. For that feedback exchanges need to take place throughout the duration of the assignment instead of solely at the end. In this way, learners are guided towards active feedback utilisation. Generally, design assignments are an excellent example of a learning context with great emphasis on using feedback. Often there are multiple feedback moments planned within an assignment, during which feedback utilisation is expected to be showcased through the adjusted and improved design (Anthony, 1991; Goldschmidt et al., 2015; Oh et al., 2013). For the feedback receivers, this increases the need to take action and encourages feedback uptake. Although this type of set-up might be common in design education, it is often not present in general primary education (Black & Wiliam, 1998).

To summarise, three key principles have been discussed that are expected to enable young designers' active role in design feedback processes and to stimulate their feedback uptake, namely: (1) Design of a learning environment that allows for and caters to active design feedback utilisation, (2) implement high-quality peer feedback, teaching how to give

constructive and valuable feedback, and (3) provide explicit guidance through the process of receiving, evaluating and utilising feedback while enabling autonomy. These principles will form the core of the peer feedback intervention constructed and used in this study, which led to the following research question: *In what way does the peer feedback intervention enable pupils in their process of design feedback uptake?*

5.3 RESEARCH DESIGN

To answer the research question, we utilised an educational design research approach, comprising two cases over the course of one year (Bakker, 2018; Van den Akker et al., 2006; Yin, 2014). These two cases, named Case 2 and 3 (see *Figure 1, Chapter 1*), are the same as those discussed in *Chapter 4*. A qualitative research design is deemed suitable for the research objective, as research on receiving and utilising design feedback at a primary school level is scarce, if not non-existent. Qualitative research aims to explore the nature of a phenomenon or learn about the views of individuals with the researcher as the primary instrument for data collection and analysis (Creswell, 2012).

Since this fourth study was done on the same two cases as the third study described in *Chapter 4*, the description of the participants and design sessions will be identical. Reference will be made to tables and figures presented in the previous chapters.

5.3.1 Participants

The two cases took place at two different primary schools in the Netherlands. The participating schools were selected based on their interest in design and technology education and their wish to be introduced to design through a guided hands-on project. From each school, one classroom of children (age 8 -12) participated in the study. There were two main case studies, which were preceded by one pilot case study to enable a quick test run of several guiding tools. *Table 5 (Chapter 4)* gives an overview of the two main case studies, which we will now name Case 2 and B. In both school classes, the children had no previous hands-on experience with designing, apart from 8 children of Case 2 who participated in a short pilot case study a few weeks prior (Van Mechelen et al., 2018). Right before the start of each design project, the teacher divided the children into gender-mixed heterogeneous design teams of four children. In Case 2, the teacher made sure to put the pupils who participated in the pilot case study in different teams. From each school class, four design teams were selected for in-depth data collection and analysis. The selection was made by the teachers and based on our request to select four teams that could represent the class as a whole regarding academic achievement and collaboration.

5.3.2 Design Sessions

During the two cases, the design teams worked on solving real-life design challenges presented to them by real clients. To solve the challenges, they were guided through the entire design cycle in six design sessions of 90 to 120 minutes spread over 2 to 3 weeks. The design sessions were structured as follows: introduction & sensitising, exploring the design theme, defining a point of view, ideation, selection & detailing, feedback on the design ideas, concept development & prototyping, and feedback on the final designs. The design activities were based on tools and methods from the CPS tradition (Isaksen et al., 2010; Tassoul, 2009), design tools from the Delft Design Guide (Van Boeijen et al., 2013) and lessons learned from previous studies conducted by the researchers connected to this study. These lessons learned included, but are not limited to, the following topics: design fixation (Schut, Klapwijk, Gielen, van Doorn, et al., 2019), design feedback (Schut, Klapwijk, Gielen, & De Vries, 2019), group dynamics (Van Mechelen et al., 2015), co-design processes (A. van Boeijen et al., 2020; Van Mechelen, 2016; Van Mechelen, Laenen, et al., 2019), and children's design skills (Van Mechelen et al., 2018; Van Mechelen, Schut, et al., 2019). *Table 6 (Chapter 4)* gives a concise overview of the content of each of the design sessions. Furthermore, the tools used in the design sessions can be found on the following websites: www.tudelft.nl/codesignkids (English version) and www.tudelft.nl/yourturn (Dutch version).

The design sessions took place in a normal classroom setting, and all design teams participated simultaneously. The first and third authors facilitated the sessions, and both had experience in doing so. Having two researchers lead the sessions was a deliberate choice to ensure that the content of the sessions was implemented as envisioned. The class teacher was present during all of the design sessions to assist with any classroom management or behavioural issues.

5.3.3 Peer Feedback intervention

The peer feedback intervention is developed to encourage the design teams to take an active role in the feedback process, thereby enabling their feedback uptake. Specifically, the intervention was developed to facilitate design teams and pupils to: (1) appreciate feedback and understand its value, (2) maintain an emotional balance to encourage openness towards feedback, (3) develop an evaluative judgement, and (4) take action through concurrent design moves. To achieve this, the intervention was based on the three key principles which concluded the literature review - (1) Create a learning context which allows for and caters to design feedback utilisation, (2) implement peer feedback, teaching how to give constructive and valuable feedback, and (3) provide explicit guidance through the process of receiving feedback while enabling autonomy.

Principle 1: Create a learning environment which allows for and caters to design feedback utilisation

Following the first key principle, giving, receiving and utilising feedback had a central position throughout the design sessions and was not just reserved for the end. This set-up was intentionally created to ensure a learning environment that caters to and actively asks for feedback utilisation. The feedback intervention was implemented in the 4th, 5th, and 6th design sessions and consisted of an elaborate procedure to guide giving, receiving and utilising feedback. In the 4th session, design critiques took place, during which the design teams took turns to present their design and receive questions and comments from their peers (the other design teams) and the clients. Additionally, the peers and clients constructed written feedback via feedback forms. During the 5th session, the design teams discussed the feedback forms and selected those they wanted to utilise to improve their design. Finally, in the 6th session, design critiques took place again, during which the design teams presented their improved designs and received verbal feedback from their peers and the clients.

Principle 2: Implement high-quality peer feedback, teaching how to give constructive and valuable feedback

Following the second key principle, a core component of the intervention was implementing continuous peer feedback. The design teams actively participated in the construction of verbal and written peer feedback in the 4th and 6th design sessions. They were taught and guided in both design sessions on how to share valuable and constructive feedback. This guidance was based on an initial set of key principles that are discussed and analysed by Schut et al. (2020): (1) guide towards a shared understanding of the design through low-level convergent feedback, (2) stimulate critical reflection and evaluation of the design to help identify and internalise possible shortcomings through high-level convergent feedback, and (3) provide a way to move forward by guiding new generative thoughts through high-level divergent feedback. For more detail on the guidance of giving feedback, we refer you to *Chapter 4*. These guiding principles were taught to the pupils through meta-dialogues on the use of design feedback and analysing exemplars, which are considered fitting teaching methods (Carless & Boud, 2018; Carless & Chan, 2017; Sadler, 2010). Furthermore, a feedback form was used as a scaffolding tool to help pupils and clients construct their feedback during the 4th design session. Each 'peer' design team collaboratively filled in a feedback form for each presenting team. If more than one client was present, they also collaboratively filled in a feedback form for each team. *Table 8* gives a concise overview of the procedure of the feedback forms in the 4th design session and the modifications from Case 2 to 3. During the 6th design session, a similar approach was followed; only no feedback forms were used. There, the guiding prompts on the forms were instead verbalised by the facilitators.

Table 8: Overview of the procedure of the feedback forms in the 4th design session of Cases 2 and 3. The quotations are copied and translated from the feedback forms or are the translated verbal prompts.

Part	4th design session	
Preparation	Meta-dialogue, analysing examples and modelling exercises guided by facilitators to teach the intention and procedure of the feedback intervention to the design teams and the clients.	
	Modification in Case 3:	*More time was reserved for the meta-dialogue and for analysing exemplars, so more examples could be discussed.*
	Reasoning:	*To uplift the quality of the feedback on the forms. Several feedback forms in Case 2 were not fully filled in according to the format, which interfered with the quality.*
The next parts form one turn per design team.		
(1) Guiding towards a shared understanding	Design team presents design idea.	
	Peers and clients received verbal prompts to pose clarification questions to work towards a shared understanding of the design. "*What do you not yet understand about the design?"*	
Peers and clients receive scaffolding guidance through feedback forms		
(2) Stimulating critical reflection and evaluation	Peers and clients are guided to construct specific compliments. "*What do you think is already good about the design?"*	
	Peers and clients are guided to construct high-level convergent feedback. "*We think this could be better about the design… because …"*	
(3) Providing a way forward	Peers and clients are guided to construct a high-level divergent how-question. *"How can you …"*	
	Peers and clients are guided to construct possible solutions to their how-question. *"We think this could maybe be a solution …"*	
	The clients and a few peers share their feedback with the design team by reading the feedback forms aloud.	
	Modification in Case 3:	*Quality Check. When the shared feedback did not adhere to the format of the feedback forms, time and guidance were given to the peers to adjust the forms accordingly.*
	Reasoning:	*To uplift the quality of the feedback forms. Several feedback forms in Case 2 were not fully filled in according to the format, which interfered with the quality.*

Principle 3: Provide explicit guidance through the process of receiving feedback while enabling autonomy

During the 5th design session, each design team ultimately received all feedback forms filled in by each of the 'peer' design teams and the clients. Following the final key principle, the feedback procedure provided explicit guidance to the design teams through the process of receiving and discussing the filled-in feedback forms, and selecting those they deemed valuable. The design teams were encouraged to utilise the selected feedback as a starting point to generate new additions and solutions to adjust further, develop and improve their design. *Table 9* gives an overview of the feedback procedure during the 5th design session and the modifications from Case 2 to Case 3.

To start, the design teams participated in a meta-dialogue led by the facilitators to remind them of the value of feedback for improving their design and to discuss how the received feedback could be utilised. The facilitators used examples from a real design context to explain how feedback could help with discovering shortcomings and generating new solutions and additions. Furthermore, it was continuously stated that '*feedback is shared to help you as a designer*'. Subsequently, the procedure of receiving, discussing and selecting feedback forms was shortly explained. Aside from this, the researchers also facilitated each step of the procedure in real-time through verbal prompts, to guide the procedure as planned. With regards to the evaluation of the feedback, the design teams were encouraged to select feedback that they could utilise to improve their design within the time they had. No specific guidelines on how to select were given, as the design teams were presumed to have gained insight into the quality of feedback through the peer feedback process. This freedom to make their own choices regarding feedback selection and utilisation enabled a level of autonomy.

5.3.4 Data collection

Four design teams were selected from each case for in-depth data collection and analysis. The teacher made the selection based on our request to select four teams that could represent the class as a whole concerning variety in academic achievement and collaboration. This selection was made before the start of the design sessions. The selected design teams were audio and video recorded during the design sessions. Due to the focus of this study on the pupils' active role during the feedback process, the recordings of the 5th design session were selected for data analysis. More specifically, the teams' conversations regarding feedback evaluation, selection and utilisation were selected. The feedback forms were collected. Additionally, the first and third authors held semi-structured post-interviews with the selected design teams that were video and audio recorded. The interviews started with a card sorting activity. Each pupil was given cards with the primary activities of the design project and asked to rank them from successful to less successful based on their personal experience. This ranking was then discussed with each pupil. The interview then moved to question the design teams on two

topics: co-design skills and design feedback. Here, the focus lies on the second topic. To uncover the pupils' cognitions and perceptions regarding design feedback in general and the peer feedback procedure, questions were asked regarding their understanding, perception and experience of giving and receiving design feedback.

5.3.5 Data analysis

The process model of design feedback uptake that we introduced previously (see *Figure 13*) was used as a framework for data analysis. This decision was based on the aim to gain insight into the success and obstacles of the peer feedback intervention by understanding the interplay between the key principles of the intervention and the process of design feedback uptake. To achieve this, we categorised the data in the elements of this model – emotional balance, evaluative judgment, take action, and appreciating feedback. To establish this categorisation, we followed the Verbal Analysis approach (Chi, 1997), which consisted of the following steps: segmenting the transcripts into units of analysis, selecting and developing the coding frameworks, applying the coding frameworks in a coding process, and pattern identification and interpretation.

This approach was selected because it helps to determine what happens at different grain sizes within the data so that patterns can be identified. In turn, these patterns allow us to understand the actions, perceptions and experiences of the design teams during the different parts of the feedback procedure and determine their quality in relation to the process model of design feedback uptake. In other words, we were interested in uncovering what is desirable in terms of pupils' actions, expressions, and thoughts in relation to the process of design feedback uptake. The primary data sources consisted of the transcriptions of the audio-video recordings of the 5th design session and post-interviews of the selected design teams. Combined, these two moments would give an understanding of the pupils' real-time behaviour and responses when following the feedback procedure and their reflection on the experiences in hindsight. The upcoming sections give a detailed description of the analysis process of the aforementioned data.

Besides Chi's Verbal Analysis approach, an additional small analysis was done to determine the quality of the feedback on the feedback forms. As pointed out in the theoretical framework, the quality of the feedback that is shared can influence how constructive the feedback exchange will be. Establishing constructive feedback exchanges is an important pre-condition when aiming at encouraging young novice designers' active role in the feedback process. The feedback forms were designed to guide towards valuable and constructive feedback by requiring the clients and peers to adhere to a strict format when writing their feedback. In the quality analysis of the feedback forms, we determined to what extent the feedback content adhered to this format.

Table 9: Overview of the procedure of the feedback intervention in the 5th design sessions of Cases 2 and 3.

Part:	5th design session	
Preparation	Meta-dialogue guided by facilitators to remind the participants of the value of feedback for improving their design and discuss how the feedback could be utilised. An explanation of the steps of the receiving, discussing and selecting procedure.	
Receiving	Design teams receive the filled-in feedback forms and are prompted first to read all the feedback forms.	
	Modification #2 in Case 3:	*Addition of a specific prompt so the members of the design team would take turns to read the feedback forms out loud to each other.*
	Reasoning:	*In Case 2, some design teams' process of reading the forms was somewhat disorganised, leaving some members with little knowledge of some of the feedback forms.*
	Modification #3 in Case 3:	*Addition of a specific prompt so the design teams would not yet read the proposals on the feedback forms. To enable this, these proposals were hidden in an envelope.*
	Reasoning:	*In Case 2, the proposals appeared to hinder some of the design teams' creative thinking processes due to copying behaviour.*
Discussing and Selecting	Design teams are prompted to discuss and then select the feedback form of the clients and one feedback form from their peers.	
	Modification #4 in Case 3:	*Addition of specific verbal prompts creates a more distinct separation between the process of discussing and selecting feedback forms.*
	Reasoning:	*In Case 2, some design teams could not follow the prompting of several small tasks at once. This led to distraction, which hindered their participation.*
Utilising	Design teams are prompted to discuss how they can utilise the feedback to improve their design and make this visible within their prototype.	
	Modification #5 in Case 3:	*Addition of a specific verbal prompt to first discuss how the feedback could be utilised to improve the prototype before starting the building process again.*
	Reasoning:	*In Case 2, the dialogue about how to take action based on the feedback selected was not as prominent due to the immediate start of the building process.*
	Modification #6 in Case 3:	*Midway through this dialogue the design teams were prompted to check the proposals in the envelopes accompanying the selected feedback forms.*
	Reasoning:	*In Case 2, it appeared that not all design teams were fully aware that the proposals were meant as inspiration and some direct copying took place, which hindered the stimulation of their own creative thinking processes.*

Units of analysis

From the transcripts of the 5th design session, units of analysis were created with different grain sizes, which were nested within each other. First, a coarse grain size (GS1) was made based on each episode, in other words, on the parts of the feedback procedure initiated by the verbal prompts, e.g. preparation, receiving, selecting and discussing, followed by utilising (see *table 9)*. A finer grain size (GS2) was made on the feedback form at the centre of each part of the dialogue. This grain size was also made to determine the type of feedback and the responses it evoked. This way, each piece of feedback could be followed throughout the dialogues. For the post-interview, units of analysis were created on two different grain sizes, which were also nested. Since the post-interview questioned the pupils' entire designed experience, a courser grain size was first made on each episode. Meaning that the interview questions and concurrent responses were in their content focused on specific parts of the feedback procedure. Secondly, a finer grain size was made on the consecutive responses of the pupils to the interview questions.

Coding frameworks

A set of coding frameworks were developed to establish the nature of the feedback and its responses in earlier studies. To determine the type of feedback at the centre of each dialogue in GS2, the *Design Feedback Model* of Schut et al. (2020) was used, which is displayed in *Figure 10 (Chapter 4)*. This model gives insight into the divergent or convergent nature of the feedback and the level of cognitive strain needed to answer. To determine the nature of the responses to the feedback in GS2, the *Direct Responses Model* of Schut et al. (2020) was used, which is displayed in *Figure 11 (Chapter 4)*. This model gives insight into different groups of direct responses, namely: resistance responses, report type responses, agreement type responses, and deep reasoning responses. We refer to Schut et al. (2020) for a detailed explanation of the models. As previously discussed in the theoretical framework, the constructiveness and value of feedback exchanges were influenced by the interplay between the type and timing of feedback and responses. Therefore, using these frameworks can give insight into how the content of the feedback forms and how they were processed related to the elements of the process model of design feedback uptake.

Coding process

Of the transcripts of the 5th design session, the episodes of GS1 were coded with the predetermined parts of the feedback procedure, as can be found in *Table 9*. In GS2, the parts of the feedback forms were coded with the feedback codes from Schut's *Design Feedback Model*. Additionally, we classified who the feedback was from, the client(s) or peers, and the quality of the feedback on the form. The direct responses of the pupils were coded with the response codes from Schut's *Direct Responses Model*. Furthermore, we inductively coded for evaluative criteria that arose within the responses, and explicit verbalisations on the appreciation or meaning of feedback. These types of responses were not part of the model but were important for the categorisations of 'evaluative judgement' and 'appreciating feedback'. All the aforenoted

codes were used to code the post-interview transcripts. The main reason for this was to connect the pupils' reflective perceptions to the events in the 5th design session.

Trustworthiness was ensured by the consensus-seeking manner in which the coding was done. To start, the first author coded the transcripts of the 5th design session. When an understanding was formed of the data of the 5th design session, the first author coded the transcripts of the post-interviews. Consistency was promoted by routinely discussing the coded data with the second author.

Pattern identification and interpretation

To analyse the coded data, tables were constructed per design team with the four elements of the process model of design feedback: emotional balance, evaluative judgment, take action, and appreciating feedback. Per element, descriptions and quotes were added to the tables to create an understanding of the actions, perceptions, and experiences of each design team. With regards to *emotional balance,* we looked for instances of openness and resistance of the design teams towards the received feedback. For *evaluative judgement,* we looked at the construction and use of evaluation criteria to form a judgement on the feedback forms. For *take action,* we looked at instances in which the design teams used the feedback to inform future design moves, which means that we looked for evidence of ideation, reflection and evaluation in the transcripts. For *appreciating feedback,* we looked at indications of appreciation and understanding of the value of feedback. Additionally, we looked at instances that could evidence the design teams' understanding of their active role in the feedback process. These tables were then used to interpret the data and look for patterns.

5.4 FINDINGS

The following sections introduce the results of the qualitative analysis. The descriptions of the results are supported by translated excerpts of the transcripts of the design teams' conversations during the 5th design session and post-interviews. In these examples, the pupils that were part of the design team are indicated as 'child' and, if necessary, a number. Likewise, the facilitators are indicated as such. Furthermore, numbers are assigned to each design team to enable specific references when describing the results. For Case 2, this is teams 1, 2, 3, and 4, and for Case 3, teams 5, 6, 7, and 8 (also see *Table 5, Chapter 4*).

5.4.1 Emotional balance

In this section, we discuss to what extent the design teams maintained an emotional balance when receiving the feedback forms during the 5th design session. Keeping an emotional balance means that the teams display openness to the critical comments and questions in the feedback.

They need to be aware of the possibility of being misdirected in their thought processes, and that feedback can help them improve and move forward.

Case 2

In Case 2, one of the teams, team 3, clearly showcases openness when reading and discussing the feedback forms during the 5th design session. From their dialogue, it can be observed that they have a positive attitude when reading feedback and are very accepting of the shortcomings it points out within their design. During their post-interview, they stated their focus was on improving their design and perceived the feedback as an opportunity to achieve this. These results indicate that they could maintain an emotional balance when receiving feedback.

> Case 2, 5th design session, team 3
> Child: *I thought it was nice, the feedback. Because, yeah, else the idea would have been really different. The feedback is always nice to get some tips, like 'add points, then* it [the game] *will be fun for a longer amount of time'.*

Two other teams in Case 2, teams 2 and 4 displayed resistance towards some of the feedback forms, primarily those constructed by their peers. This resistance was observed by how they instantly dismissed and disagreed with the content of most of these feedback forms. Although the teams should be free to reject feedback that holds no value to their design process, this rejection should ideally be a weighed and thought-out decision and not driven by negative emotions. We presume that their resistance is linked to the poor quality of many of the feedback forms these two teams received. In contrast to these observations, one team member of team 2 was able to take a step back and reflect on their resistance, as is shown in the example below. She was, however, not able to convince the other team members to do the same.

> Case 2, 5th design session, team 2
> Child: *But it is not only about the clarity of it* [the feedback form]. *It's about if we can do something with the tip.*

Both teams showed openness towards the clients' feedback forms, which were complete and filled in according to the format. It appears that the quality of the feedback forms influences the ability of the receiver to maintain an emotional balance. Additionally, the teams might be slightly more open to feedback from the clients than their peers, which could be due to the difference in status.

Furthermore, both teams show a level of openness to the feedback during the post-interviews. Although it is clear they did not agree with all of the feedback, they also describe moments of understanding and openness, as illustrated here.

> Case 2, post-interview, team 2
> Child: *Well, someone said something, and then I started thinking and then I thought, 'yes, maybe that's also possible'.*

In team 4 this level of understanding and openness appears to be tied to how 'easily' the feedback could be solved. The following example showcases this. One could therefore argue that this is not genuine openness.

