Design Feedback that Stimulates Children's Creative Thinking
A Feedback Intervention

Alice Schut, Maarten Van Mechelen, Remke Klapwijk, Mathieu Gielen and Marc J. de Vries

Designing is an inherently creative process in which divergent (generative) and convergent (evaluative) thinking drive the creation and development of a design. Nevertheless, navigating these creative thinking processes is not an easy endeavour, especially for young novice designers. In Design & Technology education, design feedback is often seen as an essential pedagogical tool to help guide novice designers' divergent and convergent paths while designing. Although design feedback can help the creative design process greatly, this does not happen by default. This paper reports on the construction and utilization of a design feedback intervention during a real-life design project with two groups of primary school children (aged 7-12). The goal of the intervention was to stimulate the young novice designers' creative thinking by guiding the design feedback dialogues with their peers and clients. It guides convergent and divergent design feedback to minimize the resistance towards the feedback and creates openness for new processes of reflection, evaluation, and generation. Our main contribution entails a detailed understanding of the successes and obstacles within the feedback dialogues, as guided by the new feedback intervention, and possible future improvements. Overall, the results show that the intervention can support young novice designers, their peers, and clients in engaging in constructive feedback dialogues, thereby stimulating their creative thinking.

Keywords: Design feedback, Divergent Thinking, Convergent Thinking, Design Fixation, Creative Thinking

Introduction

Designing is undoubtedly a creative activity (Barlex, 2007; Goldschmidt, 2014; Howard, Culley, & Dekoninck, 2007). When designing, children are confronted with ill-structured open-ended problems (Dorst, 2003; Lewis, 2005), for which no formula or single 'right' answer exists. Consequently, they are required to resort to creative thinking processes (Dorst & Cross, 2001).

However, behaving creatively does not always come naturally to children (Luo, 2015; McLellan & Nicholl, 2009; Nicholl & Mclellan, 2007). Creative thinking asks for a continuous shifting between divergent (generative) and convergent (evaluative) thinking processes (Goldschmidt, 2014, 2016; Guilford, 1967; Howard-Jones, 2002). Several different factors can easily stagnate this shifting. In the research project "Co-Design with Kids", we have observed these instances of stagnation first-handed during one of the case-studies with a group of primary school children. There, the instances of stagnation became visible through the responses of the children design teams during the design feedback dialogues with their peers and the clients (Schut, Klapwijk, Gielen, van Doorn, & de Vries, 2019a; Schut, Klapwijk, Gielen, & De Vries, 2019b).

In this paper, we report on the construction and use of a feedback intervention meant to stimulate constructive feedback dialogues between design teams of primary school children, their peers, and the clients while participating in a real-life design project.

Literature review

Feedback in design education

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). During these critiquing moments, 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, Ishizaki, Gross, & Yi-Luen Do, 2013). The feedback dialogues are often centred around improving and developing a design and can directly impact the divergent or convergent paths a novice designer might take (Cardoso, Eris, Badke-schaub, & Aurisicchio, 2014; Oh et al., 2013; Yilmaz & Daly, 2016).

Resistance towards design feedback

Design feedback is generally assumed to be beneficial to the creative design process (Crilly, 2015). However, the results of our previous case-studies show that children's creative thinking is not necessarily stimulated or enhanced by the feedback conversations. Instead, the children showed resistance towards the feedback and a lack of evaluative and generative thinking processes (Schut et al., 2019a). Multiple studies have observed similar results at a university level (ea. see Cardella, Buzzanell, Cummings, Tolbert, & Zoltowski, 2014; Cardoso et al., 2014; Cummings, Tolbert, Zoltowski, Cardella, & Buzzanell, 2015; Daly & Yilmaz, 2015; Yilmaz & Daly, 2014, 2016). Since we observed problems with receiving and constructing design feedback, we believe that guiding these processes can create new opportunities to stimulate and enhance the children's creative thinking while designing.

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). However, before posing high-level feedback, a shared understanding of the design needs to be reached (Schut et al., 2019b; Stables et al., 2016). Therefore, questions that ask for verification and clarification still appear to be a critical first step.

In conclusion, in order 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 primary guidelines for the construction of the new design feedback intervention.