> Case 2, post-interview, team 4
> Facilitator: *Why did you not mind it* [receiving critical feedback] *that much?*
> Child: *The points were easy. They believed that somebody* [a player of the game] *should win and that the rules should not be too difficult. So that was easy to solve.*

Finally, team 1 had little communication and a lack of collaboration during session 5, which led to few observable conversations. During the post-interviews, this team stated on several occasions that they understood why they received the feedback and agreed with the shortcomings it pointed out. This understanding does indicate openness, yet does not directly give insight into their emotional balance.

Case 3

In Case 3, two of the four teams, teams 6 and 8, clearly display openness when reading and discussing the feedback. Their dialogue in the 5th design session showcases them agreeing with some of the feedback and disagreeing with other feedback, while keeping a level of calmness. During their post-interview, both teams generally talked positively about receiving feedback and stated that they perceived it as an opportunity to improve their design, illustrated in the quote below.

> Case 3, post-interview, team 6
> Child: *Yes, we handled it* [the feedback] *well. We thought ok, this is again a tip and this is how we could still improve. And then we also built it that way.*

In contrast, team 8 also stated that they perceived some of the feedback as 'useless', since it uncovered shortcomings in their design that they had already solved. Even though they generally displayed openness to feedback, this response does show resistance to feedback that is no longer relevant.

One team, team 7, did not showcase any strong emotions towards the feedback, either positive or negative. Although this is not a direct indication of openness, it does indicate a certain level of emotional balance. Additionally, the team showcased a positive attitude when talking about receiving feedback during their post-interview. However, this team's overall communication and collaboration was somewhat disorganised and chaotic. Therefore, it is unclear how invested they were in the process of utilising the feedback to improve their design. It could potentially be easier for a team to maintain an emotional balance when they are less invested in the process.

Lastly, team 5 clearly displayed a lack of openness when reading and discussing their feedback forms. Similar to Case 2, this resistance was primarily directed toward the peers' feedback. As illustrated by the two examples below, the team often stated that the feedback they received was something they had already solved or was irrelevant to their design. Justified or not, these initial responses showCase a lack of openness which could set the tone for future feedback encounters and compromise their evaluative judgement.

> Case 3, 5th design session, team 5
> Child: *'How can you make sure that you can also play on your own?'* [red from the feedback form]*. Ok, this is no use to us.*

> Case 3, 5th design session, team 5
> *Child: (shrugs its shoulders) Yes, but this (looks at feedback form) doesn't make sense! So many mistakes!*

However, the team displays some openness toward the feedback in their post-interview. They state that feedback should be received openly and used to improve a design, as showcased in the example below. This statement indicates that the pupils are aware that they should ideally control their negative emotions when receiving feedback.

> Case 3, post-interview, team 5
> Child: *Just take it* [the feedback] *and don't say for example 'yes, it is really annoying that you all think it's a bad idea'. We actually should just take it well and thank them for wanting to help to improve it [the design].*

Similar to Case 2, this resistance appears to be linked to the quality of the feedback and who is the giver. During their post-interview, team 5 stated that the feedback they received lacked quality. While this indicates a level of resistance, it also showcases an ability to judge the value of the received feedback. The feedback of the clients, which was often of better quality, was met with more openness. Besides the difference in quality, the teams explicitly mention how the status of the clients influenced their decision and thereby their openness towards the feedback. The following example illustrates how the clients are viewed as experts through experience.

Case 3, post-interview, team 5
Facilitator: *How was it to make a choice [between the feedback forms]?*
Child: *It was kind of easy. Because for example the Kinderraad* [child representatives of the hospital]*, they are sick themselves.*

Conclusions
To conclude, several teams of Cases 2 and 3 showcased that they were able to maintain an emotional balance when receiving feedback. In some cases, this openness was not as clearly observed when they initially received the feedback, but the presence of openness could then be derived from the post-interviews. These teams displayed openness towards the feedback and understood the possibility of being misdirected. Furthermore, they could indicate how the feedback changed their perspective on a particular aspect of the design and how this led to alterations.

The results appear to indicate that the presence of resistance and lack of emotional balance is affected by the quality of the received feedback and the status of the giver. For example, good quality feedback from the clients was well-received by all teams, even if a team displayed negative emotions towards other feedback just before they read the client's feedback. In Case 3, several modifications have been made to the feedback intervention. One of the effects was the improvement of the quality of the constructed feedback, which we presume to have had a positive impact on the emotional balance of teams.

5.4.2 Evaluative judgement
This section discusses the design teams' sense-making and evaluation of the feedback forms they received during the 5th design session. As explained in the research design, the design teams were prompted to select one feedback form from their peers and the form of the clients to utilise to improve their design. No specific guidelines were given to the teams on how to make this selection, since it was presumed that they had developed an understanding of feedback quality through the peer feedback process.

Case 2
Observations of the dialogues of the teams during the 5th design session in Case 2 did not give a conclusive insight into how the teams made sense of and evaluated the feedback forms they received. Several teams mentioned the completeness of the forms, which often led to them rejecting forms that were not filled in fully. Additionally, the teams talk about 'good' and 'bad' feedback forms, which appear to be linked to the quality of the written feedback. However, these evaluation criteria remain rather ambiguous and only give some indication for a tacit understanding of quality. Therefore, we primarily focus on the data of the post-interviews when describing the results.

During the post-interviews, teams 1, 2 and 3 stated that they focussed on the reasoning of the convergent feedback when evaluating the feedback forms, which means that they directed their attention to the section on the feedback forms that explained why the uncovered shortcoming in their design would cause an issue according to the giver. This focus is illustrated by the following example.

> Case 2, post-interview, team 2
> Child: *Well, with some of the feedback I thought "this is not so useful", because it would say what was wrong, but would not explain why.*

Team 4 focussed on the convergent feedback in a slightly different manner. This team explicitly described how they selected the feedback that uncovered a shortcoming they did not address yet, as showcased in the quote below. This means the team evaluated the content of the convergent feedback in relation to the state of their design.

> Case 3, post-interview, team 4
> Facilitator: *How was it to make a choice* [between the feedback forms]*?*
> Child: *It was rather easy I think. It was just the ones we thought were good, as we had not thought of any solutions for those yet. It was kind of easy.*

Besides that, most teams paid attention to the divergent feedback, specifically how this feedback could help them move forward with their design. For example, team 1 primarily paid attention to the how-questions, while teams 2 and 3 mainly focussed on the proposals. In contrast, several teams describe having had trouble when constructing divergent feedback for their peers. This experience indicates the importance of adequate guidance for the feedback givers, as convergent feedback clearly holds value to the receivers. Additionally, team 1 specifically mentioned that the feedback needed to be written clearly on the feedback form, and team 2 explicitly noted the importance of completeness. Team 2 even showcases frustration when talking about incomplete and 'bad' quality forms, which appears to affect their ability to keep an emotional balance.

Case 3

Similar to Case 2, it was difficult to observe from the dialogues how the teams made sense of and evaluated the feedback forms they received. Again, the teams mention 'good' and 'bad' feedback forms, while the underlying evaluation criteria are often missing. The few instances in which the teams give an evaluation criterion are mainly linked to the forms that get rejected. The rejection then is based on the feedback being 'not relevant to the design', 'not focussed on the design, or 'addressing a shortcoming that is already solved'. Additionally, only team 5 specifically mention the 'completeness' of the forms. This difference from Case 2 can be attributed to the improved quality of the filled-in feedback forms in Case 3. Although these

rejection criteria also give some insight into the possible criteria for acceptance, these observations are insufficient. Therefore, we will again focus on the data of the post-interviews.

Similar to Case 2, all the teams of Case 3 paid attention to shortcomings uncovered by the convergent feedback and how well these shortcomings were explained. These evaluation criteria appear to be connected to the teams' belief that 'good' feedback makes improvement of the design possible. The following example illustrates this belief.

> Case 3, post-interview, team 6
> Child: *Well, good feedback means that you can improve it* [the design]. *So, for example the feedback of the Kinderraad* [child representatives of the hospital] *said that we should make it* [the design] *safer. So, then we did that. And it* [the design] *became much better, because if you receive good feedback you can make better things.*

The example above shows similarities to team 4 in Case 2, who also selected feedback that uncovered an unaddressed shortcoming in their design. Another similarity to Case 2 is that most teams of Case 3 also note the importance of providing a 'way forward' through divergent feedback in the form of proposals or a how-question. The example below illustrates this notion. Although divergent feedback was a core feature of the intervention, its importance was not explicitly explained to the design teams.

> Case 3, post-interview, team 6
> Child: *Yes, because when you say 'this is wrong and that is wrong', then you also have to come up with a solution. Because if you don't come up with a solution, then you can't say that something is wrong.*
> Facilitator: *Are you allowed to say what's wrong with an idea if you don't have a solution, or is that not allowed?*
> Child: *Yes, it's allowed. But it's better if you also add how it could be improved.*

A final similarity to Case 2 is that teams 6, 7 and 8 of Case 3 also mentioned that feedback needed to be written clearly on the feedback form. Furthermore, the teams of Case 3 said to have paid attention to three additional evaluation criteria: feedback should focus on the design (team 5, 6, and 8), be honest and objective (team 5, 7, and 8), and have a balance between positive and critical feedback (team 6 and 8).

> Case 3, post-interview, team 6 (Focus on the design)
> Child: (…) *Then we thought, it's* [the feedback] *is not focussed on the idea. It's about the presentation. So, then we did not select that one* [the feedback form].

Case 3, post-interview, team 5 (Honest and objective)
Child: *That you give your honest opinion. And not that, say, if my best friend would think 'well, that's a very bad idea, but I will still give it a good grade because she is my best friend'.*

Case 3, post-interview, team 8 (Balance positive and negative)
Facilitator: *Okay, and what components does good feedback consist of, according to you?*
Child: *By saying what you think is good and what could be improved. Don't just say 'this is wrong, that is wrong', but also say 'this is good, that is good'.*

These criteria were not mentioned in Case 2. There were also other differences in Case 2 regarding the evaluation criteria. For example, the level of 'completeness' of the feedback forms was not mentioned as an evaluation criterion during the post-interviews of Case 3.

Conclusions

To conclude, these results show that the teams developed an understanding of feedback quality through the peer feedback process, leading to a list of evaluation criteria. A prominent evaluation criterium mentioned by the teams of both cases was that feedback should uncover relevant and well-explained shortcomings in their design, while also providing a 'way forward' through well-constructed how-questions and proposals. Furthermore, the modifications to the feedback procedure in Case 3 have improved the feedback quality, thereby possibly improving the design teams' sense-making and evaluation processes.

5.4.3 Take action

This section discusses the design teams' ability to take action after discussing and evaluating the feedback forms during the 5th design session. As described, the teams were encouraged to utilise the selected feedback to improve their design, just like a real designer would. As this focus on improvement should spark creative thinking processes, we specifically looked at identifying the divergent or convergent thought processes of the teams. In other words, instances of ideation, reflection or evaluation in their dialogues.

Case 2

In Case 2, the process of selecting the feedback forms instantly initiated a chain of reflection, evaluation and ideation with two of the four teams, namely teams 3 and 4. After reflecting and evaluating the feedback forms, thereby uncovering the shortcomings in their design, both teams engaged in a sustained ideation process. These generative thoughts were primarily initiated by the divergent feedback on the feedback forms, meaning the how-questions and

especially the proposals. Presented below is an example of such a sustained ideation process in which team 3 generates alterations to the point system of a calculus game they designed.

> Case 2, 5th design session, team 3
> Child1: *And the crossbar is, for example, a hundred points, yes and then, you have the posts on the sides… Yeah, I don't know.*
> Child 2: *Posts, the posts, five points.*
> Child 1: *Yes, those are fifty points. It depends on what the answer to the calculation is.*
> Child 2: *The top corners could be maybe twenty-five. And then something else points five.*
> Child 1: *Five, that's possible.*
> Child 2: *Then the players have to throw quite far.*
> Child 3: *Depends on how far the distance is, they can also stand closer.*

During the post-interviews, teams 3 and 4 acknowledged that the feedback forms sparked ideation. The teams did not directly state that the forms also sparked reflective and evaluative thinking. However, both teams remarked that they adjusted their design, which inherently entails the utilisation of these thinking processes. This insight is illustrated by the example below, where a team member states that the alterations to their design would not have been made without the feedback forms.

> Case 2, post-interview, team 3
> Facilitator: (…) *did that feedback form spark new ideas for you?*
> Child: *Yes, I think it did. Because now we have additional points on the sides and top of the goal and the pawns. Otherwise, I don't think we would have had those ideas.*

Furthermore, team 4 strongly focused on utilising feedback that uncovered an unsolved shortcoming in their design which they then wanted to solve. The example below showcases this focus. The way this team utilised the feedback is consistent with their views on feedback quality and their reasons for selecting certain feedback forms.

> Case 2, team 4, post-interview
> Facilitator: *How did you actually select? How did you handle the feedback forms?*
> Child: (…) *Well, it* [a feedback form] *said you should be able to see who the ticker is. We have done that. There was another one* [a feedback form] *that said that someone should win, so we also did that.*

The other teams, 1 and 2, did not directly engage in such a chain of creative thinking processes after selecting the feedback forms. Instead, both teams ignored the forms directly after the selection process and immediately started discussing or reviewing the available materials for making the prototypes. With team 1, this lack of creative thinking appears to be predominantly caused by their poor communication and collaboration. After selecting the feedback forms, the

team members direct their attention to the prototyping materials, which they review individually. For team 2, the lack of generative, reflective and evaluative thinking appears to be caused by the persisting resistance towards the feedback they received. As described in the previous sections, the team displayed a lack of openness when discussing and selecting the feedback forms.

In contrast, teams 1 and 2 disclosed during the post-interviews that the selected feedback forms led to some moments of ideation. Furthermore, both teams remarked that they adjusted or improved their design based on the feedback they selected, which indicates the presence of reflective and evaluative thinking. These responses are presented in the examples below.

> Case 2, post-interview, team 1
> Facilitator: *What was the effect when you received those feedback forms?*
> Child 1: *If you know what they think could be improved, then you have new ideas to continue again.*
> Child 2: *Yes. For example, we did instead of an assignment…*
> Child 3: [interrupting] *…walking ten times.*
> Child 2: *Yes, to make it more active. Because that was also the feedback of the client.*

> Case 2, post-interview, team 2
> Facilitator: *And did you use that solution right away? Or have you adjusted it?*
> Child 1: *Yes.*
> Child 2: *They said that a player should call out the sums, and then we thought "You can also make a container with the sums instead". That way all players can participate in the game.*

In the end, the final designs showed that all four design teams addressed the two selected feedback forms in full, which became visible through the adjustments in their design. Some of the adjustments appeared to be copied from the proposals of the feedback forms, which is not desirable when aiming to encourage pupils' creative thinking. This finding led to a modification in Case 3, which involved hiding the proposals in an envelope attached to the feedback forms. Hiding the proposals would force the teams in Case 3 to first generate their own solutions, before being confronted with the ideas of the feedback givers. Furthermore, to help encourage the teams to engage in creative thinking right after selecting the feedback forms, modifications were made to the verbal prompts given by the facilitators during the 5th design session in Case 3. The details of these modifications can be found in *Table 9*.

Case 3

In Case 3, the process of selecting the feedback forms initiated a chain of reflection, evaluation and ideation with three of the four teams: teams 5, 6 and 8. At first, team 5 displayed some short instances of resistance, yet this was quickly followed by instances of creative thinking. The example below illustrates their shift.

> Case 3, 5th design session, team 5
> Child 1: *Okay, so how to make the cable car safer... (shows big contemplating eyes)*
> Child 2: *We were already planning that.*
> Child 1: *So, I'm thinking ... But then we have to completely ... Maybe we can make a dome…*

Although team 8 instantly displayed instances of creative thinking, they did appear to focus strongly on 'solving' all the feedback they received, which is illustrated by the following example. This behaviour showcases some similarities to team 4 of Case 2, who also focussed on solving uncovered shortcomings. This strong focus on 'solving' or 'fixing' could possibly compromise the quality of the solutions generated.

> Case 3, S5, Team 8
> Child: *And we've actually already solved 3* [feedback forms]. *We have already solved the feedback of the Kinderraad* [child representatives of the hospital]. *Because that* [feedback] *was about having more fresh air, but most skating rinks usually already have fresh air.*

All three teams affirmed their engagement in reflective, evaluative and generative thinking during the post-interviews. Similar to teams 3 and 4 of Case 2, they do not specifically state that they engaged in reflective and evaluative thinking. However, the teams remarked that they adjusted and improved their design, which inherently entails the utilisation of these thinking processes.

> Case 3, post-interview, team 8
> [when asked if they used the feedback they received]
> Child 1: *We had already taken 15 minutes to cut mini holes in our prototype, but we did not think: "We have put so much work into it now, we just keep it like it is". No, we really thought: "Hey, that must indeed hurt. We take it out* [of the prototype]*".*
> Child 2: *The same also applies to the feedback of the Kinderraad* [child representatives of the hospital]. *They said: "How can you ensure that the children get more fresh air?". Then you can just take away the roof* [of the ice-skating ring]. *So, in the end we did that.*

Team 7 did not instantly engage in creative thinking processes after selecting the feedback forms, as they were often distracted. During their post-interview, team 7 also does not mention

engaging in any creative thinking processes. This could indicate a lack of awareness of the team regarding the types of behaviours expected from them. Eventually, they did showcase reflective, evaluative and generative thinking during the 5th design session when urged by the verbal prompts of the facilitators. For team 7, these prompts proved to be essential in sparking any creative thinking processes, as they experienced continuous moments of distraction. The effect of the verbal prompts is illustrated in the example below.

> Case 3, S5, team 7, 5th design session
> [the team is distracted and talks about gifts in relation to a Dutch holiday]
> Facilitator *(centrally addressing the whole class)*: *So, start discussing* [which feedback forms to select].
> Child 1: *In the evening when I have to go to bed I always go to my gifts.*
> Child 2: *Guys, we're not going to make new ones.* [meaning new prototypes]
> Child 1: *(Not listening to Child 2, continues talking about gifts)*
> Child 2: *(Taps child 1, slightly aggressive, to get attention) It* [feedback form] *says if the IV stays on, it gets stuck behind to slide and can tear out. What if we put someone there who walks along with the IV when you slide down?*
> Child 1: *Yes, or we change the IV pole.*
> Child 3: *No! A shelf (mimics with his hands)! A shelf like this and there you have to ...*

These prompts also initiated an instance of ideation with team 8 when they went slightly off-topic. However, these verbal prompts had a different effect on the other two teams, 5 and 6. For these two teams, instances of reflective, evaluative and generative thinking naturally followed after selecting the feedback forms. Therefore, the verbal prompts were often irrelevant or timed too late, which at times led to a counteractive effect where it disturbed their natural workflow.

Another modification to the procedure in Case 3 was hiding the proposals on the feedback forms, which could only be reviewed after another verbal prompt from the facilitators. Although reading the proposals sparked a few generative processes with two teams in Case 2, this modification was implemented in Case 3 to avoid copying and stimulate the teams' autonomous ideation. In contrast to Case 2, three of the four teams in Case 3 reacted with resistance to the proposals when prompted to review them. The teams for example stated that they had already devised better solutions. This was affirmed during the post-interviews, where team 6 explicitly stated they did not copy the proposals on the feedback forms:

> Case 3, post-interview, team 6
> Child: *Differently than how they stated it, but we did use it* [the feedback]. *To make it* [the design] *safer, they suggested putting belts and magnets. And then we thought, we can change this and then use cable tie around it and above it.*

One team, team 7, did instantly display openness when discussing the proposals, which induced a short instance of ideation. For this team, being prompted to read the proposals redirected their attention to the task at hand. See the following example, which illustrates this openness.

> Case 3, S5, team 7
> Facilitator: *Boys and girls, you can use the proposed ideas [on the feedback forms] as inspiration. You don't necessarily have to adopt them.*
> Child 1: *(reads proposal from feedback form) "Do not leave IV pole on the ground; think of something else". (stops reading) Guys! (Reads again) "Do not leave the IV pole on the ground; think of something else"... Someone can just walk along maybe?*
> Child 2: *That way, the IV pole can move along.*
> Child 1: *Yes!*

When comparing these results to Case 2, it appears that proposals can primarily benefit a team's ideation when presented before a team has generated their own solutions. The delayed reviewing of the proposals during Case 3 appears to stimulate the generation of autonomous solutions. The team that did not yet start their autonomous solution generation process during this delayed time did benefit from the extra push reading the proposals provided.

In the end, almost all design teams addressed the two selected feedback forms in full, which was observed through the adjustments they made to their designs. Team 7 only slightly addressed one of the selected feedback forms, even though they made several other adjustments to their design throughout their design process. We presume that this lack of feedback utilisation can be attributed to the team's continuous distraction from the task at hand. Unlike in Case 2, the teams did not copy any of the proposals. We presume that this is due to the delayed review of the proposals.

Conclusions

The goal of the feedback procedure was to stimulate the teams' generative and evaluative thinking by guiding them in selecting and discussing the feedback forms. These actions and accompanied thinking processes where then meant to drive them to take action. In the end, all of the teams in Cases 2 and 3 made adjustments and improvements to their design to address the feedback on their selected feedback forms. These changes indicate that the teams in both cases ultimately all engaged in creative thinking processes and were able to take action. The results show several improvements from Case 2 to Case 3. The teams in Case 3 were more engaged in creative thinking and showed more openness towards the selected feedback forms. This openness might be due to the improved procedures, but could also be caused by other factors. Furthermore, the teams in Case 3 generated their own solution directions and refrained from directly copying the proposals on the feedback forms.

5.4.4 Appreciating feedback

In this section, we discuss the results that give insight into the appreciation and understanding the design teams showcase towards the feedback they received. We also discussed if they understood the active role they needed to take to utilise the feedback to their advantage. In other words, did the teams internalise that the feedback was meant to help them improve their design and did they take an active role in the feedback process?

Case 2

In Case 2, the results indicate that most of the design teams appear to understand the value of design feedback and took an active role in the feedback process. Three teams, 2, 3, and 4, did showcase evidence of understanding the value of feedback and taking an active role in the feedback process. However, they expressed this in different ways.

Team 3 displayed an overall positive attitude towards the feedback forms they received and took a proactive role when discussing and utilising them. These feedback forms were predominantly of good quality, and the team mentioned on several occasions that the feedback could be used to improve the design; see the example below. These statements indicate that the team understands the value of the feedback. Furthermore, their final design showcases the active utilisation of the selected feedback forms.

> Case 2, team 3, post-interview
> Child: *Well, I thought it was more fun to present the idea, because then you could still get tips on how to make it [the design] even better.*

Team 2 and 4 also took an active role in their feedback process, even though team 4 had two members who experienced several moments of distraction. However, instead of an overall positive attitude, they displayed several instances of dissatisfaction with the feedback they received. We presume that this dissatisfaction is linked to the poor quality of the feedback forms they have received. In general, both teams were able to construct good quality feedback forms in their role as peers, which indicates that they would be able to identify good quality feedback. Therefore, we presume that the teams' dissatisfaction to the received feedback indicates that they were disappointed by the lack of quality and usefulness. Their negative responses when receiving poor quality feedback appears to demonstrate an understanding of its value when it would be of good quality. Furthermore, teams 2 and 4 indicate that they perceive feedback as something that can help solve shortcomings; see the example below. When combined, their behaviour and responses indicate a level of understanding of the value of feedback for a design process.

Case 2, team 2

Child: *Yes, and then you could come up with a solution* [on the feedback form]*, and they* [the team receiving the feedback form] *could do something with it. And it is also nice to think along with the idea of someone else.*

Facilitator: *Yes. And what exactly do you like about that? To think along with the ideas of someone else?*

Child: *Well, then you are not only working on your own ideas. Then you think, 'Yeah, that is also a good idea, and maybe you could do this* [an aspect of the idea] *even better'.*

As previously discussed, there was one team, team 1, which experienced a lack of communication and collaboration, which illustrates a non-active role. Additionally, the responses in their post-interview do not showCase an understanding of the value of feedback, as they only state that they understand the content.

Case 3

Similar to Case 2, the results indicate that most design teams appeared to understand the value of design feedback and took an active role in the feedback process. Again, one of the teams, team 7, did not directly showcase this clear understanding or an active role. Instead, they displayed a somewhat non-active role due to continuous instances of distraction during the feedback process. During their post-interview, the team does link the quality of feedback to the ability to improve a design. However, it is unclear if they consciously utilised feedback in that way and therefore really internalised the value of feedback.

The other three teams, 5, 6, and 8, showcase evidence of understanding the value of feedback and taking an active role in the feedback process. Teams 6 and 8 displayed a generally positive attitude when discussing the feedback forms during the 5th design session and took an active role when discussing and utilising the feedback forms. Furthermore, the teams state that feedback can help improve a design and solve shortcomings; see the example below. When combined, their behaviour and responses indicate a level of understanding of the value of feedback for a design process.

Case 3, team 6

Child: *Well, good feedback means you can make it* [the design] *better. So, for example, the feedback from the Kinderraad* [child representatives of the hospital] *was that we should make it safer. So, then we really made it safer. And it worked out much better that way, because if you get good feedback you can make better things.*

Team 5 also took an active role in their feedback process, yet displayed several moments of dissatisfaction with the feedback. We again presume this dissatisfaction was caused by the poor quality of the feedback forms, which led to disappointment and a lack of usefulness. Also,

this team provided excellent quality feedback for others in their role as peers, which illustrates their understanding of quality and thereby the value of feedback for a design process. Furthermore, team 5 directly links feedback to the ability to improve a design during their post-interview and stated that they actively worked towards this during their design process.

Conclusions

To conclude, most of the teams in Cases 2 and 3 developed an understanding of the value of feedback. Additionally, almost all teams took an active role in the feedback process to utilise the selected feedback forms to adjust or improve their design.

5.5 DISCUSSION

The results demonstrate how the peer feedback intervention supported and encouraged the actions underlying the processes of design feedback uptake. The different types of guidance underlaying the intervention supported pupils in giving, receiving, discussing, selecting and utilising design feedback. On multiple occasions, the pupils showed that they were able to: maintain an emotional balance and showcase openness, evaluate feedback through the use of (self) constructed criteria, develop a feeling of quality, take action in (re)starting their creative thinking process, appreciate feedback by understanding the improvement effect it can bring, and take an active role in the feedback process. In the upcoming sections, we will discuss how the results link back to the design of the peer feedback intervention and relevant literature. Successes will be highlighted, and remaining concerns will be addressed.

5.5.1 Emotional balance

The results indicate that guidance of design feedback processes positively influences young novice designers' emotional balance. In guided sessions, defensiveness and resistance to feedback was less prevalent than detected in our earlier research on unguided settings with primary school children (Schut, Klapwijk, Gielen, & de Vries, 2019; Schut, Klapwijk, Gielen, van Doorn, et al., 2019). Several factors within the three guiding key principles of the peer feedback intervention have contributed to this. Here, we will discuss two of the most prominent factors related to the implementation of peer feedback (key principle 2).

Implementation of high-quality peer feedback

To start, the quality of the feedback on the feedback forms has influenced the pupils' emotional balance. In the verbal responses showcasing resistance, some of the design teams refer to the quality of the content of the feedback in relation to their designs, especially in Case 2. These teams for example state how, according to them, the feedback is 'not relevant to their design' or

'something they already addressed'. As stated before, the teams reacted with more openness in Case 3, which may indicate that they experienced the quality of the feedback as sufficient and relevant. These findings can be linked to the results of the quality analysis of the feedback forms showing a lower level of adherence to the format in Case 2. This lack of quality led to improvements in the feedback procedure of Case 3 and a corresponding increase in the feedback quality. These improvements, an elaborated meta-dialogue with analysing exemplars and a quality check on the shared feedback (see *Table 9*), were based on recommendations by Carless & Boud (2018) and shown to positively affect feedback quality in the current study. From this, we conclude that this type of guidance can indeed have a positive effect on the process of design feedback uptake. Actively guiding for high feedback quality can improve pupils' emotional balance.

Next, the person giving the feedback seems to affect the pupils' emotional balance as well. Overall, the design teams reacted with openness to the clients' feedback, as opposed to their peers' feedback. The previous analysis of the current peer feedback intervention in *Chapter 4*, which focused on the constructed verbal feedback and the concurrent direct responses, also showcased how the design teams displayed more openness towards the verbal feedback of the clients than their peers (Schut et al., 2020). Interestingly, an instant switch in openness could be detected in the current study when client feedback was discussed, even when the pupils just displayed their dissatisfaction with a preceding feedback form. This ability to quickly switch toward an open mindset can be considered beneficial for feedback uptake. Sudden change in openness could be due to the quality of the client feedback forms, which were generally better than that of the peers. The status of the clients, who were introduced as experts by profession or experience, could have been of influence. Literature suggests pupils can perceive their peers, rightly or wrongly, as incompetent or lacking the expertise to give valuable feedback (Panadero, 2016). This could explain why the design teams were more open to the feedback of the clients.

As is made clear in the previous examples, not all design teams were able to maintain an emotional balance when receiving a variety of feedback forms. However, the goal of the feedback intervention was never to eliminate all resistance completely, but to encourage openness to the possibility of being misdirected in the design process. Some resistance might even be positive since it indicates signs of persistence, a quality that is needed when engaging in creative processes (Crilly, 2015; Csikszentmihalyi, 1999). However, justified or not, initial negative responses and resistance to feedback can set an unfavourable tone for future feedback encounters and comprise one's evaluative judgement (Robinson et al., 2013; To, 2016). Therefore, a key learning for young novice designers is comprehending how to manage this delicate balance between persistence and openness, which is not an easy task.

5.5.2 Evaluative judgement

The results demonstrate how the young novice designers were able to identify, develop and utilise relevant criteria to evaluate the feedback they received in relation to their design. Furthermore, they gained an understanding of what compromises quality in a design in the context of the design assignment they were working on. These capabilities are considered essential regarding evaluative judgment (Tai et al., 2017; Tai et al., 2016). The studies in *Chapters 2* and *3* on design feedback in unguided settings showcase a lack of sense making and evaluative thinking (Schut, Klapwijk, Gielen, & de Vries, 2019; Schut, Klapwijk, Gielen, van Doorn, et al., 2019). Therefore, the results in the current study indicate that the guidance from the peer feedback intervention in the current study had a positive influence on the pupils' evaluative judgement. Several factors within the three guiding key principles of the intervention have contributed to this. Here, we will discuss the principles that could be attributed to the design of the learning environment (key principle 1) and the implementation of peer feedback (key principle 2).

Design of the learning environment

There are many indications that the designed learning environment was a critical driving force behind these generally successful evaluation processes. The project was centred around a real-life design challenge with clients, which means that the design teams would need to earnestly consider the clients' expectations when discussing and selecting the feedback forms. Especially since the clients would participate in the final presentation and expected to see improvement in the designs based on their intermediate feedback. The involvement of the client likely created a sense of urgency with the design teams when evaluating the feedback. Additionally, the intervention provided the pupils with clear guidance in discussing and selecting the feedback forms. Still, autonomy was promoted within this guidance by providing the design teams with the freedom of choice to only work with the feedback they perceived as fruitful and rejected the feedback they deemed irrelevant. Although more research is needed, indications are that the design of the intervention, combined with the clients' involvement, led the pupils to make well-considered choices showcasing their evaluative abilities.

Implementation of peer feedback

The implementation of peer feedback also contributed to the pupils' evaluative abilities, especially regarding the use of evaluation criteria and the development of a sense of quality. The results show how the design teams used an assortment of evaluation criteria when evaluating the feedback forms. Several of these criteria can be linked back to the structure of the feedback forms. For example, almost all teams explicitly note the importance of the high-level convergent (i.e. *"We think this could be better about the design… because …"*) and high-level divergent feedback (i.e. *"How can you…"*-question and "*We think this could maybe be a*

solution…") as evaluation criteria. Regarding the convergent feedback, the teams paid attention to the shortcomings this feedback uncovered and the reasoning behind it. Additionally, some of the teams expressed that they needed the feedback to be relevant, focused on their design and bring an issue to light they did not consider or solved yet. Regarding the divergent feedback, almost all teams stated that they paid attention to how this type of feedback would help them to 'move forward' in their design process. Emphasising divergent feedback within the peer feedback intervention has been a calculated decision, as literature shows that especially the combination of convergent and divergent feedback is needed to propel the creative design process forward (Cardoso et al. 2016; Eris 2004) and stimulate exploratory thinking and risk-taking (Daly & Yilmaz, 2015; Tolbert & Daly, 2013; Yilmaz & Daly, 2016). As these underlying intentions were not communicated to the pupils, they have discovered this themselves, which makes the aforementioned findings rather compelling.

Apart from the convergent and divergent nature of the feedback, the design teams had created a few additional criteria when evaluating the written feedback forms: completeness, clarity, honesty/objectivity, and a balance between positive and negative feedback. When combined, the different evaluation criteria create a rather extensive list, showcasing the different foci within the pupils' evaluation processes. On the one hand, the foci on divergent and convergent feedback can be traced back to the use of the feedback forms, which guided their evaluation process when receiving feedback. On the other hand, several of the criteria can be linked to the implementation of high-quality peer feedback, through which pupils were also put in the role of feedback giver. For example, we presume that learning how to give divergent feedback enhanced the pupils' understanding of how feedback is meant to help a designer within their creative process, thereby picking up on the underlying intention of 'moving forward'. This is not necessarily a surprising outcome but a treasured one, as it points towards the value that learning to construct peer feedback can have for young novice designers' evaluative judgement. Additionally, it creates a strong argument for actively implementing peer feedback within the context of design education since 'moving forward' is considered crucial within creative design processes.

Sense of quality

The design teams adhered to their self-developed sense of quality of the feedback. Besides some biased evaluations, moments of misunderstanding, and occasional resistance, they generally appeared to have had a good understanding of what compromises quality. An illustration of this is the subsiding of resistance when receiving feedback in Case 3 when the feedback improved in quality compared to Case 2. We presume that the teams' engagement in constructing peer feedback made them more capable of handling the ambiguity prevalent in design feedback and improved their confidence in their own evaluation of quality. Furthermore, they made active comparisons to the current state of their design to see where improvement

possibilities might lie. These comparisons showcase that the pupils had ideas on what good feedback should be and, ergo, what is a good design.

5.5.3 Take action

The results showcase how discussing and selecting the received feedback initiated an observable chain of reflection, evaluation and ideation with most teams. Furthermore, most design teams state that they engaged in creative thinking processes to adjust and improve their design, and all final designs display these adjustments and improvements based on the selected feedback. These results indicates that all design teams engaged in creative thinking, meaning the alternation of divergent and convergent thinking (Howardet al., 2008; Smith, 1995; Sowden et al., 2015), which are the key processes within the process of design feedback uptake. These results support the argument for guiding design feedback processes. Especially when compared to previous studies presented in *Chapters 2* and *3* in unguided settings, where the design feedback did not appear to directly spark many creative thought processes (Schut, Klapwijk, Gielen, & de Vries, 2019; Schut, Klapwijk, Gielen, van Doorn, et al., 2019).

Again, several factors within the three guiding key principles of the feedback intervention have contributed to forming these creative thinking processes. Here, we will discuss those that could be attributed to the design of the learning environment (key principle 1) and the explicit guidance (key principle 3).

Design of the learning environment

It appears that the feedback initiated critical reflection and evaluation (CT) to help uncover shortcomings while also providing a way forward and sparking the ideation of new solutions (DT) to these uncovered issues, thereby informing the teams' concurrent design decisions. This chain of action is precisely what design feedback should ideally do (Cardoso et al., 2014; Oh et al., 2013; Yilmaz & Daly, 2016). However, as described before, it is generally believed that feedback is not likely to initiate further action by itself (Carless & Boud, 2018; Hattie & Timperley, 2007). The design of the learning environment contributed greatly to the design teams' ability to take action. Firstly, the design of the feedback procedure, with an intermediate feedback moment (4th design session) and final feedback/presentation moment (6th design session), directly created the room and time for feedback utilisation and indirectly implied the need to do so (O'Donovan et al., 2016). Secondly, similar to the reasoning given regarding the capacity of evaluative judgement, the presence and expectations of the clients during this final presentation moment created a sense of urgency for the design teams to utilise the feedback they selected. Explicitly providing space within the learning environment to directly work with and apply the received feedback is considered critical regarding feedback uptake (REF).

Use of explicit guidance

The use of explicit guidance appears to have contributed to the design teams' ability to take action. From Case 2 to Case 3, extra verbal prompts were added to the procedure to explicitly separate and initiate the moments of receiving, selecting and utilising the feedback. These extra prompts were implemented to help spark moments of creative thinking with teams unable to operate autonomously. In Case 3, these additional prompts positively influenced the design teams who experienced singular or repeated moments of distraction. The prompts by the facilitators brought their attention back to the task at hand and, consequently, helped to initiate moments of reflection, evaluation and ideation. However, the research results also indicate that these prompts were not necessarily helpful for those teams who were naturally engaged in creative thinking processes. For them, *the verbal prompts were often irrelevant or timed too late, which at times led to a counteractive effect disturbing the pupils' natural workflow.* Nonetheless, the case study shows that the use of verbal prompts can be helpful to those who are not able to work as independently and need more guidance on the steps they should take when processing feedback. We suppose that a less rigid format might be more beneficial in a classroom situation, where facilitators and educators need become aware when novice designers are in need of such prompts.

Another modification from Case 2 to Case 3 is related to the guidance of a specific part of the received feedback, namely the proposals of the clients and peers (possible solutions to the uncovered shortcomings by the feedback). In Case 2, several teams copied the proposals that were presented to them on the feedback forms, which is counteractive to an ideally autonomous process of creative thinking. It can even increase the occurrence of design fixation, which is already a known issue in this age group (Luo, 2015; Nicholl & McLellan, 2007a; Schut, Klapwijk, Gielen, van Doorn, et al., 2019). Therefore, in Case 3, the proposals of the clients and peers were hidden in a separate closed envelope attached to the feedback forms and a specific verbal prompt was added to delay the viewing of these proposals. As a result, none of the teams directly copied any proposals to their design and generated their own solution directions. The modification in guidance thus contributed to the teams' autonomous creative thinking processes and their ability to take action. An unexpected side effect was that the proposals were met with resistance by most of the teams. Although these resistance responses indicate a lack of emotional balance, it showcases the teams' confidence in their ability to generate their own solution directions. One could argue that it would be better to eliminate these proposals altogether, yet several teams mention them as an evaluation criterion during their post-interviews. This preference appears to indicate that the teams do value proposals as a form of feedback, even if they are not immediately met with openness.

5.5.4 Appreciating feedback

The results showcase how participating in the peer feedback intervention aided the pupils in recognising the value of the feedback they received and stimulated them to take an active role in the feedback process. Most of the design teams highlighted the improvement-effect feedback

can bring to their design and the support it can give in uncovering undetected shortcomings. Additionally, almost all teams took an active role in the feedback process to utilise the selected feedback forms to adjust or improve their design. We determined previously that the element of 'appreciating feedback' has a more overarching position within the process of feedback uptake. Therefore, we will relate this element to the influence of the intervention as a whole, as it is the combination of the three key guiding principles that are responsible for the current results.

Recognising the value of feedback

The previous sections discuss how the feedback procedure guided the design teams in receiving, discussing, evaluating and utilising design feedback, which gives insight into the actions they take during the feedback process. Besides these actions, we consider how pupils talk about the feedback processes in hindsight is telling. The results showcase how the underlying intention and goal of the feedback procedure were internalised. Meaning that the pupils understood that the feedback was there to support them in their creative design process and initiate improvement of their design. Even of those teams who did not always respond with openness to feedback they received, most were still able to verbalise the value design feedback can have with regards to improving their design. It indicates that the pupils lean towards a growth mindset and are able to take feedback as something they can learn and develop from (Dweck, 2016). Furthermore, it reaffirms our assumption that the element of 'appreciating feedback' indeed leans towards being an overarching quality of someone engaging in these types of feedback processes.

These results tie in well with previous studies in higher education where design students have also shown to understand the value design feedback can bring to their design process and design skills (Dannels et al., 2011; Oh et al., 2013). Nonetheless, we want to highlight our surprise, as we did not expect the young pupils to showcase this level of understanding after participating in only one design project. It showcases the value of doing real-life design projects within a primary school context.

Taking an active role

The results indicate that the feedback procedure was able to stimulate the pupils to participate actively in the feedback processes. Compared to results by other design researchers, this active participation would not have been as widespread without the guidance of the intervention, as several studies have highlighted the generally passive and consumerist role students take with feedback processes (Bunce et al., 2017; McLean et al., 2015a). It could be argued that it is difficult to determine the actual level of active participation of the students, as the feedback procedure provided a rather strict level of guidance. Nonetheless, there were still times in which certain design teams experienced moments of distraction and non-active participation. The occurrence of these moments emphasises the level of autonomy the pupils possessed within

the feedback procedure, as they were able to find a way to 'opt-out' of the planned activity. Therefore, being guided by the feedback procedure still requires active involvement of the pupils. It could be said that by merely following the guided feedback procedure, the first step in active participation is reached.

Then the next step within this active participation can be found with those teams which initiated next steps within the feedback procedure before receiving specific guiding prompts from the facilitators. Examples of this are teams who, without support, started to select the most valuable feedback or generate solutions for the uncovered shortcomings in their design. These actions indicate that in these specific moments, certain teams actually transitioned towards taking an active role in their feedback process. Although these results indicate a positive first step, caution is necessary. Even if these transition moments were done intently, it is not directly clear how aware the pupils were about the need to take an active role in their feedback process. (Gravett, 2020) argues that, even in higher education, this active role might entail more agency than students indeed possess and notes that the responsibility is to be shared with the educators, which is also underlined by Carless' (2020) research. This means that, for enabling students to take this active role, the design of the learning environment and the manner in which the specific guidance is structured by the educators are crucial.

5.6 CONCLUDING REMARKS

This chapter describes the results of an explorative case study at two primary schools in the Netherlands. Even though this was a small qualitative study, it is one of the first to tackle the complex processes of design feedback uptake in a primary school context. The results make a solid start with mapping out the intricate processes and dynamics of design feedback uptake in a detailed manner. We believe it provides a stepping stone for future research in this specific context and outside of it, as we presume that many insights can be translated to different educational levels and domains.

To conclude, the guidance of the designed peer feedback intervention largely had a positive influence on the actions and elements underlying the processes of design feedback uptake, e.g. emotional balance, evaluative judgement, take action, and appreciating feedback. Our study shows that guidance of design feedback can support pupils in showcasing openness, developing a feeling for quality, (re)starting their creative thinking processes, understanding the improvement-effect feedback can bring, and taking an active role in the feedback process. For the long-term, actively and successfully working on these actions and elements within the process of design feedback uptake can lead to the development into capacities and dispositions. Through repetition, these actions become a general ability and quality within the pupils, which ultimately leads to the development of their design feedback literacy.

The identified and implemented key design principles within the intervention – design of a learning environment that allows for and caters to active design feedback utilisation, implementation of peer feedback, and providing explicit guidance while enabling autonomy - have shown to support the pupils in achieving this. We strongly believe that its success cannot be attributed to a single principle, but is dependent on the conjunction of all three (and perhaps more). Although refinements to the implementation of these design principles can be made, we conclude that they provide a solid first step in guiding toward valuable and constructive design feedback processes. Future research to refine and expand on these principles could provide valuable additions to the development of feedback literate learners in design education. This study demonstrates that initial successes in design feedback uptake can be achieved in a primary school context with the appropriate guidance. It would be interesting to see how the pupils' actions possibly evolve into capacities and dispositions when trained over an extended period. Also, implementing feedback in different creative contexts could provide exciting research opportunities.