We are interested in the influence of the design 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 questions: *What influence does the (peer)feedback intervention have on the convergent and divergent nature of the design feedback given by the client(s) and peers and the concurrent direct responses of the design teams?*

Research design

To answer the RQ, we utilized a design-based research approach, comprising a series of two case-studies over one year (Bakker, 2018; Van den Akker, Gravemeijer, McKenney, & Nieveen, 2006; Yin, 2014). During these case-studies, two groups of primary school children (ages 7-12) from two different schools were guided to design solutions for real-life design challenges. From each school, one classroom of children participated in the study. Table 1 gives an overview of the two case studies, which we will now name case A and case B.

Table 1. Overview of cases A and B.

	Case A	**Case B**
Education type	Montessori	Dalton
Participants	School class of 27 children (age 8-12), 7 design teams total, of which 4 selected for in-depth analysis	School class of 27 children (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: Design 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 children.	Adult representative: Head of the education department and manages the hospital's children's council. Child representatives: Final 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.

Design Sessions

During the two case studies, the design teams worked in their regular classroom on solving real-life design challenges presented to them by real clients. They were guided through the entire design project in six design sessions facilitated by the first and second author. The design activities were based on tools and methods from the CPS tradition (Isaksen, Dorval, & Treffinger, 2010; Tassoul, 2009), design tools from the Delft Design Guide (Boeijen van, Daalhuizen, Zijlstra, & Schoor van der, 2013) and lessons learned from previous research conducted by the authors. These lessons learned included, but are not limited to, the following topics: design fixation (Schut et al., 2019a), design feedback (Schut et al., 2019b), group dynamics (Van Mechelen, Zaman, Laenen, & Vanden Abeele, 2015), co-design processes (Van Mechelen, 2016; Van Mechelen, Laenen, Zaman, Willems, & Abeele, 2019), and children's design skills (Van Mechelen, Schut, Gielen, & Klapwijk, 2018; Van Mechelen, Schut, Gielen, & Södergren, 2019). Table 2 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).

Table 2: 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. Children 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

Design Feedback intervention

Overall, the goal of the feedback intervention was to support a constructive feedback dialogue that would stimulate the design teams' creative thinking and help prevent and/or overcome resistance. Since the focus of this study is on the feedback dialogues, the focus will lie on the implementation of the feedback intervention during the 4th and 6th design sessions. In those sessions, 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. 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. During the 6th design session, the facilitators utilized verbal prompts to remind the peers and clients of the structure of the feedback form. Table 3 gives a concise overview of the procedure.

Table 3: Overview of the procedure of the feedback intervention in the 4th and 6th design sessions of cases A and B. 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 feedback intervention.	A reminder of the intention and procedure of the feedback intervention.
Next parts form one turn per design team.		
Part 1. Guide towards a shared understanding of the design.	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. Stimulate critical reflection and evaluation of the design.	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. Provide a way to move forward by guiding new generative thoughts.	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.	

Data collection

During both case-studies, all design sessions were audio and video recorded as different researchers covered different research angles as part of the overarching research project. Due to the focus of the current study on the verbal feedback interactions, only the recordings of the 4th and 6th design sessions were selected for data analysis.

Data analysis

To analyse the data, we followed the Verbal Analysis approach (Chi, 1997). The transcriptions of the audio-video recordings of the interactions of the selected design teams during 4th and 6th design sessions during cases A and B 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. Within the units, pairs of feedback and response were formed.

Coding frameworks

To determine the nature of the feedback of the clients and the peers, Schut's Design Feedback Model was used, which is displayed in figure 1 (Schut et al., 2019). To determine the different types of direct responses of the design teams Schut's Direct Responses Model was used, which is displayed in figure 2 (Schut et al., 2019). When instances of feedback could not be coded with the models, additional codes were formed through inductive coding and added.
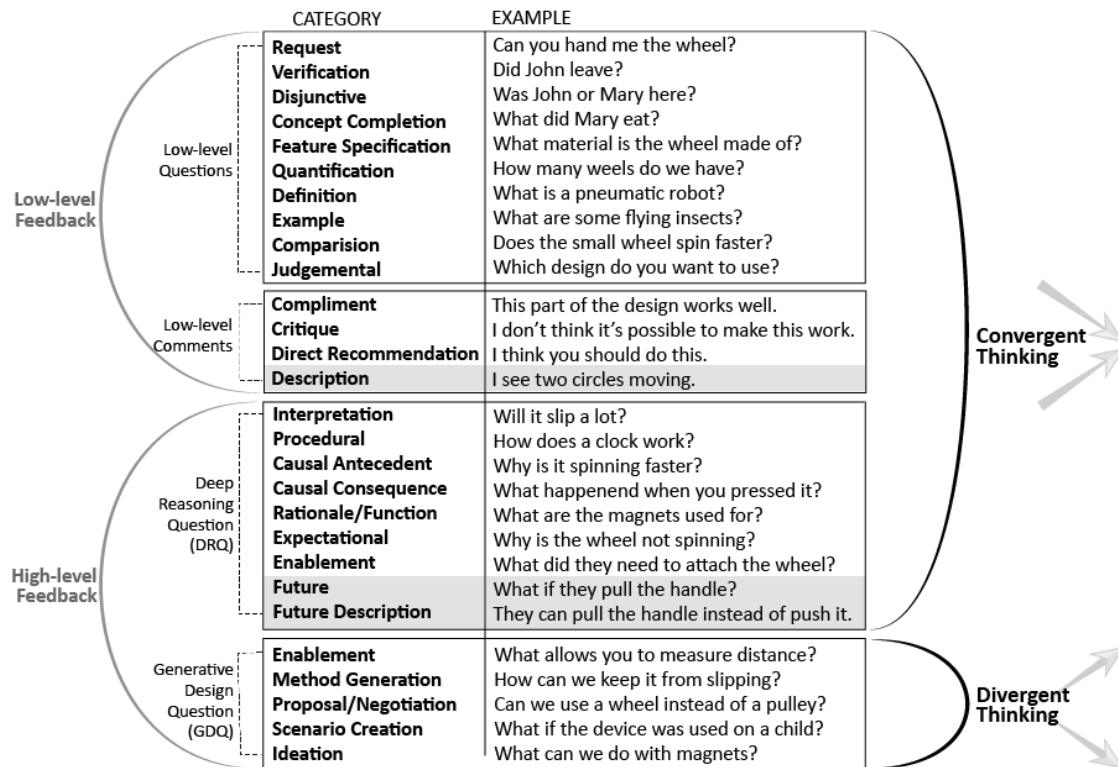
CATEGORY	EXAMPLE
Low-level Questions	
Request	Can you hand me the wheel?
Verification	Did John leave?
Disjunctive	Was John or Mary here?
Concept Completion	What did Mary eat?
Feature Specification	What material is the wheel made of?
Quantification	How many weels do we have?
Definition	What is a pneumatic robot?
Example	What are some flying insects?
Comparision	Does the small wheel spin faster?
Judgemental	Which design do you want to use?
Low-level Comments	
Compliment	This part of the design works well.
Critique	I don't think it's possible to make this work.
Direct Recommendation	I think you should do this.
Description	I see two circles moving.
Deep Reasoning Question (DRQ)	
Interpretation	Will it slip a lot?
Procedural	How does a clock work?
Causal Antecedent	Why is it spinning faster?
Causal Consequence	What happenend when you pressed it?
Rationale/Function	What are the magnets used for?
Expectational	Why is the wheel not spinning?
Enablement	What did they need to attach the wheel?
Future	What if they pull the handle?
Future Description	They can pull the handle instead of push it.
Generative Design Question (GDQ)	
Enablement	What allows you to measure distance?
Method Generation	How can we keep it from slipping?
Proposal/Negotiation	Can we use a wheel instead of a pulley?
Scenario Creation	What if the device was used on a child?
Ideation	What can we do with magnets?

Low-level Feedback · High-level Feedback · Convergent Thinking · Divergent Thinking

Figure 1. Design Feedback Model, based on Schut et al., (2019). 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 immediately 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 2. Direct Responses Model based on Schut et al., (2019). The responses highlighted in grey emerged in the current study.