Chapter 6

Conclusion & General discussion

6.1 INTRODUCTION

In this dissertation, we aimed to understand the interplay between design feedback and pupils' creative thinking processes to develop and test feedback interventions that stimulate these thinking processes and help mitigate pupils' design fixation. Within primary education, there is a growing interest in developing pupils' creative abilities, for which design-related subjects can bring many opportunities (Klapwijk, 2017; Lewis, 2005, 2009; Rutland & Barlex, 2008). When implemented and executed well, design feedback can be a powerful tool for stimulating pupils' creative thinking (Cardoso et al., 2014; Daly & Yilmaz, 2015; Yilmaz & Daly, 2016). Ideally, the questions and comments pupils receive will encourage their generative and evaluative thinking. The intent is that they use this feedback to improve and develop their design.

However, several studies have shown that the feedback exchanges within design education are not always as successful in encouraging novice designers' creative thinking and mitigating their fixation (Cardella et al., 2014; Cardoso et al., 2014; Cummings et al., 2015; Schut, Klapwijk, Gielen, & de Vries, 2019). Furthermore, there is little research looking in-depth at these design feedback processes to investigate where opportunities for improvement lie, especially at a primary school level. Gaining insight into this interplay between design feedback and pupils' creative thinking leads to understanding how to guide and support these feedback exchanges properly. What this support could specifically be and how it could be implemented in practice were explored in this dissertation. The following main research question guided the current research: *Which qualities of design feedback processes stimulate pupils' creative thinking and mitigate their design fixation in the concept development stage of the design process?*

The aforementioned research question was addressed through the design and execution of four in-depth qualitative studies. Within these studies, we focused on understanding the issue of design fixation during pupils' design processes and on developing and testing interventions to mitigate its occurrence. To start, efforts were put into the early identification of design fixation, instead of in hindsight, through the unguided design feedback dialogues in the classroom (Chapter 2). Next, the interplay between the design feedback given and responses from the pupils within these unguided dialogues was investigated to diagnose factors hindering pupils' creative thinking (Chapter 3). Finally, from the insights of these first two studies, an intervention was developed to investigate how certain key principles could stimulate pupils' creative thinking and mitigate the occurrence of design fixation. Firstly, efforts were put into understanding how this guidance shaped the interplay between the design feedback and the direct responses of the pupils within the guided dialogues to uncover possible successes and obstacles for stimulating pupils' creative thinking (Chapter 4). Secondly, the aim was to gain insight into how the intervention was able to support the pupils beyond their direct responses within these guided feedback dialogues and enable their process of feedback uptake (Chapter 5).

In the upcoming sections, the results and conclusions of these four studies will be summarised. These sections will be followed by a general discussion addressing the main research question. Then, a description of limitations and suggestions for future research is given, after which practical implications for teachers and design education as a whole are outlined. Reading this final chapter will give an understanding of how to position the newly generated knowledge on the issue of pupils' design fixation within educational design research and provide a starting point on how to mitigate its occurrence within primary school design practice.

6.2 FINDINGS AND CONCLUSIONS PER STUDY

6.2.1 Chapter 2

In the first study presented in *Chapter 2*, we aimed to uncover ways in which pupils' design fixation could be identified during their design process instead of in hindsight. This early identification was done through the analysis of verbal design feedback exchanges taking place within the classroom. The following research question guided the study: *What are early indicators of design fixation within pupils' design feedback exchanges, and how can they be identified?* To explore the issue of design fixation and investigate its early indicators, a case was carried out with a class of primary school pupils in the Netherlands. Here, the 24 pupils (ages 9 - 11) participated in a design project through a series of design sessions in which several unguided verbal feedback exchanges took place with the client, their peers, and the facilitators.

The analysis of these feedback dialogues in this first study revealed that it is indeed possible to signal pupils' fixation on their design ideas in the conversations held in the classroom through the resistance they show towards the feedback given. Four categories of response behaviours indicating this type of fixation - i.e. concept fixation - were uncovered during our analysis: 'band-aids', 'already taken care of', 'it is not possible', and 'question not relevant'. All of these resistance responses allow the designing pupils to keep the core characteristics of their idea intact and unchanged, leaving them fixated on the current state of their design idea. Here, we want to note that this list of resistance type responses is incomplete. A fifth type was uncovered within the analysis of our third study, namely 'it's you', and we are under the premise that additional types might be identified in other datasets.

The study illustrates how the occurrence of concept fixation stagnated pupils' creative thinking by hampering the continuous alternation of divergent and convergent thinking processes. Specifically, their lack of critical evaluation left sub-problems within their design ideas hidden and discarded the need for new generative processes. From a pedagogical perspective, these early indicators bring opportunities for targeted interventions to regain pupils' openness and support new convergent and divergent thoughts. Furthermore, studies have shown that design feedback can counteract fixation and encourage designers to take

divergent and convergent paths during their design process (Cardoso et al., 2014; Crilly, 2015; Yilmaz & Daly, 2014, 2016). Although our results show that feedback on (intermediate) design ideas does not necessarily have this desired effect, design feedback exchanges can still provide opportunities. After all, novice designers need to develop the skills to be able to balance between remaining open to possible flaws within the design ideas and staying persistent in developing a promising idea despite receiving negative feedback (Crilly, 2015; Csikszentmihalyi, 1999).

6.2.2 Chapter 3

Design feedback exchanges can trigger novice designers to reflect on, evaluate and revise their designs (Oh et al., 2013), thereby impacting the divergent or convergent paths they might take (Cardoso et al., 2014; Yilmaz & Daly, 2014, 2016). With that in mind, the second study presented in *Chapter 3* aimed to further understand the occurrence of pupils' design fixation by investigating the unguided design feedback exchanges in more detail. The goal was to gain insight into the interplay between the design feedback given by the client and peers and the direct responses of the pupils to diagnose factors hindering their creative thinking. Specific attention was directed to the exchanges in which resistance to the feedback was present, which was previously found to be a possible indicator for the occurrence of design fixation. The current study was guided by the following research question: *What is the convergent and divergent nature of the design feedback given by the client and peers, and what are the pupils' direct responses in an unguided situation?*

Since this study aimed at exploring the unguided design feedback exchanges in more detail, the data from the first case was re-used. To determine the divergent or convergent nature of the design feedback, we build on Eris' question-driven design model (Eris, 2004). Through its adaptation and extension, a *Design Feedback Model* was constructed. To determine the different types of direct responses, we build on the previously uncovered resistance responses by Schut et al. (2019) and two frameworks on student responses of Cardella et al. (2014) and Cummings et al. (2015). A Direct Responses Model was constructed through the adaptation and extension of these models.

The co-occurrence feedback and responses analysis revealed several interesting patterns and insights useful for improving design feedback practices. In short, the study showed that, within unguided design feedback exchanges, the divergent or convergent nature of the feedback does not necessarily evoke the expected concurrent responses and thinking processes. This means that divergent feedback questions do not necessarily evoke generative thoughts, and convergent feedback questions do not necessarily evoke evaluative thoughts. Resistance responses to the feedback were widespread. The pupils frequently rejected feedback immediately instead of temporarily accepting it to explore its merit. These immediate rejections led to the stagnation of divergent and convergent thinking processes within the

teams, resulting in a lack of critical reflection and a loss of openness, hampering their creative process.

A few hindering factors were identified within the feedback: a high level of convergent feedback, which is associated with a lack of exploratory thinking and risk-taking (Tolbert & Daly, 2013; Yilmaz & Daly, 2016); and several implicit assumptions and expectations of clients and peers that were present in the feedback, which can lead to communication issues that increase the risk of interpretative challenges (Sadler, 2010). Results suggest first reaching for a mutual understanding of assumptions and expectations on the design. Then, when an understanding of subproblems is reached, regain openness and steer towards generative processes to solve the subproblems in the design.

6.2.3 Chapter 4

Based on the results and insights of the aforementioned studies, an intervention was developed to investigate how the guidance of design feedback exchanges could (re-)stimulate pupils' creative thinking, thereby mitigating the occurrence of design fixation. The third study presented in *Chapter 4* aimed at understanding to what extent the guidance provided by the intervention was able to support the creation of constructive and valuable feedback dialogues to (at least initially) stimulate pupils' creative thinking. Within this study, three principles were investigated that focussed on shaping the construction and delivery of divergent and convergent feedback as a means to support the feedback givers and the receivers. By creating valuable and constructive design feedback exchanges (better quality), the premise was that receiving feedback would evoke less resistance (mitigate fixation) and stimulate pupils' creative thinking. Additionally, engaging in peer feedback would lead to a better understanding of the feedback process by the pupils and enhance their evaluative thinking.

The study was guided by the following research question: *In what way does the peer feedback intervention influence the convergent and divergent nature of the design feedback given by the clients and peers and the concurrent direct responses of the pupils?* The goal was to again gain insight into the interplay between the design feedback given by the client and peers and the pupils' direct responses to diagnose successes and obstacles to pupils' creative thinking. To answer the research question, two cases were carried out with two classes of primary school pupils from two schools in the Netherlands. Similar to the first case, the pupils (aged 8 - 12) participated in a design project through a series of design sessions. The intervention was implemented to explicitly guide the pupils (and clients) in giving and receiving design feedback. The third study used data from both cases. The analysis of the third study was similar to the second study and focussed on the verbal feedback exchanges between the designing pupils, their peers, and the client(s). To determine the divergent or convergent nature of the design feedback and the different types of direct responses, the models developed in the previous study were used: Schut et al. (2019) *Design Feedback Model* and *Direct Responses Model*. Again,

an analysis was done on the co-occurrence of feedback and responses to reveal patterns and insights.

The study's results demonstrated how the different types of guidance could support the pupils, their peers, and clients in engaging in constructive and valuable feedback dialogues. Several successes were uncovered during the analysis, showing how the intervention was able to (1) guide towards a shared understanding of the design, (2) stimulate cognitive modelling, (3) encourage an initial calmness towards feedback, and (4) evoke deep reasoning responses, i.e. responses indicating divergent and convergent thinking. Resistance to the feedback was not eliminated (although also not the goal) and mainly came after high-level convergent feedback from the peers. The study again confirmed that the divergent or convergent nature of the feedback does not necessarily evoke the expected concurrent responses. Based on our findings, we proposed a set of revised principles for constructive design feedback dialogues, intending to stimulate pupils' creative thinking: (1) continuously guide towards a shared understanding through low-level questions, especially before posing high-level feedback, (2) emphasise positive aspects of the design through specific and concrete compliments, (3) stimulate reflective, evaluative and generative thoughts through alternating and iterating high-level divergent and convergent feedback, and (4) repeatedly provide a way forward, thereby fostering improvement, by posing high-level divergent feedback.

6.2.4 Chapter 5

The fourth study, presented in *Chapter 5*, aimed at understanding how the intervention could support the pupils' creative thinking processes beyond the initial direct responses within the guided feedback dialogues. Within this study, the investigated intervention principles focussed on supporting the pupils in their process of feedback uptake in consecutive design activities (and stimulating them to take an active role in these processes). The focus lay on supporting four key elements that were determined essential within the process of design feedback uptake (see *Figure 13, Chapter 5*): (1) appreciating feedback and understanding its value, (2) maintaining an emotional balance to encourage openness towards feedback, (3) developing an evaluative judgement, and (4) taking action through consecutive design activities. In order to achieve this, the intervention was based on the three key principles which were concluded from the literature review: (1) Create a learning environment which allows for and caters to design feedback utilisation, (2) implement high-quality peer feedback, and (3) provide explicit guidance through the process of receiving feedback, while enabling autonomy.

The study was guided by the following research question: *In what way does the peer feedback intervention enable pupils in their process of design feedback uptake?* The goal was to gain insight into the extent to which the intervention was able to support the pupils in their process of feedback uptake. To answer the research question, data of design activities and

post-interviews of the second and third cases were analysed. The intervention was implemented in these two cases, which also entailed the principles of this fourth study. The analysis aimed at categorising the data in the elements of the process model of design feedback uptake as displayed in *Figure 13 (Chapter 5)*. To establish this categorisation, we followed the Verbal Analysis approach (Chi, 1997), which consisted of the following steps: segmenting the transcripts into units of analysis, selecting and developing the coding frameworks, applying the coding frameworks in a coding process, and pattern identification and interpretation. In turn, these patterns then allowed us to understand what is desirable in terms of pupils' actions, expressions, and thoughts in relation to their process of design feedback uptake.

The results of the study demonstrated how the guidance of the peer feedback intervention largely had a positive influence on the actions and elements underlying the processes of design feedback uptake, e.g. emotional balance, evaluative judgement, take action, and appreciating feedback. The study showed that guiding design feedback processes can support pupils in (1) showcasing openness, (2) developing a feeling for quality, (3) (re)starting their creative thinking processes, (4) understanding the improvement-effect feedback can bring, and (5) taking an active role in the feedback process. We strongly believe that its success cannot be attributed to a single principle and is dependent on the conjunction of all three (and perhaps more). Although refinements to the implementation of the principles can be made, we conclude that they provide a solid first step in guiding toward valuable and constructive design feedback processes.

6.3 GENERAL DISCUSSION

As previously highlighted, we aimed to understand the interplay between design feedback and pupils' creative thinking processes to develop and test feedback interventions that stimulate these thinking processes and help mitigate pupils' design fixation. By investigating the successes and obstacles within unguided design feedback exchanges in primary school classrooms, a peer feedback intervention guiding these exchanges could be developed and tested. By doing so, we gained understanding and practical know-how on the early identification of design fixation in the concept development stage of design processes and the nurturing of pupils' creative thinking through the use of design feedback.

To start, *Chapter 2* demonstrated that it is indeed possible to identify pupils' (unconscious) adherence to the possibly unfavourable state of their design idea, i.e. concept fixation (Schut, Klapwijk, Gielen, van Doorn, et al., 2019), at an earlier stage in their design process. By analysing the (feedback) dialogues that took place between the designing pupils, their peers, clients, and facilitators, a set of five resistance responses were uncovered that indicate the occurrence of concept fixation. An overview of these indicators can be found in

Table 10. Previous research on design fixation primarily identifies design fixation indirectly and in hindsight by analysing the design ideas, prototypes and other artefacts when a design project has ended (Luo, 2015; Nicholl & McLellan, 2007a, 2007b, 2008; Sio et al., 2015; Vasconcelos & Crilly, 2016). This newly uncovered direct and early form of identification brings about a whole new array of intervention possibilities for its mitigation. Identifying fixation during the design process can transform its occurrence into learning opportunities that can develop pupils' awareness of the issue and the ability to mitigate it.

Table 10: Early indicators of concept fixation.

Resistance responses	*Description*	*Initially identified in:*
Band-aids	Proposing adjustments or elaborations that don't present a valuable and relevant development and leave the flawed core of a design idea intact.	Study 1, 2
Already in there	Dismissing uncovered shortcomings by stating (falsely) that they have been present within the design idea all along.	Study 1, 2
Question not relevant	Indicating that the given feedback holds no relevance to the design idea.	Study 1, 2
It's not possible	Dismissing proposed adjustments or elaborations on feasibility without proper evaluation.	Study 1, 2
It's you	Dismissing uncovered shortcomings by making future users responsible for its correct use.	Study 3, 4

Furthermore, the studies in *Chapters 4* and *5* confirm that the use of design feedback can aid in the mitigation of design fixation, specifically concept fixation, by stimulating pupils' divergent and convergent thinking processes. In other words, the peer feedback intervention that was developed and tested aided pupils in uncovering shortcomings in their designs and developing possible solution directions while containing the level of resistance towards this feedback. Previous studies in the context of higher design education presumed that design feedback could bring these types of opportunities for creative thinking (Cardoso et al., 2014,

2016; Eris, 2004; Goldschmidt et al., 2010). These presumptions are strengthened by the studies presented in this dissertation.

Although opportunities are present, the presented studies also clearly show that a suitable form of guidance is necessary within these design feedback processes in a primary school context. *Chapter 3* demonstrates how the designing pupils often responded with resistance to the feedback given in an unguided setting. Meaning, a setting in which both feedback givers and receivers did not receive any support in constructing or processing the feedback. In these exchanges, the pupils displayed a lack of openness and frequently rejected feedback immediately instead of accepting it temporarily to explore its merit. There was resistance to feedback from the peers as well as the clients. *Chapters 4 and 5* demonstrate that pupils need to receive support in the actions they need to take during design feedback processes while simultaneously encouraging the development of the relevant capacities and dispositions needed to adequately receive, evaluate, utilise, and appreciate this feedback. Not only is guidance needed on a more micro level within the design feedback exchanges to ensure these are valuable and constructive, but also on a more overarching macro level on the design feedback processes itself. In answering the main RQ - *Which qualities of design feedback processes stimulate pupils' creative thinking and mitigate their design fixation in the concept development stage of the design process?* - the set of principles presented in *Figure 14* were developed and tested throughout the studies within this dissertation.

6.3.1 PRINCIPLES FOR DESIGN FEEDBACK PROCESSES

Design of the learning environment

Among the intervention's success factors is how it created a learning environment that allows for and caters to design feedback utilisation. Here, we presume that combining an interim and final feedback moment and using real-life co-design challenges with actual clients has been essential in its success. These set moments created an explicit need for pupils to utilise the feedback they received and an implicit sense of urgency. In addition, the implementation of an intermediate and final feedback moment created a specific time frame in which there was an explicit need for feedback utilisation to show improvements that were made (O'Donovan, Rust, & Price, 2016). Explicitly creating a learning environment in which there is space to work with and apply the received feedback is critical for feedback uptake, as it is generally believed that feedback is not likely to initiate further action in itself (Carless & Boud, 2018; Hattie & Timperley, 2007).

Additionally, we presume that the client's involvement in the interim and final feedback moments created a sense of urgency in the design teams when evaluating the feedback. The pupils would need to earnestly consider the clients' expectations when discussing and selecting the feedback forms, as the clients would expect to see improvement in the designs based on their intermediate feedback. These added expectations can be regarded

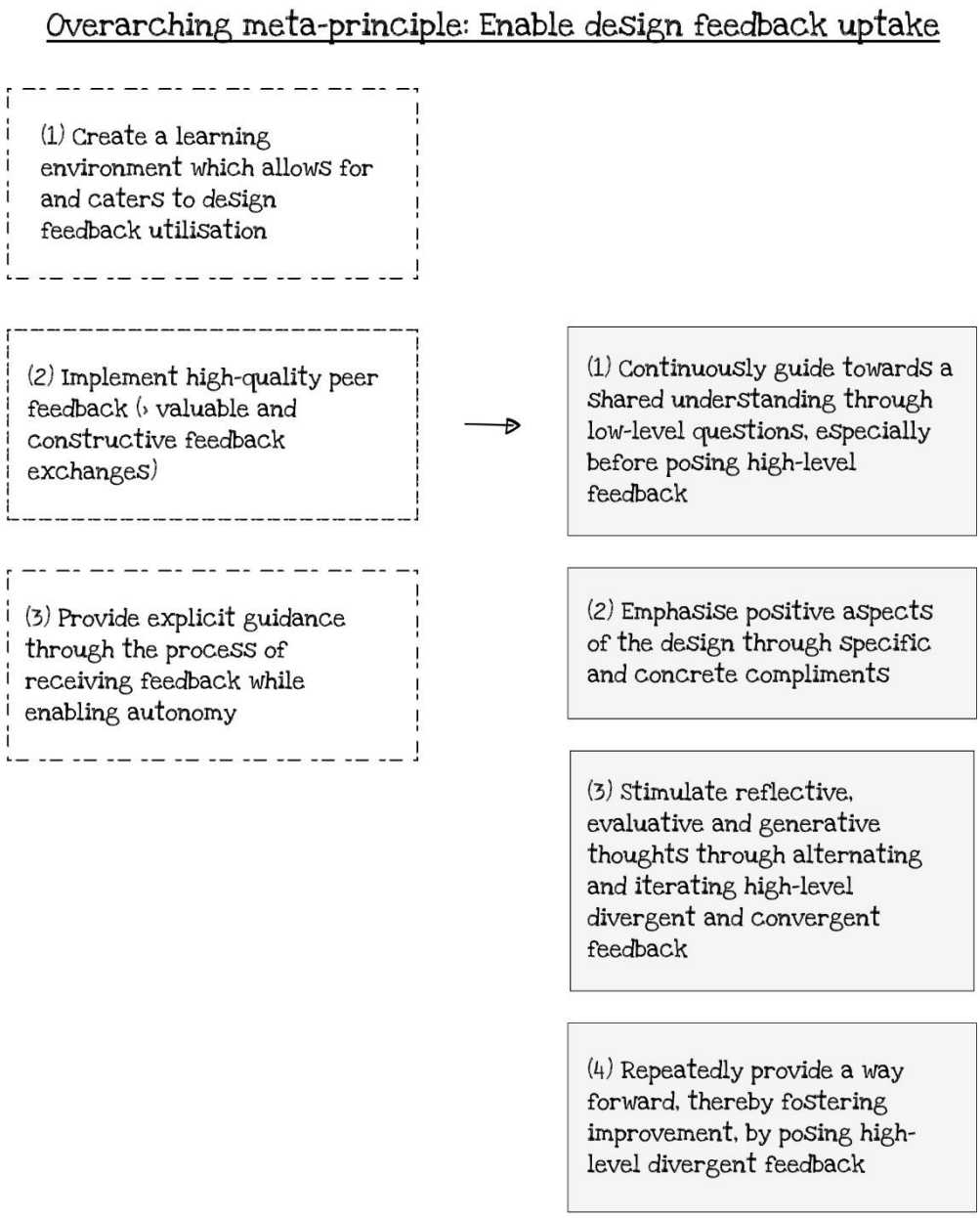


Figure 14: Design Principles for design feedback processes (in primary education) to support pupils' creative thinking

as an argument for clients' involvement in primary design education when aiming to develop an active disposition in the pupils. However, nuance to this argument will be given in the upcoming section around the implementation of peer feedback, as this involvement of clients also appears to need guidance and training.