Coding process

All of the created 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. To analyse coded data, tables were constructed with the code occurrences and code co-occurrences of cases A and B. These tables, together with the coded transcripts, were used as a means to interpret the data and look for patterns.

Findings

The following sections introduce the results of the qualitative analyses. Translated excerpts of the transcripts of the feedback dialogues are given to illustrate the results.

Fourth Design Session: Feedback Procedure 'Part 1'

Clarifying the design through low-level convergent feedback

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. As intend, the majority of the direct responses (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]
>
> Child: The answer, that number is how often you have to score (in the goal). [Report]

Besides *report* type responses, the low-level convergent questions in case A 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]
>
> Child: 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.

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 with the guidance of a feedback form. The DF of the clients and peers in both cases was generally in accordance with the structure of the feedback form. Almost all of the DRQs consisted of *future description*, which is one of the new feedback codes added to the model during analysis. As intended, almost all of the GDQs on the feedback forms consisted of *method generation* and *proposal/negotiation*. In both cases, the feedback forms read out-load by the clients and peers primarily co-occurred with the DR.

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

In this design session, only verbal prompts were used to guide the dialogues and all of the feedback parts (1,2 and 3) follow each other directly during each feedback conversation.

The peers' focus on convergence

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. However, the peers did not adhere to the order of the feedback form when posing high-level feedback in this session. Instead mainly convergent feedback was posed, with only a few instances of divergent feedback. The high-level convergent feedback (DRQs) of the

peers was varied in case A, while in case B the majority consisted of *future* and *future description*. In both cases, around half of the DRs consisted of report type responses, of which around half was *report justify*. Besides this, the DRQs of the peers were also met with resistance responses, especially *band-aids* and *question not relevant*. These responses imply that the design teams were not as open to the DRQs posed by the peers as to the DRQs by the clients.

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

Opposite to this, there were a few instances of deep reasoning responses, as illustrated in the example below. However, these types of DRs predominately occurred when a design team already displayed a certain level of openness in the feedback dialogue preceding the DRQs.

> 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]
>
> Child 1: Well, you also have pons, and there are also numbers on there. [Report]
>
> Child 2: Oh, yeah. Those (the pons) are not an uneven number. [Reflection]

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-rank? [Verification]
>
> Child 1: Yes, I guess so. [Confirm] [Insecure]
>
> Client: And this means that the ice-rank is there all year round? [Verification]
>
> Child 1: Yes. [Confirm]
>
> Child 2: It depends on if you want to ice-skate in the summer. [Reflection]
>
> (…)
>
> Client: So the ice-ring will be there permanently? [Verification]
>
> Child 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]
>
> Child 1: Maybe you can then also use it as a pool. [Ideation]

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.

Discussion and conclusion

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.

1. 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. 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 et al., 2019b; Stables et al., 2016).

2. The repeated occurrence of the high-level convergent feedback types *future* and *future description*, especially from peers, showcase the peers' ability to 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).

3. The primary direct response of the design teams to the reading out-loud of the feedback forms by 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 et al., 2019b; Schut et al., 2019a).

4. Through these reflective, evaluative, and generative responses, the teams showcased their willingness to further elaborate on and improve their design. These responses were often preceded by feedback of the clients of case B during the sixth design session. 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 design feedback intervention. Firstly, the clients repeatedly checked the shared understanding of the designs. Secondly, the clients almost solely constructed high-level divergent feedback, while only a few instances of high-level convergent feedback were observed. 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). Lastly, another possible contributor to this open atmosphere is the many compliments the clients shared when compared to their peers. Although the opinions on praise as an effective form of feedback for learners appear to vary (Hattie & Timperley, 2007; Voerman, Korthagen, Meijer, & Simons, 2014), our results show that in the context of design feedback dialogues it could encourage more openness with young novice designers.

To conclude, the results have shown that the (peer) feedback intervention is able to help direct the divergent and convergent nature of the feedback posed. The presented successes showcase how this directive ability positively influenced the children's initial responses towards the feedback, which makes a compelling case for why design feedback should be guided.

Future work

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-depth view of the influence design feedback can have on young novice designers' creative thinking.

Acknowledgments

References

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

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. https://ojs.lboro.ac.uk/DATE/article/view/1532

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

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. In *DTRS 10: Design Thinking Research Symposium*.