There are other studies within the context of design education that highlight and discuss components, strategies, or frameworks to improve design feedback practices (i.e. design crits) (Anthony, 1991; Healy, 2016; McDonald et al., 2019; McDonald & Michela, 2019; Oh et al., 2013; Yilmaz & Daly, 2016). However, these do not focus explicitly on this 'need' for feedback utilisation. Generally, effort is directed towards understanding and improving what happens during the feedback exchanges, yet not what happens afterwards. It is known from other educational contexts that feedback uptake is not a given, which can leave valuable feedback to left unused (Carless & Boud, 2018). It can be presumed that it is not different within design education, especially since initial resistance toward design feedback might already create a first barrier (Cardella et al., 2014; Cardoso et al., 2014; Cummings et al., 2015; Schut, Klapwijk, Gielen, & de Vries, 2019; Schut, Klapwijk, Gielen, van Doorn, et al., 2019). Therefore, conscious effort was put into creating a learning environment that caters explicitly to and allows for the use of feedback within the intervention discussed in *Chapters 4* and *5*. The results that followed make a compelling case for the activation of designing pupils within the feedback processes, as it appeared to have contributed to their feedback uptake.

Implementing high-quality peer feedback

Next to the design of the learning environment, the implementation of high-quality peer feedback was another key factor within the intervention. The use of peer feedback within design education is not a new phenomenon and is put in place regularly by educators (Anthony, 1991; Oh et al., 2013). However, these processes are generally unguided. The feedback givers and receivers are expected to simply participate in these processes successfully, while *Chapters 1* and *2* show that this is not a given. Research focussing on the explicit guidance of these design feedback processes is uncommon; therefore, the current dissertation brings new insight and opportunities. The findings presented in *Chapters 4* and *5* showcases that the intervention supported the peers (and clients) in creating and sharing valuable and constructive feedback. In other words, the intervention provided a first step in teaching pupils how to approach constructing and sharing feedback with their designing classmates. The result was an improvement in the quality and delivery of the feedback, which helped mitigate resistance and stimulate creative thinking.

Furthermore, participating in peer feedback processes simultaneously encouraged pupils' feedback uptake by aiding the development of their emotional balance and evaluative judgement. Engaging in peer feedback practices can help develop the capacities and dispositions pupils need to become active feedback receivers (Carless & Boud, 2018). By

learning how to give appropriate feedback, an opportunity for increasing their abilities to receive feedback is created. *Chapters 4* and *5* showcase how the peer feedback intervention aided in developing these capacities and dispositions as opposed to the unguided design feedback processes in *chapters 2* and *3.* Here, we focused on developing pupils' emotional balance and evaluative judgement, in which we presume the peer feedback component to have played an important role. Resistance to feedback was less prominent within the guided design feedback processes discussed in *chapters 4* and *5*. Even when faced with critical and negative feedback, there were many occurrences where the receiving pupils' were able to maintain their initial emotional balance and take the feedback as an opportunity to improve their design. Encouraging openness was an important underlying goal within the peer feedback intervention, as initial negative responses and resistance towards feedback can set an unfavourable tone for future feedback encounters and comprise one's evaluative judgement (Robinson et al., 2013; To, 2016).

Learning how to balance persistence and openness is a central element for successful feedback uptake, which the intervention was able to support the pupils with. The peer feedback component played a key role in this, as it helped improve the quality of the feedback given by the peers (and clients), initiated an overarching understanding of the value of feedback with the pupils, and developed the pupils' evaluative capacities which helped deepen their understanding of the received feedback. In other words, engaging in peer feedback aided their evaluative capacities, making them more capable of handling feedback and understanding its value for their design process. The results of *chapter 5* show how the pupils created an extensive list of evaluation criteria when handling the received feedback and making comparisons to the state of their design. It illustrates how the pupils developed grounded ideas on what good feedback should be and, ergo, what good design is. Combined, these results create a strong argument for actively implementing peer feedback within the context of primary design education and 'do more of it'.

It is the details that matter

When aiming for valuable and constructive feedback exchanges and stimulating pupils' design feedback uptake, this research shows that the details within the organisation and guidance of these processes appear to matter. Firstly, *Chapters 4* and *5* show that guided convergent and divergent feedback does not necessarily evoke the expected concurrent evaluative, reflective, or generative thinking processes with the pupils. Meaning, that convergent feedback does not necessarily evoke responses indicating reflection and evaluation, and divergent feedback does not necessarily evoke responses indicating generative processes. These results align with *Chapters 2* and *3* and are similar to findings in other studies (Cardella et al., 2014; Cardoso et al., 2014; Cummings et al., 2015).

When sharing feedback, the giver often has a particular intent. For example, when highlighting shortcomings in the design, the intent is often to help a novice designer evaluate and reflect on its quality. This intent requires convergent thinking from the novice designer, which is why, presumably, feedback givers generally resort to convergent feedback in these situations. However, the previous results argue that the intention of the feedback giver, either pushing towards convergence or divergence, could be attained by either type of high-level feedback. Hence, there might be more merit in consciously and carefully alternating, combining, and iterating both types of feedback until the set intention is reached. What type of feedback works in which situation is likely dependent on the preferences and abilities of the receiver. The improved guiding principles that highlight this insight were presented in *Chapter 4*, which bring new opportunities for future research. A key takeaway is that a catered approach seems to be necessary within these design feedback exchanges. The feedback giver needs to be conscious of their intention and consciously pose convergent and divergent feedback to see what works for each designing pupil.

Secondly, *Chapters 4* and *5* show that certain types of divergent feedback can indeed initiate pupils to move forward in their design process. Divergent feedback and stimulating divergence, in general, are deemed essential for the creative design process (Cardoso et al., 2016; Daly & Yilmaz, 2015; Eris, 2004; Tolbert & Daly, 2013; Yilmaz & Daly, 2016). However, the results within these chapters also clearly illustrate that not all types of divergent feedback, as initially proposed by Eris (2004), are received equally. Especially when comparing the results of *Chapters 3, 4* and *5*, it becomes clear that proposing new additions and solutions does not have the same effect as divergent feedback questions that ask pupils to imagine their own alternative possibilities (see *Figure 10, Chapter 4*, '*method generation'* and '*scenario creation*'). Proposals seem to be met with more resistance, which is also why these were firstly kept 'hidden' in the second case when pupils read the received feedback forms (see the third study, *Chapter 4*). It can be argued that divergent feedback questions better allow pupils to generate their own solution directions, thereby ultimately aiding the uptake of design feedback.

Thirdly, a final detail that all studies highlight is that it appears to matter who is the feedback giver. The designing pupils seemed to appreciate the clients' feedback over that of their peers throughout the studies presented here. *Chapter 4* discusses such an example in which the designing pupils are quickly able to regain their openness when confronted with the feedback of the client. This appreciation is speculated to be linked to several factors, among which are the feedback quality, the manner in which was given by the client, and the possible perceived lack of expertise of the peers (Panadero, 2016). Although feedback given by the peers might have been met with more resistance, this does not take away from the overall value peer feedback has (see the previous section 'Implementing high-quality peer feedback'). The general openness towards the clients' feedback led to several evaluative and generative responses by the pupils. These insights demonstrate that participating in co-design projects and including

clients within the design and technology classroom can have value when aiming to enhance pupils' creative design process.

Arguing for a guided design feedback culture

The research presented here showcases the complexity of design feedback processes and sets itself apart by not only looking at the feedback exchanges with a great level of detail, but the entire feedback process. This detailed analysis highlighted the complexity within these design feedback processes even stronger, leading to the conclusion that the use of design feedback within an educational context appears to not be something that can be left unattended and learned 'in the wild'.

The studies within this dissertation make a compelling case for the stimulation of pupils' creative thinking by guiding their design feedback processes. These results align with previous studies, which also argue for a more structured approach when implementing and using design feedback in an educational context (Cardoso et al., 2014; Goldschmidt et al., 2010; Oh et al., 2013). However, those studies mainly touch on what instructors can and should do differently within design feedback exchanges. When comparing this to our studies, we point out that not only the quality and constructiveness of the feedback given can benefit from guidance, but the entire design feedback process. Which includes receiving and utilising feedback and the overall design of the learning environment. Through, for example, the implementation of high-quality peer feedback, focus was put on developing capacities and dispositions needed to become active feedback receivers. Compared to results by other design researchers, this active participation would not have been as widespread without the guidance of the intervention. Several studies have highlighted the generally passive and consumerist role students take with feedback processes (Bunce et al., 2017; McLean et al., 2015b). Our research thereby shows that guidance and training are not only relevant for educators, but also the designing pupils, their peers, clients, and other stakeholders. Ultimately, guidance combined with training can benefit pupils' creative design process immensely.

In our studies, we implemented guidance on different levels of the feedback process, ranging from the overarching design within the educational context to the sentence level of feedback questions. The results point out that the details within these processes matter; therefore, its guidance needs to be organised and executed in a specific manner. The principles put forward in this dissertation do not yet create the ideal situation. Although refinements to the implementation of these principles can be made, we conclude that they provide a concrete first step towards the creation of pedagogical and didactic strategies that aim to encourage valuable and constructive design feedback processes. We want to highlight that it is not only about guiding towards an ideal design feedback situation, but also about making novice designers active and skilled feedback receivers. For the long-term, actively and successfully working on the actions and elements within the process of design feedback uptake can lead to

the development of capacities and dispositions. Meaning that these actions become a general ability and quality, ultimately leading to developing novice designers' design feedback literacy. Combined, the argument might be to actively work towards a design feedback culture.

6.4 LIMITATIONS & FUTURE RESEARCH

The research that is presented in this dissertation is explorative, detailed, and small-scale. The implemented educational design research approach allowed us to study design feedback processes in a naturalistic setting, iteratively implement and improve developed interventions, and create new theoretical insights from the analyses (Bakker, 2018; Yin, 2014). As there was little pre-existing knowledge on the topic, the qualitative nature of the research enabled us to 'look inside the black box' and investigate design feedback exchanges and the process of design feedback uptake in detail. This set-up proved successful in revealing successes and obstacles regarding the stimulation of pupils' creative thinking and mitigation of design fixation through the use of design feedback. However, follow-up research is desirable to further develop the current collection of indicators and models, continue the investigation and improvement of the proposed key principles, and explore the relevance of these outcomes for other design education contexts.

Chapter 2 demonstrated the possibility of identifying pupils' design fixation during their design process through the dialogues in the classroom. The list of uncovered indicators in *Table 10* provides an initial starting point for this early identification, which we encourage future research endeavours to build upon. As this research has an explorative and qualitative nature, the collected data covered only three Dutch primary schools. Implementing this research set-up with a larger set of primary schools might lead to additional, yet to be discovered, indicators. Additionally, pupils in different countries and cultures might display alternative indicators than the Dutch pupils.

As discussed previously, the early identification of design fixation pioneered in this research brings new pedagogical opportunities for its mitigation within the classroom. Design fixation is generally detected at the end of a design project through 'stereotypical' designs made by the children (Luo, 2015; Nicholl & McLellan, 2007b, 2007a, 2008). In the research presented here, an intervention guiding the design feedback process was used to mitigate the occurrence of design fixation. We encourage research into other interventions, as a diverse set allows for a fitting approach for different pupils and their teachers. An alternative avenue to help mitigate design fixation can be in the realm of prototyping. Currently, there are studies pointing to the possible benefit as well as harm of prototyping for the creative process (Vasconcelos & Crilly, 2016; Viswanathan & Linsey, 2011; Youmans, 2011). Detailed studies with targeted prototyping interventions could help uncover novel insights around its potential for mitigating design fixation.

The studies within this dissertation demonstrate that guiding design feedback processes can help stimulate pupils' creative thinking while designing and encourage subsequent design moves (Chapter 4; Chapter 5). The principles created and investigated in these studies provide a first step towards successfully guiding design feedback processes in a primary educational context. We recommend further investigation of these principles to increase the number of design cycles, as is preferred within a design research context (Bakker, 2018). Our efforts show that practising certain skills and procedures within a design process while maintaining a level of autonomy can be beneficial to novice designers. Here, the relevance of practice has been shown in stimulating pupils' creative thinking through design feedback. Applying educational principles within aspects of the (co-)design process can aid in improving the design skills of those designing and, consequently, the quality of their contributions (Van Boeijen et al., 2020). We encourage future research efforts to aid in fine-tuning the proposed principles within this research to suggest additional and improved versions. For example, the improved principles suggested in *Chapter 4* have not yet been studied.

This research shows that looking at design feedback processes in detail is valuable, as it allows for a deeper understanding of its complexity. Subsequent research efforts within primary design education could help build on the models of design feedback, direct responses, and process of design feedback uptake (see *Figures 10, 11, and 13*). New types of feedback questions, comments, and responses are expected to be added through the analysis of different data sets. Additionally, the process model on design feedback uptake is expected to be detailed further. *Chapter 5* demonstrates that initial successes in design feedback uptake can be achieved in a primary school context with the appropriate guidance. Building on these successes, future research efforts could investigate how the pupils' actions possibly evolve into capacities and dispositions when trained over a more extended period of time. Taking the process model as a starting point, it could be refined and translated into a model for design feedback literacy, similar to the model which Carless & Boud (2018) created for general higher education. The topic of feedback literacy is gaining more and more traction in recent years, and researchers have stated the importance of making feedback literacy context-specific (Carless & Boud, 2018; Molloy et al., 2020). Combined, this provides strong grounds to explore the field of feedback literacy for design education.

Other angles of relevance can include the detailed investigation of design feedback processes within secondary and tertiary design education, as well as efforts to explore the implementation of the principles put forward in this research in those educational contexts. We presume the principles to be easily translated and adapted, as several principles and processes of the intervention were based on research results and education material from tertiary design education (Cardoso et al., 2014; Carless & Boud, 2018; Eris, 2004; Isaksen et al., 2010; Tassoul, 2009; Van Boeijen et al., 2013). Overall, a systematic investigation of similarities and differences

between different design education contexts could provide new insight into prolonged means of support for developing pupils' creative abilities.

6.5 PRACTICAL IMPLICATIONS

The studies in this dissertation also generate recommendations for teacher practice, teacher education and professionalisation, and policymakers regarding primary (design) education.

6.5.1 Implications for teacher practice

Chapter 2 addresses the obstacle of design fixation within the concept development stage of the design process, i.e., concept fixation. Several indicators of design fixation have been uncovered through the analysis of conversations between the designing pupils, their peers, clients, and facilitators (see *Table 10*). Since design fixation is a prevalent issue within the design and technology classroom (Luo, 2015; Nicholl & McLellan, 2007a, 2008; Schut et al., 2020; Schut, Klapwijk, Gielen, van Doorn, et al., 2019), which is again confirmed throughout these studies, practising its identification through these indicators can help increase teachers' sensitivity to this stagnating factor. As described previously, identifying design fixation at an early stage opens up new possibilities for its mitigation.

As a solution to this issue, *Chapters 4* and *5* present several practical principles and guidelines to help achieve valuable and constructive design feedback processes within a primary school classroom. They provide a concrete means to support pupils' creative thinking while designing and help mitigate their design fixation - see www.tudelft.nl/codesignkids (English version) and www.tudelft.nl/yourturn (Dutch version). We advise teachers to try these principles and guidelines within their classrooms to help give support in these complex processes. As these chapters show, practising with pupils (and other stakeholders) how to give, receive, and utilise design feedback can help spark their generative and evaluative thinking, thereby advancing their design processes. We understand that it might be needed to slightly adapt the principles and guidelines brought forward in this research to make them fit different types of teaching preferences and learning styles. For example, the level of support and autonomy each classroom needs within these design feedback processes might differ. We are aware that the day-to-day classroom activity creates a situation that is not directly comparable to the research setting within these studies. However, it is vital for teachers not to lose sight of the important details within these principles and guidelines, as that could hinder their potential to stimulate pupils' creative thinking.

Furthermore, *Chapters 4* and *5* demonstrate pupils' ability to actively engage in design feedback processes, construct valuable generative and evaluate feedback, and utilise the received feedback consciously to improve their design. The successes after merely one design

project make one wonder what would happen with the prolonged implementation of design feedback practices within a classroom. Making peer feedback a common occurrence in design-related subjects and actively involving pupils and other stakeholders in these processes can help create a valued design feedback culture. To be active receivers and adequately use feedback, learners require certain competencies and dispositions, known as feedback literacy (Carless & Boud, 2018; Sutton, 2012). Working towards a design feedback culture creates a learning environment of continuous practice, through which pupils can develop the necessary capacities and dispositions to ultimately develop a form of design feedback literacy. Perhaps the development of such a feedback culture in the classroom could even translate to other (creative) subjects that could benefit from question-asking practices.

6.5.2 Implications for teacher education and continued professionalisation

Implementing design feedback within the classroom can offer various opportunities to stimulate and develop pupils' creative abilities. However, doing so successfully might not be such an easy task for teachers. Design might be a subject among many for most primary school teachers. Therefore, practice and experience in teaching design-related skills and processes might be lacking. On top of that, even the most experienced design instructors in tertiary education are still trying to navigate the complexity of design feedback exchanges (Cardoso et al., 2014; Goldschmidt et al., 2010; Yilmaz & Daly, 2016). During informal conversations with the teachers of the classes participating in our studies, many voiced the difficulty and insecurity they experienced when having to criticise their pupils' work in the context of creative subjects like design. As a result, their comments often stayed superficial, broad, and generally positive, as they were not sure how to voice the concerns they might see. Although there is no single right way for teachers to guide design feedback processes in their classrooms, the principles and guidelines brought forward in these studies provide concrete and practical support that can help empower teachers. Here, we see an essential role for teacher educators in supporting teachers in successfully implementing these guided design feedback practices in their classrooms. To emulate the successes presented in these studies, ample resources and support must be dedicated to teacher education and professionalisation.

6.5.3 Implications for policymakers in primary education

The research presented in this dissertation emphasises the importance of design-related subjects in primary education when aiming at developing complex skills like creativity. Although it is generally regarded as an important and sought-after trait, creativity often remains something elusive in many primary school classrooms. A core problem is a lack of knowledge and proven methods to teach a skill like creativity. It is reminiscent of Ken Robinson's TED Talk, where he stated: "*I believe this passionately: that we don't grow into creativity, we grow out of it. Or rather, we get educated out of it*" (Robinson, 2006). Luckily, designing is an intrinsically

creative activity (Barlex, 2007; Goldschmidt, 2014; Howard et al., 2007), which is again underlined in this dissertation. Dutch policymakers and educators (e.g. PO-Raad and Stichting Leerplan Ontwikkeling) generally recognise and emphasise the potential of design-related subjects in primary schools. It is especially valuable as a vehicle for developing creativity and other 21st century skills (Thijs, Fisser, & van der Hoeven, 2014; van Graft et al., 2014). However, systematic promotion of design subjects is lacking, as well as comprehensive support for schools and teachers. The studies presented here again highlight the successes designing can bring to stimulating pupils' creativity. We provide evidence that the quality of primary design education lies in the details of such educational efforts. Furthermore, we offer a specific approach and detailed guidelines that, when implemented, direct towards successful application of such education. We aim to alert policymakers of this potential and persuade them to take further action. After all, we do not want to educate our future generations out of creativity.

References

Amabile, T. M. (1996). *Creativity in Context*. Westview Press, Inc.

Anthony, K. H. (1991). *Design Juries on Trial: The renaissance of the design studio*. Van Nostrand Reinhold.

Atkinson, S. (2000). Does the need for high levels of performance curtail the development of creativity in design and technology project work? *International Journal of Technology and Design Education*, *10*(3), 255–281. https://doi.org/10.1023/A:1008904330356

Baer, M., & Brown, G. (2012a). Blind in one eye: How psychological ownership of ideas affects the types of suggestions people adopt. *Organizational Behavior and Human Decision Processes*, *118*(1), 60–71. https://doi.org/10.1016/j.obhdp.2012.01.003

Baer, M., & Brown, G. (2012b). Blind in one eye: How psychological ownership of ideas affects the types of suggestions people adopt. *Organizational Behavior and Human Decision Processes*, *118*(1), 60–71. https://doi.org/10.1016/j.obhdp.2012.01.003

Bakker, A. (2018). *Design Research in Education: A Practical Guide for Early Career Researchers* (1st edition). Taylor & Francis Ltd.

Barlex, D. (2007). Creativity in school design & technology in England: a discussion of influences. *International Journal of Technology and Design Education*, *17*(2), 149–162. https://doi.org/10.1007/s10798-006-0006-x

Baynes, K. (2010). Models of Change: The Future of Design Education. *Design and Technology Education*, *15*(3), 10–17.

Benson, C., & Lawson, S. (Eds.). (2017). *Teaching Design and Technology Creatively* (1st edition). Routledge.

Benson, C., & Lunt, J. (2011). We're Creative on a Friday Afternoon: Investigating Children's Perceptions of their Experience of Design & Technology in Relation to Creativity. *Journal of Science Education and Technology*, *20*(5), 679–687. https://doi.org/10.1007/s10956-011-9304-5

Black, P., & Wiliam, D. (1998). Assessment and Classroom Learning. In *Assessment in Education: Principles, Policy & Practice* (Vol. 5, Issue 1). https://doi.org/10.1080/0969595980050102

Blom, N., & Bogaers, A. (2018). Using Linkography to investigate students' thinking and information use during a STEM task. *International Journal of Technology and Design Education*, *0123456789*. https://doi.org/10.1007/s10798-018-9489-5

Boud, D., & Molloy, E. (2013). Rethinking models of feedback for learning: the challenge of design. *Assessment & Evaluation in Higher Education*, *38*(6), 698–712. https://doi.org/10.1080/02602938.2012.691462

Bunce, L., Baird, A., & Jones, S. E. (2017). The student-as-consumer approach in higher education and its effects on academic performance. *Studies in Higher Education*, *42*(11), 1958–1978. https://doi.org/10.1080/03075079.2015.1127908

Cardella, M. E., Buzzanell, P. M., Cummings, A., Tolbert, D., & Zoltowiski, C. B. (2014). A Tale of Two Design Contexts : Quantitative and Qualitative Explorations of Student-Instructor Interactions Amidst Ambiguity. *DTRS 10: Design Thinking Research Symposium*. https://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=1038&context=dtrs

Cardoso, C., Badke-Schaub, P., & Eris, O. (2016). Inflection moments in design discourse: How questions drive problem framing during idea generation. *Design Studies*, *46*, 59–78. https://doi.org/10.1016/j.destud.2016.07.002

Cardoso, C., Eris, O., Badke-schaub, P., & Aurisicchio, M. (2014). Question asking in design reviews: how does inquiry facilitate the learning interaction? *Design Thinking Research Symposium*.

Carless, D. (2015). Exploring learning-oriented assessment processes. *Higher Education*, *69*(6), 963–976. https://doi.org/10.1007/s10734-014-9816-z

Carless, D., & Boud, D. (2018). The development of student feedback literacy: enabling uptake of feedback. *Assessment and Evaluation in Higher Education*, *43*(8), 1315–1325. https://doi.org/10.1080/02602938.2018.1463354

Carless, D., & Chan, K. K. H. (2017). Managing dialogic use of exemplars. *Assessment & Evaluation in Higher Education*, *42*(6), 930–941. https://doi.org/10.1080/02602938.2016.1211246

Chi, M. T. H. (1997). Quantifying Qualitative Analyses of Verbal Data: A Practical Guide. *The Journal of the Learning Sciences*, *6*(3), 271–315. https://www.jstor.org/stable/1466699

Colfer, C. (2017). Exploratory and Dialogic Talk and Creative Learning. In C. Benson & S. Lawson (Eds.), *Teaching Design and Technology Creatively* (pp. 98–113). Routledge.

Craft, A. (2002). *Creativity and Early Years Education: A lifewide foundation* (1st edition). Continuum

Crilly, N. (2015). Fixation and creativity in concept development: The attitudes and practices of expert designers. *Design Studies*, *38*, 54–91. https://doi.org/10.1016/j.destud.2015.01.002

Crilly, N., & Cardoso, C. (2016). Where next for research on fixation, inspiration and creativity in design? Findings from an international workshop. *Design Studies*, *0*, 1–38. https://doi.org/10.1016/j.destud.2017.02.001

Cropley, A. J., & Urban, K. K. (2000). Programs and strategies for nurturing creativity. In K. A. Heller, F. J. Monks, R. F. Subotnik, & R. J. Sternberg (Eds.), *International handbook of giftedness and talent* (pp. 481–494). Elsevier. https://doi.org/10.1016/B978-008043796-5/50034-6

Cropley, D., & Cropley, A. (2010). Recognizing and fostering creativity in technological design education. *International Journal of Technology and Design Education*, *20*(3), 345–358. https://doi.org/10.1007/s10798-009-9089-5

Csikszentmihalyi, M. (1999). *CREATIVITEIT: Over flow, schepping en ontdekking (Dutch edition)* (3rd edition). Uitgeverij Boom.

Cummings, A., Tolbert, D., Zoltowiski, C. B., Cardella, M. E., & Buzzanell, P. M. (2015). A Quantitative Exploration of Student-Instructor Interactions Amidst Ambiguity. In R. S. Adams & J. A. Siddiqui (Eds.), *Analyzing Design Review Conversations* (pp. 395–412). Purdue University Press.

Daly, S. R., & Yilmaz, S. (2015). Directing Convergent and Divergent Activity through Design Feedback. In R. S. Adams & J. A. Siddiqui (Eds.), *Analyzing Design Review Conversations* (pp. 413–429). Purdue University Press.

Dannels, D. P., Gaffney, A., & Martin, K. (2008). Beyond Content, Deeper than Delivery: What Critique Feedback Reveals about Communication Expectations in Design Education. *International Journal for the Scholarship of Teaching and Learning*, *2*(2). https://doi.org/10.20429/ijsotl.2008.020212

Dannels, D. P. (2005). Performing Tribal Rituals: A Genre Analysis of “Crits” in Design Studios. *Communication Education*, *54*(2), 136–160. https://doi.org/10.1080/03634520500213165

Dannels, D. P. (2011). Relational Genre Knowledge and the Online Design Critique: Relational Authenticity in Preprofessional Genre Learning. *Journal of Business and Technical Communication*, *25*(1), 3–35. https://doi.org/10.1177/1050651910380371

Dannels, D. P., Gaffney, A. L. H., & Martin, K. N. (2011). Students’ talk about the climate of feedback interventions in the critique. *Communication Education*, *60*(1), 95–114. https://doi.org/10.1080/03634523.2010.487111

Dannels, D. P., & Martin, K. N. (2008). Critiquing critiques: a genre analysis of feedback design studios. *Journal of Business and Technical Communication*, *22*(2), 135–159.

Dorst, K. (2003). *Understanding Design*. BIS Publishers.

Dorst, K., & Cross, N. (2001a). Creativity in the design process: co-evolution of problem-solution. *Design Studies*, *22*, 425–437.

Dorst, K., & Cross, N. (2001b). Creativity in the design process, convolution of problem-solution. *Design Studies*, *22*, 425–437. https://doi.org/10.1016/S0142-694X(01)00009-6

Duncker, K. (1945). On problem-solving. *Psychological Monographs*, *58*(5), i–113.

Dweck, C. S. (2016). *Mindset: the new psychology of success*. Ballantine Books.

Eris, O. (2004). *Effective Inquiry for Innovative Engineering Design*. Kluwer Academic Publishers.

Finke, R. A., Ward, T. B., & Smith, S. M. (1992). *Creative Cognition: Theory, Research and Application*. MIT Press.

Fox-Turnbull, W. (2016). The nature of primary students' conversation in technology education. *International Journal of Technology and Design Education*, *26*(1), 21–41. https://doi.org/10.1007/s10798-015-9303-6

Fox-Turnbull, W. (2018). Classroom Interaction in Technology Education. In M. J. de Vries (Ed.), *Handbook of Technology Education* (1st ed., pp. 551–566). Springer International Publishing.

Glaser, B. G. (2008). Conceptualization: On theory and theorizing using grounded theory. *International Journal of Qualitative Methods*, *1*(2), 23–38. https://doi.org/10.1103/Physics.3.106

Glaser, B., & Strauss, A. (1967). *The Discovery of Grounded Theory*. Aldine Publishing Company.

Goldschmidt, G. (2014). *Linkography: Unfolding the Design Process*. MIT Press.

Goldschmidt, G. (2016). Linkographic Evidence for Concurrent Divergent and Convergent Thinking in Creative Design. *Creativity Research Journal*, *28*(2), 115–122. https://doi.org/10.1080/10400419.2016.1162497

Goldschmidt, G., Casakin, H. P., Avidan, Y., & Ronen, O. (2015). Three studio critiquing cultures: Fun follows function or function follows fun ? *Anlayzing Design Review Conversations*, 455–480. https://doi.org/10.5703/1288284315933

Goldschmidt, G., Hochman, H., & Dafni, I. (2010). The design studio crit: Teacher-student communication. *Artificial Intelligence for Engineering Design, Analysis and Manufacturing: AIEDAM*, *24*(3), 285–302. https://doi.org/10.1017/S089006041000020X

Gravett, K. (2020). Feedback literacies as sociomaterial practice. *Critical Studies in Education*, *00*(00), 1–14. https://doi.org/10.1080/17508487.2020.1747099

Gray, C. M. (2013a). Factors That Shape Design Thinking. *Design and Technology Education: An International Journal*, *18*(3), 8–20.

Gray, C. M. (2013b). Informal peer critique and the negotiation of habitus in a design studio. *Art, Design & Communication in Higher Education*, *12*(2), 195–209. https://doi.org/10.1386/adch.12.2.195_1

Greven, J., & Letschert, J. (2006). Kerndoelen Primair Onderwijs. *Ministerie van Onderwijs, Cultuur En Wetenschap*, 1–84.

Guilford, J. (1987). Creativity research: Past, present and future. *Frontiers of Creativity Research*, 33–65.

Guilford, J. P. (1956). The Structure of Intellect. *Psychological Bulletin*, *53*, 267–293.

Guilford, J. P. (1962). Factors that aid and hinder creativity. *Teachers College Record*, *63*, 380–392.

Guilford, J. P. (1967). *The Nature of Human Intelligence*. McGraw-Hill.

Hattie, J., & Timperley, H. (2007). The Power of Feedback. *Review of Educational Research*, *77*(1), 81–112. https://doi.org/10.3102/003465430298487

Healy, J. P. (2016). The Components of the "Crit" in Art and Design Education. *Irish Journal of Academic Practice*, *5*(1), 0–17. http://arrow.dit.ie/ijap%0Ahttp://arrow.dit.ie/ijap/vol5/iss1/7

Higgins, R., Hartley, P., & Skelton, A. (2001). Getting the Message Across: The problem of communicating assessment feedback. *Teaching in Higher Education*, *6*(2), 269–274. https://doi.org/10.1080/13562510120045230

Hokanson, B. (2012). The Design Critique as a Model for Distributed Learning. In *The Next Generation of Distance Education* (pp. 71–83). Springer US. https://doi.org/10.1007/978-1-4614-1785-9_5

Howard, T., Culley, S., & Dekoninck, E. (2007). Creativity in the Engineering Design Process. *Proceedings of ICED 2007, the 16th International Conference on Engineering Design*, *Vol. DS 42*.

Howard, T. J., Culley, S. J., & Dekoninck, E. (2008). Describing the creative design process by the integration of engineering design and cognitive psychology literature. *Design Studies*, *29*(2), 160–180. https://doi.org/10.1016/j.destud.2008.01.001

Howard-Jones, P. A. (2002). A dual-state model of creative cognition for supporting strategies that foster creativity in the classroom. *International Journal of Technology and Design Education*, *12*(3), 215–226. https://doi.org/10.1023/A:1020243429353

Isaksen, S. G., Dorval, B. K., & Treffinger, D. J. (2010). *Creative Approaches to Problem Solving: A Framework for Innovatin and Change* (3rd edition). SAGE Publications.

Isaksen, S. G., & Treffinger, D. J. (2004). Celebrating 50 years of reflective practice: Versions of creative problem solving. *Journal of Creative Behavior*, *38*(2), 75–101. https://doi.org/10.1002/j.2162-6057.2004.tb01234.x

Jansson, D. G., & Smith, S. M. (1991). Design Fixation. *Design Studies*, *12*(1), 3–11.

Keirl, S. (2007). Critiquing in a democratics of Design and Technology Education. In J. R. Dakers, W. J. Dow, & M. J. De Vries (Eds.), *Proceedings Pupils Attitutes Towards Technology (PATT 18)* (Issue June, pp. 306–312). Faculty of Education, University of Glasgow.

Keirl, S. (2017). Critiquing as Design and Technology Curriculum Journey: History, Theory Politics and Potential. In P. J. Williams & K. Stables (Eds.), *Critique in Design and Technology Education* (1st ed., pp. 109–134). Springer Singapore.

Klapwijk, R. (2017). Creativity in Design. In C. Benson & S. Lawson (Eds.), *Teaching Design and Technology Creatively* (pp. 51–72). Routledge.

Klapwijk, R., & Holla, E. (2018). *Leidraad onderzoekend en ontwerpend leren*.

Lawson, B. (2006). *How Designers Think: The design process demystified* (4th edition). Architectural Press, Elsevier.

Lazonder, A. W., & Harmsen, R. (2016). Meta-Analysis of Inquiry-Based Learning: Effects of Guidance. *Review of Educational Research*, *86*(3), 681–718. https://doi.org/10.3102/0034654315627366

Leenknecht, M. J. M., & Prins, F. J. (2018). Formative peer assessment in primary school: the effects of involving pupils in setting assessment criteria on their appraisal and feedback style. *European Journal of Psychology of Education*, *33*(1), 101–116. https://doi.org/10.1007/s10212-017-0340-2

Lewis, T. (2005). *Creativity — A Framework for the Design/Problem Solving Discourse in Technology Education*. *17*(1), 35–52.

Lewis, T. (2009). Creativity in technology education: providing children with glimpses of their inventive potential. *International Journal of Technology and Design Education*, *19*(3), 255–268. https://doi.org/10.1007/s10798-008-9051-y

Linsey, J. S., Tseng, I., Fu, K., Cagan, J., Wood, K. L., & Schunn, C. (2010). A Study of Design Fixation, Its Mitigation and Perception in Engineering Design Faculty. *Journal of Mechanical Design*, *132*(4), 041003. https://doi.org/10.1115/1.4001110

Luo, Y. (2015). Design Fixation and Cooperative Learning in Elementary Engineering Design Project: A Case Study. *International Electronic Journal of Elementary Education*, *8*(1), 601–613. http://search.ebscohost.com/login.aspx?direct=true&db=eue&AN=110195040&site=ehost-live

McConlogue, T. (2015). Making judgements: investigating the process of composing and receiving peer feedback. *Studies in Higher Education*, *40*(9), 1495–1506. https://doi.org/10.1080/03075079.2013.868878

McDonald, J. K., & Michela, E. (2019). The design critique and the moral goods of studio pedagogy. *Design Studies*, *62*, 1–35. https://doi.org/10.1016/j.destud.2019.02.001

McDonald, J. K., Rich, P. J., & Gubler, N. B. (2019). The Perceived Value of Informal, Peer Critique in the Instructional Design Studio. *TechTrends*, *63*(2), 149–159. https://doi.org/10.1007/s11528-018-0302-9

McDonnell, J. (2016). Scaffolding practices: A study of design practitioner engagement in design education. *Design Studies*, *45*, 9–29. https://doi.org/10.1016/j.destud.2015.12.006

McLean, A. J., Bond, C. H., & Nicholson, H. D. (2015a). An anatomy of feedback: a phenomenographic investigation of undergraduate students' conceptions of feedback. *Studies in Higher Education*, *40*(5), 921–932. https://doi.org/10.1080/03075079.2013.855718

McLean, A. J., Bond, C. H., & Nicholson, H. D. (2015b). An anatomy of feedback: a phenomenographic investigation of undergraduate students' conceptions of feedback. *Studies in Higher Education*, *40*(5), 921–932. https://doi.org/10.1080/03075079.2013.855718

McLellan, R., & Nicholl, B. (2009). "If i was going to design a chair, the last thing i would look at is a chair": Product analysis and the causes of fixation in students' design work 11-16 years. *International Journal of Technology and Design Education*, *21*(1), 71–92. https://doi.org/10.1007/s10798-009-9107-7

McLellan, R., & Nicholl, B. (2013). Creativity in crisis in Design & Technology: Are classroom climates conducive for creativity in English secondary schools? *Thinking Skills and Creativity*, *9*, 165–185. https://doi.org/10.1016/j.tsc.2012.11.004

McLellan, R., & Nicholl, B. (2013). Creativity in crisis in Design & Technology: Are classroom climates conducive for creativity in English secondary schools? *Thinking Skills and Creativity*, *9*, 165–185. https://doi.org/10.1016/j.tsc.2012.11.004

Mercer, N., & Littleton, K. (2014). *Dialogue and the Development of Children's Thinking: A sociocultural approach*. Routledge. https://doi.org/10.4324/9780203946657

Mioduser, D., & Kipperman, D. (2002). Evaluation/Modification Cycles in Junior High Students' Technological Problem Solving. *International Journal of Technology and Design Education*, *12*, 123–138.

Molloy, E., Boud, D., & Henderson, M. (2020). Developing a learning-centred framework for feedback literacy. *Assessment & Evaluation in Higher Education*, *45*(4), 527–540. https://doi.org/10.1080/02602938.2019.1667955

Moreno, D. P., Yang, M. C., Hernández, A. A., Linsey, J. S., & Wood, K. L. (2015). A Step Beyond to Overcome Design Fixation: A Design-by-Analogy Approach. In *Design Computing and Cognition '14* (pp. 607–624). Springer International Publishing. https://doi.org/10.1007/978-3-319-14956-1_34

Nicholl, B. (2004). Teaching and Learning Creativity. *International Research Conference*, 1–8.

Nicholl, B., & McLellan, R. (2007a). "Oh yeah, yeah you get a lot of love hearts. The year 9s are notorious for love hearts. Everything is love hearts." Fixation in pupils' design and technology work (11-16 years). *Design and Technology Education: An International Journal*, *12*(1), 34–44.

Nicholl, B., & McLellan, R. (2007b). The contribution of Product analysis to Fixation in Students' Design and Technology Work. *Linking Learning: DATA International Research Conference 2007*, 71–76. https://dspace.lboro.ac.uk/dspace/handle/2134/3315

Nicholl, B., & McLellan, R. (2008). 'We're all in this game whether we like it or not to get a number of As to Cs., Design and technology teachers' struggles to implement creativity and performativity policies. *British Educational Research Journal*, *34*(5), 585–600. https://doi.org/10.1080/01411920802223875

Nicol, D., Thomson, A., & Breslin, C. (2014). Rethinking feedback practices in higher education: a peer review perspective. *Assessment & Evaluation in Higher Education*, *39*(1), 102–122. https://doi.org/10.1080/02602938.2013.795518

Oak, A. (2000). It's a Nice Idea, but it's not actually Real: Assessing the Objects and Activities of Design. *International Journal of Art and Design Education*, *19*(1), 86–95.

O'Donovan, B., Price, M., & Rust, C. (2004). Know what I mean? Enhancing student understanding of assessment standards and criteria. *Teaching in Higher Education*, *9*(3), 325–335. https://doi.org/10.1080/1356251042000216642

O'Donovan, B., Rust, C., & Price, M. (2016). A scholarly approach to solving the feedback dilemma in practice. *Assessment & Evaluation in Higher Education*, *41*(6), 938–949. https://doi.org/10.1080/02602938.2015.1052774

Oh, Y., Ishizaki, S., Gross, M. D., & Yi-Luen Do, E. (2013). A theoretical framework of design critiquing in architecture studios. *Design Studies*, *34*(3), 302–325. https://doi.org/10.1016/j.destud.2012.08.004

Panadero, E. (2016). Is it safe? Social, interpersonal, and human effects of peer assessment: A review and future directions. In *Handbook of Human and Social Conditions in Assessment* (Issue July 2016, pp. 247–266).

Pitt, E. (2019). Operationalising Dialogic Feedback to Develop Students' Evaluative Judgement and Enactment of Feedback. In *The Impact of Feedback in Higher Education* (pp. 129–146). Springer International Publishing. https://doi.org/10.1007/978-3-030-25112-3_8

Purcell, A. T., & Gero, J. S. (1996). Design and other types of fixation. *Design Studies*, *17*(4 SPEC. ISS.), 363–383. https://doi.org/10.1016/S0142-694X(96)00023-3

Richards, R. (2010). Everyday Creativity. In J. C. Kaufman & R. J. Sternberg (Eds.), *The Cambridge Handbook of Creativity* (pp. 189–215). Cambridge University Press. https://doi.org/10.1017/CBO9780511763205.013

Robinson, K. (2006). Do schools kill creativity? In *https://www.ted.com/talks/sir_ken_robinson_do_schools_kill_creativity?language=en*. TED Conferences.

Robinson, S., Pope, D., & Holyoak, L. (2013). Can we meet their expectations? Experiences and perceptions of feedback in first year undergraduate students. *Assessment & Evaluation in Higher Education*, *38*(3), 260–272. https://doi.org/10.1080/02602938.2011.629291

Robson, C., & McCartan, K. (2015). Flexible designs. In *Real World Research* (4th editionn). Athenaeum.

Rutland, M., & Barlex, D. (2008). Perspectives on pupil creativity in design and technology in the lower secondary curriculum in England. *International Journal of Technology and Design Education*, *18*, 139–165. https://doi.org/10.1007/s10798-007-9024-6

Sadler, D. R. (2010). Beyond feedback: Developing student capability in complex appraisal. *Assessment and Evaluation in Higher Education*, *35*(5), 535–550. https://doi.org/10.1080/02602930903541015

Sater-Black, K., & Iversen, N. (1994, March). How to conduct a design review. *Mechanical Engineering*, 89–92.

Schut, A., & Blom, N. (2019). Exploring the nature of young learners ' convergent thinking during. In S. Pule & M. de Vries (Eds.), *37th International Pupils' Attitudes Towards Technology Conference: Developing a knowledge economy through technology and engineering education* (Issue June, pp. 389–397). University of Malta.

Schut, A., Doorn, F. Van, & Klapwijk, R. (2017). CREATIVITY IN CHILDREN'S DESIGN PROCESSES: IDENTIFYING INDICATORS OF DESIGN FIXATION. *Engineering & Product Design Education, Proceedings 2017*, *September*.

Schut, A., Klapwijk, R., Gielen, M., & de Vries, M. J. (2019). Children's Responses to Divergent and Convergent Design Feedback. *Design and Technology Education: An International Journal*, *24*(2), 67–89. https://ojs.lboro.ac.uk/DATE/article/view/2611

Schut, A., Klapwijk, R., Gielen, M., van Doorn, F., & de Vries, M. (2019). Uncovering early indicators of fixation during the concept development stage of children's design processes. *International Journal of Technology and Design Education*. https://doi.org/10.1007/s10798-019-09528-2

Schut, A., van Mechelen, M., Klapwijk, R. M., Gielen, M., & de Vries, M. J. (2020). Towards constructive design feedback dialogues: guiding peer and client feedback to stimulate children's creative thinking. *International Journal of Technology and Design Education*, *0123456789*. https://doi.org/10.1007/s10798-020-09612-y

Scott, G., Leritz, L. E., & Mumford, M. D. (2004). The Effectiveness of Creativity Training: A Quantitative Review. *Creativity Research Journal*, *16*(4), 361–388.

Simonton, D. K. (2010). Creativity in Highly Eminent Individuals. In J. C. Kaufman & R. J. Sternberg (Eds.), *The Cambridge Handbook of Creativity* (pp. 174–188). Cambridge University Press. https://doi.org/10.1017/CBO9780511763205.012

Sio, U. N., Kotovsky, K., & Cagan, J. (2015). Fixation or inspiration? A meta-analytic review of the role of examples on design processes. *Design Studies*, *39*, 70–99. https://doi.org/10.1016/j.destud.2015.04.004

Smith, C. (2011). Understanding Students' Views of the Crit Assessment Understanding Students' Views of the Crit Assessment. *Journal for Education in the Built Environment*, *6*(1), 44–67. https://doi.org/10.11120/jebe.2011.06010044

Smith, S. M. (1995). Fixation, Incubation, and Insight in Memory and Creative Thinking. In Smith, T. B. Ward, & R. A. Finke (Eds.), *The Creative Cognition Approach* (pp. 135–156). Massachusetts Institute of Technology.