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? In *DTRS 10:Design Thinking Research Symposium*.

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://doi.org/10.1207/s15327809jls0603_1

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

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). West Lafayette, Indiana: 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). West Lafayette, Indiana: Purdue University Press.

Dannels, D., 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., & Martin, K. N. (2008). Critiquing critiques: a genre analysis of feedback design studios. *Journal of Business and Technical Communication*, *22*(2), 135–159. https://doi.org/10.1177/1050651907311923

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

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

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

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

Guilford, J. P. (1967). *The Nature of Human Intelligence*. New York: 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.

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

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

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

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

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.

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

Nicholl, Bill, & Mclellan, R. (2007). "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. https://ojs.lboro.ac.uk/DATE/article/view/Journal_12.1_RES3

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

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

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

Stables, K., Kimbell, R., Wheeler, T., Door, N. B., Derrick, K., & Assess, D. (2016). Lighting the blue touch paper: Design talk that provokes learners to think more deeply and broadly about their project work. In M. De Vries, A. Bekker-Holtland, & G. Van Dijk (Eds.), *32th International Pupils' Attitudes Towards Technology Conference: Technology Education for 21st Century Skills* (pp. 444–453).

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

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

Van Mechelen, M. (2016). *Designing Technologies For and With Children: Theoretical Reflections and Practical Inquiry Towards a Co-Design Toolkit*. KU Leuven - U Hasselt.

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. In *Proceedings of the 17th ACM Conference on Interaction Design and Children - IDC '18* (pp. 669–674).

Van Mechelen, M., Schut, A., Gielen, M., & Södergren, A. C. (2019). Children's Assessment of Co-design Skills: Creativity, Empathy and Collaboration. In *Proceedings of the Interaction Design and Children on ZZZ - IDC '19* (pp. 520–526). New York, New York, USA: ACM Press.

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.

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

Yilmaz, S., & Daly, S. R. (2014). Influences of feedback interventions on student concept generation and

development practices. In *DTRS 10: Design Thinking Research SymposiumDesign 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). Los Angeles: SAGE Publications, Inc.

Alice Schut is a PhD candidate at the Science Education and Communication group at Delft University of Technology. Her research focusses on how to encourage children's creative thinking through the guidance of design feedback processes. Furthermore, she is a lecturer at the User Experience Design program and researcher at the research group Innovation Networks, both at The Hague University of Applied Sciences.

Maarten Van Mechelen is a postdoctoral researcher at the Center for Computational Thinking & Design at Aarhus University in Denmark, specialised in the field of Child-Computer Interaction and, more specifically, the domains of Digital Design Literacy and Computational Empowerment. His current research focuses on how to support children's personal agency in a digitized society through learning activities that combine design and making with critical reflection on the ethical and societal impacts of emergent technologies, including the internet of things, augmented reality and artificial intelligence.

Remke Klapwijk is senior researcher at the Science Education and Communication Group, Delft University of Technology. She focuses on Creativity in Design Education and Formative Assessment and has published scientific and educational resources in this area. She is also leading partner in an international research project which aims to enhance the spatial ability of children and to help close the gender gap in STEAM learning (https://www.tudelft.nl/en/wetenschapsknooppunt/your-turn/ and https://sellstem.eu).

Mathieu Gielen is an Assistant Professor in Design for Children's Play at TU Delft's faculty of Industrial Design Engineering. He holds a Master's Degree in Industrial Design and founded a design studio focusing on products for children's play before returning to academia. His current research interests are participatory design practices with children and the application of psychological concepts in design for children's play.

Marc J. de Vries is professor of science and technology education and professor of (Christian) philosophy of technology at Delft University of Technology. He is the editor-in-chief of the International Journal of Technology & Design Education (Springer) and the series editor of the International Technology Education Studies book series (Bill/Sense).

Alice Schut is a PhD candidate at the Science Education and Communication group at Delft University of Technology. Her research focusses on how to encourage children's creative thinking through the guidance of design feedback processes. Furthermore, she is a lecturer at the User Experience Design program and researcher at the research group Innovation Networks, both at The Hague University of Applied Sciences.