Smith, S. M. (2003). The Constraining Effects of Initial Ideas. In P. B. Paulus & B. A. Nijstad (Eds.), *Group Creativity: Innovation Through Collaboration* (pp. 15–31). Oxford University Press.

Smith, S. M., Ward, T. B., & Schumacher, J. S. (1993). Constraining effects of examples in a creative generation task. *Memory & Cognition*, *21*(6), 837–845. https://doi.org/10.3758/BF03202751

Sowden, P. T., Pringle, A., & Gabora, L. (2015). The shifting sands of creative thinking: Connections to dual-process theory. *Thinking and Reasoning*, *21*(1), 40–60. https://doi.org/10.1080/13546783.2014.885464

Stables, K., Kimbell, R., Wheeler, T., & Derrick, K. (2016). Lighting the blue touch paper: Design talk that provokes learners to think more deeply and broadly about their project work. *PATT-32: Technology Education for 21st Century Skills*.

Sutton, P. (2012). Conceptualizing feedback literacy: knowing, being, and acting. *Innovations in Education and Teaching International*, *49*(1), 31–40. https://doi.org/10.1080/14703297.2012.647781

Tai, J., Ajjawi, R., Boud, D., Dawson, P., & Panadero, E. (2017). Developing evaluative judgement: enabling students to make decisions about the quality of work. *Higher Education*, *76*(3), 467–481. https://doi.org/10.1007/s10734-017-0220-3

Tai, J. H.-M., Canny, B. J., Haines, T. P., & Molloy, E. K. (2016). The role of peer-assisted learning in building evaluative judgement: opportunities in clinical medical education. *Advances in Health Sciences Education*, *21*(3), 659–676. https://doi.org/10.1007/s10459-015-9659-0

Tassoul, M. (2009). *Creative Facilitation* (3rd edition). VSSD.

Thijs, A., Fisser, P., & Hoeven van der, M. (2014). *21e Eeuwse Vaardigheden in Het Curriculum Van Het Funderend Onderwijs*.

Thijs, A., Fisser, P., & van der Hoeven, M. (2014). *21e eeuwse vaardigheden in het curriculum van het funderend onderwijs: een conceptueel kader*.

To, J. (2016). 'This is not what I need': conflicting assessment feedback beliefs in a post-secondary institution in Hong Kong. *Research in Post-Compulsory Education*, *21*(4), 447–467. https://doi.org/10.1080/13596748.2016.1226588

Tolbert, D. A., & Daly, S. R. (2013). First-Year Engineering Student Perceptions of Creative Opportunities in Design. *International Journal of Engineering Education*, *29*(4), 879–890.

Van Boeijen, A., Daalhuizen, J., & Zijlstra, J. (Eds.). (2020). Skillful Co-Design. In *Delft Design Guide* (pp. 34–35). BIS Publishers.

Van Boeijen, A. G. C., Daalhuizen, J. J., Zijlstra, J. J. M., & van der Schoor, R. S. A. (2013). *Delft Design Guide*. BIS Publishers.

Van den Akker, J., Gravemeijer, K., McKenney, S., & Nieveen, N. (Eds.). (2006). *Educational Design Research* (1st edition). Routledge.

Van Dooren, E., Boshuizen, E., van Merriënboer, J., Asselbergs, T., & van Dorst, M. (2020). Making the Design Process in Design Education Explicit: Two Exploratory Case Studies. *Design and Technology Education*, *25*(1).

Van Graft, M., Klein Tank, M., & Bakker, T. (2014). *Wetenschap en Technologie in het basis-en speciaal onderwijs*.

Van Loon, M., & van de Pol, J. (2019). Judging own and peer performance when using feedback in elementary school. *Learning and Individual Differences*, *74*. https://doi.org/10.1016/j.lindif.2019.101754

Van Mechelen, M. (2016). *Designing Technologies For and With Children: Theoretical Reflections and Practical Inquiry Towards a Co-Design Toolkit* [KU Leuven - U Hasselt]. https://doi.org/10.1017/CBO9781107415324.004

Van Mechelen, M., Laenen, A., Zaman, B., Willems, B., & Abeele, V. Vanden. (2019). Collaborative Design Thinking (CoDeT): A co-design approach for high child-to-adult ratios. *International Journal of Human Computer Studies*, *130*(January 2018), 179–195. https://doi.org/10.1016/j.ijhcs.2019.06.013

Van Mechelen, M., Schut, A., Gielen, M., & Klapwijk, R. (2018). Developing Children' s Empathy in Co-Design Activities: A Pilot Case Study. *Proceedings of the 17th ACM Conference on Interaction Design and Children - IDC '18*, 669–674. https://doi.org/10.1145/3202185.3210797

Van Mechelen, M., Schut, A., Gielen, M., & Södergren, A. C. (2019). Children's Assessment of Co-design Skills: Creativity, Empathy and Collaboration. *Proceedings of the Interaction Design and Children on ZZZ - IDC '19*, *June*, 520–526. https://doi.org/10.1145/3311927.3325334

Van Mechelen, M., Zaman, B., Laenen, A., & Vanden Abeele, V. (2015). Challenging group dynamics in participatory design with children: Lessons from social interdependence theory. *Proceedings of IDC 2015: The 14th International Conference on Interaction Design and Children*, 219–228. https://doi.org/10.1145/2771839.2771862

Vasconcelos, L. A., & Crilly, N. (2016). Inspiration and fixation: Questions, methods, findings, and challenges. *Design Studies*, *42*, 1–32. https://doi.org/10.1016/j.destud.2015.11.001

Viswanathan, V., & Linsey, J. (2011). Design Fixation in Physical Modeling: An Investigation on the Role of Sunk Cost. *23rd International Conference on Design Theory and Methodology; 16th Design for Manufacturing and the Life Cycle Conference*, 119–130. https://doi.org/10.1115/DETC2011-47862

Voerman, L., Korthagen, F. A. J., Meijer, P. C., & Simons, R. J. (2014). Feedback revisited: Adding perspectives based on positive psychology. Implications for theory and classroom practice. *Teaching and Teacher Education*, *43*, 91–98. https://doi.org/10.1016/j.tate.2014.06.005

Ward, T. B. (1994). Structured Imagination:the Role of Category Structure in Exemplar Generation. In *Cognitive Psychology* (Vol. 27, Issue 1, pp. 1–40). https://doi.org/10.1006/cogp.1994.1010

Wetenschapsknooppunt Zuid-Holland. (n.d.). *www.ontwerpenindeklas.nl*.

Wiliam, D. (2017). *Embedded Formative Assessment* (2nd edition). Solution Tree Press.

Williams, P. J., & Stables, K. (Eds.). (2017). *Critique in Design and Technology Education* (1st ed.). Springer Singapore. https://doi.org/10.1007/978-10-3106-9

Wood, D., & Kurzel, F. (2008). Engaging students in reflective practice through a process of formative peer review and peer assessment. *ATN Assessment 08: Engaging Students with Assessment*. https://doi.org/10.21913/ATNA.v1i1.376

Yang, M., & Carless, D. (2013). The feedback triangle and the enhancement of dialogic feedback processes. *Teaching in Higher Education*, *18*(3), 285–297. https://doi.org/10.1080/13562517.2012.719154

Yilmaz, S., & Daly, S. R. (2014). Influences of feedback interventions on student concept generation and development practices. *DTRS 10: Design Thinking Research Symposium Design Thinking Research Symposium*.

Yilmaz, S., & Daly, S. R. (2016). Feedback in concept development: Comparing design disciplines. *Design Studies*, *45*, 137–158. https://doi.org/10.1016/j.destud.2015.12.008

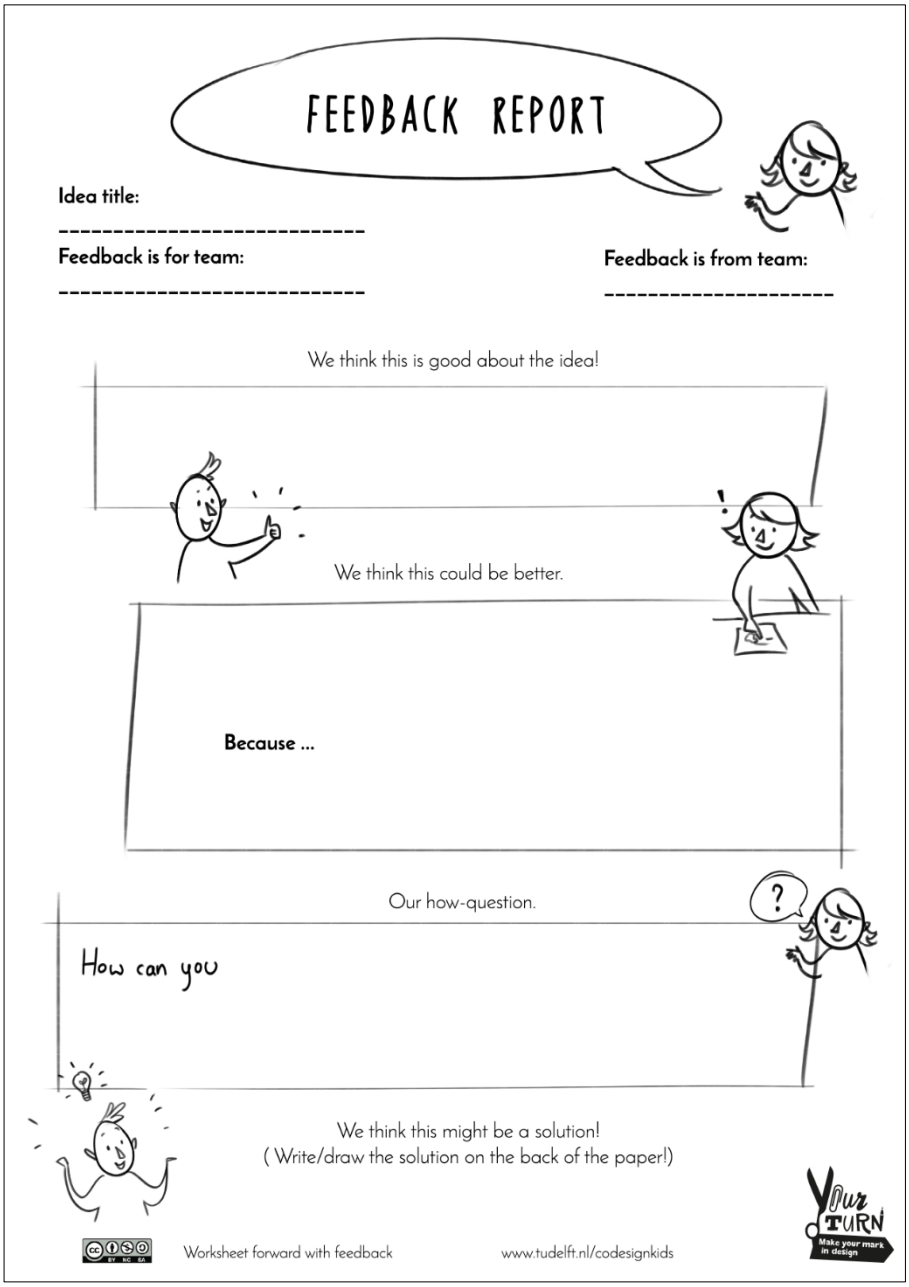
Yin, R. K. (2014). *Case Study Research: Design and Methods* (5th edition). SAGE Publications, Inc.

Youmans, R. J. (2011). The effects of physical prototyping and group work on the reduction of design fixation. *Design Studies*, *32*(2), 115–138. https://doi.org/10.1016/j.destud.2010.08.001

Appendixes

Appendix 1

Design feedback form for written feedback developed through the peer feedback intervention presented in *Chapters 4* and *5*.



Summary

Creativity is sought after and treasured in numerous domains. Within primary education, creativity is also progressively seen as a skill of great value. Schools want to foster creativity in their classrooms but often have difficulty implementing it in their curriculum and harnessing the creative talent of their pupils. Design-related subjects can offer opportunities to encourage and develop pupils' creative abilities, as it is an inherently creative activity. Even though designing can bring many creative opportunities to the classroom, there are also various obstacles. A key issue is the occurrence of a type of design fixation, which creates an (unconscious) adherence to the current state of the design. This adherence is generally unfavourable, as it stagnates pupils' creative processes and hampers the development of the design. The feedback exchanges within the classroom can provide opportunities for the early identification of this type of design fixation. Additionally, design feedback appears to be a promising avenue to explore ways of supporting pupils in mitigating this type of fixation.

In this dissertation, we aim to understand the interplay between design feedback and pupils' creative thinking processes to develop and test feedback interventions that stimulate these processes and thereby help mitigate pupils' design fixation. The following main research question was formulated: *Which qualities of design feedback processes stimulate pupils' creative thinking and mitigate their design fixation in the concept development stage of the design process?* To answer the research questions, we implemented an educational design research approach consisting of three contrasting cases and four studies over the course of three years. Qualitative methods enabled us to 'look inside the black box' and understand how, why and when things happened and worked. The goal was to first diagnose the unguided situation and uncover critical problems that hamper the pupils' creative thinking processes, then develop and research a (feedback) intervention to tackle these problems.

In the first study presented in *Chapter 2*, we aimed to uncover ways in which pupils' design fixation could be identified during their design process instead of in hindsight. This early identification was made through the analysis of verbal design feedback exchanges taking place within the classroom. The following research question guided the study: *What are early indicators of design fixation within pupils' design feedback exchanges, and how can they be identified?* To answer this research question, a case was carried out with a class of primary school pupils from a school in the Netherlands who participated in a co-design project through a series of design sessions. The analysis of the feedback dialogues in this study revealed that it is indeed possible to signal pupils' fixation on their design ideas in the conversations held in the classroom through the resistance they show towards the feedback given. Four categories of response behaviours indicating this type of fixation - i.e. concept fixation - were uncovered during our analysis: 'band-aids', 'already taken care of', 'it is not possible', and 'question not relevant'. In later chapters, another response behaviour was found named 'it's you'. All of these resistance responses allow the designing pupils to keep the core characteristics of their idea

intact and unchanged, leaving them fixated on the current state of their design idea. The study illustrates how the occurrence of concept fixation stagnated pupils' creative thinking by hampering the continuous alternation of divergent and convergent thinking processes. Specifically, their lack of critical evaluation left sub-problems within their design ideas hidden and discarded the need for new generative processes.

The second study presented in *Chapter 3* aimed to further understand the occurrence of pupils' design fixation by investigating the unguided design feedback exchanges in more detail. The goal was to gain insight into the interplay between the design feedback given by the client and peers and the direct responses of the pupils to diagnose factors hindering their creative thinking. The study was guided by the following research question: *What is the convergent and divergent nature of the design feedback given by the client and peers, and what are the pupils' direct responses in an unguided situation?* The data from the first case was re-used. To determine the divergent or convergent nature of the design feedback and the different types of direct responses, a *Design Feedback Model* and a *Direct Responses Model* were constructed through the adaptation and extension of existing models. In short, the study showed that, within unguided design feedback exchanges, the divergent or convergent nature of the feedback does not necessarily evoke the expected concurrent responses and thinking processes. This means that divergent feedback questions do not necessarily evoke generative thoughts, and convergent feedback questions do not necessarily evoke evaluative thoughts. Resistance responses to the feedback were widespread. The pupils frequently rejected feedback immediately instead of temporarily accepting it to explore its merit.

Based on the results and insights of the studies mentioned above, an intervention was developed to investigate how the guidance of design feedback exchanges could (re-)stimulate pupils' creative thinking, thereby mitigating the occurrence of design fixation. In the third study presented in *Chapter 4*, three principles were investigated that focussed on shaping the construction and delivery of divergent and convergent feedback to support the feedback givers and the receivers. The following research question guided the study: *In what way does the peer feedback intervention influence the convergent and divergent nature of the design feedback given by the clients and peers and the concurrent direct responses of the pupils?* To answer the research question, two cases were carried out with two classes of primary school pupils from two schools in the Netherlands participating in co-design projects through a series of design sessions. The analysis of the third study was similar to the second study and used the models developed there as a starting point. The results demonstrated how the different types of guidance could support the pupils, their peers, and clients in engaging in constructive and valuable feedback dialogues. Several successes were uncovered during the analysis, showing how the intervention was able to (1) guide towards a shared understanding of the design, (2) stimulate cognitive modelling, (3) encourage an initial calmness towards feedback, and (4) evoke deep reasoning responses, i.e. responses indicating divergent and convergent thinking. Based on our findings, we proposed a set of revised principles for constructive design feedback

dialogues, intending to stimulate pupils' creative thinking: (1) continuously guide towards a shared understanding through low-level questions, especially before posing high-level feedback, (2) emphasise positive aspects of the design through specific and concrete compliments, (3) stimulate reflective, evaluative and generative thoughts through alternating and iterating high-level divergent and convergent feedback, and (4) repeatedly provide a way forward, thereby fostering improvement, by posing high-level divergent feedback.

The fourth study, presented in *Chapter 5*, aimed at understanding how the intervention could support the pupils' creative thinking processes beyond the initial direct responses within the guided feedback dialogues. Within this study, the investigated intervention principles focussed on supporting the pupils in their process of feedback uptake in consecutive design activities (and stimulating them to take an active role in these processes). The focus lay on supporting four key elements that were determined to be essential within the process of design feedback uptake: (1) appreciating feedback and understanding its value, (2) maintaining an emotional balance to encourage openness towards feedback, (3) developing an evaluative judgement, and (4) taking action through consecutive design activities. To support these four elements, the intervention was based on three key principles concluded from the literature review: (1) Create a learning environment which allows for and caters to design feedback utilisation, (2) implement high-quality peer feedback, and (3) provide explicit guidance through the process of receiving feedback, while enabling autonomy. The study was guided by the following research question: *In what way does the peer feedback intervention enable pupils in their process of design feedback uptake?* The goal was to gain insight into the extent to which the intervention could support the pupils in their process of feedback uptake. To answer the research question, data from design activities and post-interviews of the second and third cases were analysed. The study showed that guiding design feedback processes can support pupils in (1) showcasing openness, (2) developing a feeling for quality, (3) (re)starting their creative thinking processes, (4) understanding the improvement-effect feedback can bring, and (5) taking an active role in the feedback process. We strongly believe that its success cannot be attributed to a single principle and depends on the conjunction of all three (and perhaps more). Although refinements to the implementation of the principles can be made, they provide a solid first step in guiding toward valuable and constructive design feedback processes.

Through the four studies presented in this dissertation, we gained understanding and practical know-how on the early identification of design fixation in the concept development stage of design processes and the nurturing of pupils' creative thinking through the use of design feedback. In answering the main research question, a set of principles was developed and tested throughout the studies within this dissertation. Although refinements to the implementation of these principles can be made, we conclude that they provide a concrete first step towards the creation of pedagogical and didactic strategies that aim to encourage valuable and constructive design feedback processes. Furthermore, this dissertation showcases the complexity of design feedback processes and sets itself apart by not only looking at the

feedback exchanges with a great level of detail, but the entire feedback process. This detailed analysis highlighted the complexity within these processes even stronger, leading to the conclusion that the use of design feedback within an educational context appears to not be something that can be left unattended and learned 'in the wild'. Ultimately, guidance combined with training can benefit pupils' creative design process immensely.

The research presented in this dissertation is explorative, detailed, and small-scale. The implemented design research approach and qualitative nature enabled us to 'look inside the black box' and investigate design feedback exchanges and the process of design feedback uptake in detail. This research shows that looking at design feedback processes in detail is valuable, as it allows for a deeper understanding of its complexity. Follow-up research is desirable to further develop the current collection of indicators and models, continue the investigation and improvement of the proposed key principles, and explore the relevance of these outcomes for other design education contexts. Subsequent research efforts within primary design education could help build on the models of design feedback, direct responses, and process of design feedback uptake (see *Figures 10, 11, and 13*). Implementing this research set up with a larger and different set of primary schools might lead to additional, yet-to-be-discovered, types of feedback questions, comments, and responses. Additionally, the process model on design feedback uptake is expected to be detailed further. Building on these successes, future research efforts could investigate how the pupils' actions possibly evolve into capacities and dispositions when trained over a more extended period. Here, the process model could be used as a starting point and be refined and translated into a model for design feedback literacy.

The studies in this dissertation generate recommendations for teacher practice, teacher education and professionalisation, and policymakers regarding primary (design) education. For teachers, several practical principles and guidelines are presented to help achieve valuable and constructive design feedback processes within a primary school classroom. They provide a concrete means to support pupils' creative thinking while designing and help mitigate their design fixation - see www.tudelft.nl/codesignkids (English version) and www.tudelft.nl/yourturn (Dutch version). We advise teachers to try and adapt these principles and guidelines within their classrooms to help give support in these complex processes. Here, we see an essential role for teacher educators in supporting teachers in successfully implementing these guided design feedback practices in their classrooms. To emulate the successes presented in these studies, ample resources and support must be dedicated to teacher education and professionalisation. Dutch policymakers and educators (e.g. PO-Raad and Stichting Leerplan Ontwikkeling) generally recognise and emphasise the potential of design-related subjects in primary schools. However, systematic promotion of design subjects is lacking, as well as comprehensive support for schools and teachers. We aim to alert policymakers of this potential and persuade them to take further action. After all, we do not want to educate our future generations out of creativity.

Samenvatting

Creativiteit wordt op tal van gebieden nagestreefd en gewaardeerd. Ook in het basisonderwijs wordt creativiteit steeds meer gezien als een waardevolle vaardigheid. Scholen willen creativiteit in hun klas stimuleren, maar vinden het echter vaak lastig om dit goed in hun lesprogramma tot recht te laten komen. Het creatieve talent van hun leerlingen wordt daardoor niet altijd volledig benut. Ontwerp-vakken kunnen mogelijkheden bieden om de creatieve vaardigheden van leerlingen aan te moedigen en te ontwikkelen. Ontwerpen is namelijk een inherent creatieve activiteit. Hoewel ontwerpen creativiteit in de klas kan aanmoedigen, zijn er ook verschillende obstakels. Een belangrijk obstakel is het optreden van een specifiek type ontwerpfixatie: concept-fixatie. Wanneer dit type fixatie optreedt, ontstaat er een (onbewuste) gehechtheid aan de huidige staat van het ontwerp. Dit type gehechtheid is over het algemeen ongunstig, omdat het de creatieve processen van de leerlingen stagneert en de ontwikkeling van het ontwerp belemmert. De feedback-dialogen die plaatsvinden in de klas, kunnen mogelijkheden bieden om dit soort ontwerpfixatie vroegtijdig te identificeren. Bovendien lijkt uitwisselen van ontwerpfeedback een veelbelovende manier om dit type fixatie te verminderen bij leerlingen.

Dit proefschrift richt zich op het begrijpen van de wisselwerking tussen ontwerpfeedback en de creatieve denkprocessen van leerlingen, om feedback-interventies te ontwikkelen en te testen die deze denkprocessen stimuleren en ontwerpfixatie helpen verminderen. De volgende onderzoeksvraag werd geformuleerd: *Welke kwaliteiten van ontwerpfeedbackprocessen stimuleren het creatief denken van leerlingen en verminderen hun ontwerpfixatie in de conceptontwikkelingsfase van het ontwerpproces?* Om de onderzoeksvraag te beantwoorden werd een zogenaamde ‘educational design research approach’ toegepast. Deze aanpak bestond uit een reeks van drie contrasterende cases en vier studies over een periode van drie jaar. Er werden kwalitatieve methoden gebruikt om zo in de ‘black box’ te kunnen kijken en te begrijpen hoe, waarom en wanneer iets gebeurde en werkte. Het doel was om eerst te kijken naar een situatie zonder begeleiding om zo problemen bloot te leggen, die de creatieve denkprocessen van de leerlingen belemmeren. Vervolgens werd een (feedback)interventie ontwikkeld en onderzocht om deze problemen aan te pakken.

De eerste studie wordt gepresenteerd in hoofdstuk 2. Deze studie richtte zich op het blootleggen van de ontwerpfixatie van leerlingen tijdens hun ontwerpproces in plaats van achteraf. Deze vroegtijdige identificatie gebeurde door de analyse van de feedback gesprekken in de klas. De volgende onderzoeksvraag stuurde deze studie: *Wat zijn vroege indicatoren van ontwerpfixatie binnen de feedbackdialogen van leerlingen en hoe kunnen deze worden geïdentificeerd?*

Om de onderzoeksvraag te beantwoorden werd een case uitgevoerd met een klas basisschoolleerlingen in Nederland, waarbinnen ze deelnamen aan een reeks ontwerpsessies

rondom een co-design project. Uit de analyse van de feedbackdialogen bleek, dat het inderdaad mogelijk is de ontwerpfixatie van leerlingen richting hun ontwerpideeën vroegtijdig te signaleren. De fixatie werd zichtbaar door de weerstand die de leerlingen tonen richting de gegeven feedback. Vier categorieën van reacties die op dit type fixatie - d.w.z. concept-fixatie - duiden, kwamen tijdens onze analyse aan het licht: 'pleisters', 'al geregeld', 'het is niet mogelijk', en 'vraag niet relevant'. In latere hoofdstukken werd nog een ander type reactiegedrag gevonden, namelijk 'het ligt aan jou'. Al deze weerstandsreacties stellen de ontwerpende leerlingen in staat om de kern van hun idee intact en onveranderd te houden, waardoor ze gefixeerd blijven op de huidige staat van hun ontwerpidee. De studie illustreert hoe het optreden van concept-fixatie het creatieve denken van de leerlingen stagneerde, door de voortdurende afwisseling van divergente en convergente denkprocessen te belemmeren. Met name door hun gebrek aan kritische evaluatie, bleven sub-problemen binnen de leerlingen, hun ontwerpideeën verborgen en werd de noodzaak van nieuwe generatieve processen terzijde geschoven.

In de tweede studie, die in hoofdstuk 3 wordt gepresenteerd, wordt de uitwisseling van ontwerpfeedback nader onderzocht om beter begrip te krijgen voor de ontwerpfixatie van de leerlingen. Het doel was om inzicht te krijgen in de wisselwerking tussen de ontwerpfeedback, die door de opdrachtgever en medeleerlingen wordt gegeven en de directe reacties van de leerlingen. Specifiek de reacties die op weerstand duiden en mogelijk hun creatief denken belemmeren. De onderzoeksvraag was als volgt: *Wat is de convergente en divergente aard van de feedback gegeven door de opdrachtgever en medeleerlingen en wat zijn de directe reacties van de leerlingen in een situatie zonder begeleiding?* De gegevens van de eerste case werden opnieuw gebruikt. Om de divergente of convergente aard van de ontwerpfeedback en de verschillende soorten directe reacties te bepalen, werd een Design Feedback Model en een Direct Responses Model geconstrueerd door aanpassing en uitbreiding van bestaande modellen. De analyse toonde aan, dat binnen niet-begeleide feedback uitwisselingen, de divergente of convergente aard van de feedback niet noodzakelijkerwijs de verwachte reacties en denkprocessen oproept. Dit betekent dat divergente feedbackvragen niet direct generatieve gedachten oproepen en convergente feedbackvragen niet direct evaluatieve gedachten. Weerstandsreacties op de feedback waren alom aanwezig. De leerlingen verwerpen de feedback vaak onmiddellijk, in plaats van deze eerst tijdelijk te accepteren om de waarde ervan te onderzoeken.

Op basis van de resultaten en inzichten van de bovengenoemde studies, werd een interventie ontwikkeld om te onderzoeken hoe de begeleiding van ontwerpfeedback het creatieve denken van de leerlingen (opnieuw) zou kunnen stimuleren en zo het optreden van ontwerpfixatie zou kunnen verminderen. In de derde studie, gepresenteerd in hoofdstuk 4, werden drie principes onderzocht die gericht waren op het begeleiden van de opbouw en levering van divergente en convergente feedback om zo de feedbackgevers en -ontvangers te ondersteunen. De studie werd gestuurd door de volgende onderzoeksvraag: *Op welke manier*

beïnvloedt de peer feedback interventie de convergente en divergente aard van de feedback gegeven door de opdrachtgevers en medeleerlingen en de gelijktijdige directe reacties van de leerlingen? Om de onderzoeksvraag te beantwoorden, werden twee cases uitgevoerd met twee klassen basisschoolleerlingen van twee scholen in Nederland. Via een reeks aan ontwerpsessies namen zij deel aan co-design projecten. De analyse van deze studie was vergelijkbaar met de tweede studie en de ontwikkelde modellen werden nogmaals gebruikt als uitgangspunt. De resultaten toonden aan hoe de verschillende soorten begeleiding, de leerlingen hun medeleerlingen en opdrachtgevers konden ondersteunen bij het aangaan van constructieve en waardevolle feedbackdialogen. Tijdens de analyse kwamen verschillende successen aan het licht, waaruit bleek hoe de interventie in staat was om (1) te begeleiden naar een gedeeld begrip van het ontwerp, (2) 'cognitive modelling' te stimuleren, (3) een aanvankelijke kalmte ten aanzien van feedback aan te moedigen, en (4) diepere redeneer-reacties op te roepen, d.w.z. reacties die wijzen op divergent en convergent denken. Op basis van deze bevindingen werd een reeks herziene principes voor constructieve feedbackdialogen voorgesteld, bedoeld om het creatieve denken van de leerlingen te stimuleren. Deze principes zijn: (1) voortdurend sturen naar een gedeeld begrip van het ontwerp door middel van zogenaamde 'low-level' vragen, vooral vóór het geven van zogenaamde 'high-level' feedback, (2) positieve aspecten van het ontwerp benadrukken door middel van specifieke en concrete complimenten, (3) reflectieve, evaluatieve en generatieve gedachten stimuleren door afwisselend en iteratief divergente en convergente 'high-level' feedback te geven en (4) herhaaldelijk te wijzen op opties voor het doorontwikkelingen van het ontwerp, om zo verbetering te bevorderen en divergente 'high-level' feedback te geven.

De vierde studie, gepresenteerd in hoofdstuk 5, had tot doel te begrijpen hoe de interventie het creatieve denkproces van de leerlingen verder kon ondersteunen. Verder dan de eerste directe reacties van leerlingen tijdens de begeleide feedbackdialogen. Binnen dit onderzoek richtten de onderzochte interventieprincipes zich op het ondersteunen van de leerlingen, terwijl ze aan de slag gingen met de feedback bij de opeenvolgende ontwerpactiviteiten (en het stimuleren van een actieve rol van de leerlingen in deze processen). De focus lag op het ondersteunen van vier elementen die essentieel zijn voor het opnemen van ontwerpfeedback: (1) feedback waarderen en de waarde ervan inzien, (2) een emotioneel evenwicht bewaren om openheid voor feedback te houden, (3) een evaluatief oordeel ontwikkelen en (4) actie ondernemen vanuit de feedback via opeenvolgende ontwerpactiviteiten. Om dit te bereiken was de interventie gebaseerd op de drie hoofdprincipes die uit het literatuuronderzoek naar voren kwamen: (1) een leeromgeving creëren die het gebruik van ontwerpfeedback mogelijk maakt en daarop inspeelt, (2) hoogwaardige peer feedback implementeren, (3) het proces van feedback ontvangen, expliciet begeleiden en tegelijkertijd autonomie bewaken. De volgende onderzoeksvraag stond centraal: *Op welke manier maakt de peer feedback interventie, het proces van opname van ontwerpfeedback mogelijk voor leerlingen?* Het doel was om inzicht te krijgen in de mate waarin de interventie in

staat was om de leerlingen te ondersteunen in hun proces van feedback-opname. Om de onderzoeksvraag te beantwoorden zijn specifieke ontwerpactiviteiten en post-interviews van de tweede en derde case geanalyseerd. De analyse toonde aan dat het begeleiden van ontwerpfeedbackprocessen de leerlingen kan ondersteunen bij (1) het tonen van openheid, (2) het ontwikkelen van een gevoel voor kwaliteit, (3) het (her)starten van hun creatieve denkprocessen, (4) het begrijpen van het verbeteringseffect, dat feedback kan opleveren en (5) het nemen van een actieve rol in het feedbackproces. Wij zijn ervan overtuigd dat het succes van de interventie niet kan worden toegeschreven aan één bepaald principe en afhankelijk is van de combinatie van alle drie (en misschien meer). Hoewel de toepassing van de principes kan worden verfijnd, vormen ze een overtuigende eerste stap in de richting van waardevolle en constructieve ontwerpfeedbackprocessen.

Door de vier studies hebben we inzicht en praktische kennis verworven over de vroege identificatie van ontwerpfixatie en het stimuleren van het creatieve denken van leerlingen door middel van ontwerpfeedback. Het beantwoorden van de hoofdonderzoeksvraag heeft geleid tot een reeks principes die ontwikkeld en getest zijn binnen de studies in dit proefschrift. Hoewel de toepassing van deze principes kan worden verfijnd, concluderen we dat ze een concrete eerste stap vormen naar de ontwikkeling van pedagogische en didactische strategieën ter bevordering van waardevolle en constructieve ontwerpfeedbackprocessen. Dit proefschrift laat de complexiteit van ontwerpfeedbackprocessen zien en onderscheidt zich door niet alleen zeer gedetailleerd te kijken naar specifieke feedback uitwisselingen, maar zelfs het gehele feedbackproces mee te nemen. Deze gedetailleerde analyse benadrukt de complexiteit binnen deze processen en concludeert dat het gebruik van ontwerpfeedback binnen een onderwijscontext niet iets is dat 'in het wild' geleerd kan worden. Uiteindelijk kan begeleiding en training van ontwerpfeedback het creatieve ontwerpproces van leerlingen enorm ten goede komen.

Het onderzoek dat in dit proefschrift wordt gepresenteerd is exploratief, gedetailleerd en kleinschalig. Door de wijze waarop de studies zijn uitgevoerd en het kwalitatieve karakter, konden we in de ‘black box’ kijken, wat ervoor zorgde dat de feedback uitwisselingen en het proces van ontwerpfeedback-opname in detail onderzocht konden worden. Dit onderzoek toont aan dat het in detail bekijken van ontwerpfeedbackprocessen waarde heeft en het benadrukt de complexiteit van deze processen. Vervolgonderzoek is wenselijk om de huidige verzameling indicatoren en modellen verder te ontwikkelen, het onderzoek en de verbetering van de voorgestelde sleutelprincipes voort te zetten en de relevantie van deze resultaten voor andere type ontwerponderwijs te onderzoeken. We sturen hierbij om voort te bouwen op de modellen van ontwerpfeedback, directe reacties en het proces van ontwerpfeedback-opname (zie figuren 10, 11 en 13). Toepassing van de huidige onderzoeksopzet binnen een grotere groep basisscholen zou kunnen leiden tot aanvullende, nog te ontdekken soorten feedbackvragen, opmerkingen en reacties. Bovendien wordt verwacht dat het procesmodel voor de opname van ontwerpfeedback verder kan worden uitgewerkt. Voortbouwend op deze successen zouden

toekomstige studies kunnen nagaan hoe het omgaan met ontwerpfeedback zich mogelijk kan ontwikkelen tot capaciteiten en disposities bij de leerlingen, wanneer ze hier over een langere periode mee aan de slag gaan. Met het procesmodel als uitgangspunt zouden deze capaciteiten en disposities mogelijk worden vertaald in een model voor feedbackgeletterdheid specifieke voor de ontwerpcontext.

De studies in dit proefschrift genereren ook aanbevelingen voor de leraren praktijk, lerarenopleiding, professionalisering en beleidsmakers met betrekking tot primair (ontwerp)onderwijs. Voor leerkrachten worden verschillende praktische principes en richtlijnen gepresenteerd om waardevolle en constructieve ontwerpfeedbackprocessen te realiseren binnen een basisschoolklas. Deze principes en richtlijnen bieden een concreet middel om het creatieve denken van leerlingen tijdens het ontwerpen te ondersteunen en hun ontwerpfixatie te verminderen - zie www.tudelft.nl/codesignkids (Engelse versie) en www.tudelft.nl/yourturn (Nederlandse versie). Wij adviseren leerkrachten om deze principes en richtlijnen in hun klas uit te proberen en vooral ook aan te passen binnen hun eigen context. We hopen zo enige ondersteuning te bieden voor het omgaan met complexe ontwerpfeedback processen. Verder zien we een belangrijke rol voor lerarenopleiders in het ondersteunen van leraren bij het succesvol implementeren van deze principes en richtlijnen binnen hun klas. Om de successen uit deze studies te evenaren, moeten voldoende middelen en ondersteuning worden uitgetrokken voor lerarenopleidingen en professionalisering. Nederlandse beleidsmakers en opleiders (bijv. PO-Raad en Stichting Leerplan Ontwikkeling) erkennen en benadrukken in het algemeen, het potentieel van ontwerpvakken in het basisonderwijs. Systematische promotie van ontwerp-vakken ontbreekt echter, evenals uitgebreide ondersteuning voor scholen en leraren. Wij willen beleidsmakers op dit potentieel wijzen en hen ertoe bewegen verdere actie te ondernemen. We willen onze toekomstige generaties immers niet zonder creativiteit opvoeden.

Acknowledgements

Although writing a dissertation might seem like a solitary undertaking, I would have never been able to reach these final words alone.

First and foremost, I want to thank my co-promotor and daily supervisor. Remke, thank you for the freedom and trust you have given me during this research adventure. Your mind, full of never-ending ideas and associations, might have caused some chaos initially, but it also showed me how explorative, creative, and exciting research can be. You have always been there for me when I needed help and guidance. And above all, you let me be free to make my own choices and craft my own story.

Next, I want to thank my promotor Marc for supporting this wonderful experience. Marc, thank you for your calming presence, trust, and wisdom. You have helped me move forward when I got stuck on the details and encouraged me to zoom out and see the bigger picture. Thank you as well for your guidance and help.

I would not have been able to complete this work without all the other researchers connected to the 'Co-Design with Kids' research project. Special thanks to my direct colleagues Fenne, Mathieu, and Maarten. Fenne, thank you for all the great advice and sparring sessions. This dissertation would not have been the same without our endless coffee dates and lunch meetings. Mathieu, thank you for your interesting perspectives, critical eye, and detailed feedback. I have valued your input a lot throughout these years. Maarten, thank you for sharing your knowledge and experience. I cannot thank you all enough for the heartwarming welcome into the world of doing research.

A big thank you to the participating schools, pupils, teachers, and clients. Without you, this research would simply not have been possible. I especially want to thank the participating pupils for their excitement to participate, positive energy, openness, and thought-provoking reflections. You have taught me more than I could have ever imagined.

While working in my office in Delft, I was able to connect with many colleagues and fellow PhD'ers. It was a pleasure to work alongside you and share my thoughts and ideas.

By attending conferences, I have had the opportunity to meet a myriad of inspiring fellow researchers. I want to thank those whom I've connected with for your interest and support. A special thanks to my dear newfound friend. Niekie, I don't think you realise how much you have influenced my work. You have not only been a dedicated soundboard, always ready to share your knowledge and ideas, but also a great friend. Thank you for welcoming me so openly into your life, and I hope we get to do a research project together soon.

Although they say you shouldn't judge a book by its cover, it doesn't hurt to make it look its best. Thank you, Joost, for creating not one but seven beautiful and enchanting illustrations to make to story of my research come to life. It is more than I could have ever

imagined, and I feel so lucky to have a friend like you. Liz, I want to thank you as well for the creative energy and time you have put into designing this lovely layout. You have helped make my playful, yet slightly gloomy children's book vision come to life.

Last but not least, I want to thank my parents, partner, and friends for always supporting me in this sometimes seemingly never-ending yet fascinating journey. You might not have always understood what I was doing, but you always showed interest and encouraged me when I most needed it.

Curriculum Vitae

EDUCATION

MASTER'S DEGREE, Media Technoloy

2012 — 2015 | Leiden University

- Master programme combining science, technology, and art.
- Thesis on divergent thinking tests

Electives, Design for Interaction

2013 — 2014 | Delft University of Technology

- Product Use, Understanding & Experience
- Interactive Technology Design

EXPERIENCE

Lecturer & Researcher

Aug 2020 — now | The Hague University of Applied Sciences

- Lecturer within the User Experience Design programme -international 3-year track of Communication & Multimedia Design (CMD)
- Member of the CMD Curriculum Committee – Co-creating the future direction of the programs & developing the vision on design feedback.
- Researcher within several research groups.

Postdoctoral Researcher

Jan 2020 — Aug 2020 | Leiden University

Short term position at the department of Science Communication & Society and Astronomy & Society. The research focused no broadening youth participation in STEMlearning through (co-)design lessons.

PHD Candidate

Jan 2016 — now | Delft University of Technology

In my research I aimed at understanding the interplay between design feedback and pupils' creative thinking processes to develop and test peer feedback interventions that stimulate these thinking processes and mitigate design fixation.

Teacher and Project manager ICT & Innovation

Aug 2015 — Jan 2016 | SintLucas MBO, Endhoven

- Teaching and developing creativity related courses.
- Developing innovation projects for the future school building.

Museum Educator

May 2014 — Nov 2015 | Museum Boi jmans van Beuningen

Publications

Journal Articles

Schut, A., van Mechelen, M., Klapwijk, R., Gielen, M., De Vries, M.J. (2020). Towards constructive design feedback dialogues: guiding peer and client feedback to stimulate children's creative thinking. International Journal of Technology and Design Education, 32, 99–127.

Schut, A., Klapwijk, R., Gielen, M., De Vries, M.J. (2019). Children's Responses to Divergent and Convergent Design Feedback. Design and Technology Education: An International Journal, 24(2), 67–89.

Schut, A., Klapwijk, R., Gielen, M., van Doorn, F., De Vries, M.J. (2019). Uncovering early indicators of fixation during the concept development stage of children's design processes. International Journal of Technology and Design Education, 30, 951–972.

Conference Proceedings

Schut, A., Van Mechelen, M., Klapwijk, R., Gielen, M., De Vries, M.J. (2020). Design Feedback that Stimulates Children's Creative Thinking: a Feedback Intervention. 38th International Pupils' Attitudes Towards Technology Conference. Techne Serien - Forskning I slöjdpedagogik Och slöjdvetenskap, 28(2), 128–139. Hämtad från

Schut, A., & Blom, N. (2019). Exploring the nature of young learners' convergent thinking during designing. 37th International Pupils' Attitudes Towards Technology Conference. University of Malta. pp. 389–397.

Van Mechelen, M., Schut, A., Gielen, M., Sodergren, A.C. (2019). Children's Assessment of Co-design Skills: Creativity, Empathy and Collaboration. 18th ACM International Conference on Interaction Design and Children (IDC). pp. 529-526.

Schut, A., Klapwijk, R., Gielen, M. (2018) Effects of Convergent and Divergent Feedback on Creative Thinking during Children's Design Processes. 36th International Pupils' Attitudes Towards Technology Conference. Athlone Institute of Technology. pp. 506–512.

Van Mechelen, M., Schut, A., Gielen, M., Klapwijk, R. (2018). Developing children's empathy in co-design activities: a pilot case study. 17th ACM International Conference on Interaction Design and Children (IDC). pp. 669-674.

Schut, A., Van Doorn, F. & Klapwijk, R. (2017). Creativity in children's design processes: identifying indicators of design fixation. International Conference on Engineering and product Design Education (E&PDE). pp 436-441.

Book Chapters

Schut, A. (forthcoming, 2022). Exploring the potential of feedback within the creative processes of a design and technology classroom. In Hardy, A. (Ed.), Debates in Design and Technology Education. (pp. -). Routledge, Taylor & Francis Group

Other

Contributor to perspective 'Skillful Co-design'. (2020). In Van Boeijen, A., Daalhuizen, J., & Zijlstra, J. (Eds.), Delft Design Guide: Perspectives, models, approaches, methods. (2nd ed.). (pp. 35). BIS Publishers.

Co-design tools for use within a primary school context - Choose your side, Inverse brainstorm, Picture brainstorm, Word brainstorm, Yes/No list, Choice-box, Traffic light rating, Forward with Feedback. www.tudelft.nl/codesignkids and www.tudelft.nl/yourturn