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Effects of Convergent and Divergent Feedback on Creative Thinking During Children's Design Processes

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This paper explores patterns in the feedback preceding instances of design fixation in children (age 9 to 11) carrying out a co-design project. Our goal is to find ways to improve the early mastering of their divergent (DT) and convergent thinking (CT) skills, which in turn will help the children to develop their creative abilities. Previous research has shown that children who participate in a design process experience difficulty in adjusting, changing and elaborating previously selected design ideas. This dynamic is referred to as design fixation. In the case study presented here we analysed the feedback preceding the fixation moments of the children, using Eris's question-driven design model. We found that most of the feedback was convergent in nature and, additionally, that feedback that could be considered divergent did, for the most part, not spark any DT processes within the design teams. We presume that the expectations and assumptions that were implicitly present in the feedback has negatively influenced the possibility of any new DT processes. Based on the conclusions of this research we will explore new methods and tools stimulating divergent feedback in order to prevent and overcome design fixation during the children's design process.

Key Words: Divergent thinking, Convergent thinking, Design education, Feedback, Design fixation.

1. INTRODUCTION

In this paper, we describe an explorative case study in which we observed the development of the design ideas of a group of primary school children (age 9 to 11) carrying out a design project. In the first analysis round of this explorative case study Schut, Van Doorn & Klapwijk found that the children experienced difficulty in adjusting and elaborating previously selected design ideas, which stagnated the development of their design ideas; the children experienced design fixation at several moments during their design process (Schut, Doorn, Klapwijk, & Design, 2017). These fixation moments were observed through the response behaviour of the children during their conversations with the problem owner (the client), facilitators and peers. This response behaviour, indicating fixation moments, could ultimately be grouped into four categories: 'band-aids', 'already-in-there', 'question-not-relevant' and 'it's-not-possible'. Building on this, we will focus in this paper on identifying the type of feedback that the children received preceding those already identified fixation moments. The goal is to get a better understanding of the type of feedback that preceded those fixation moments and uncover possible feedback patterns. It is expected that with this knowledge, new interventions can be created for future design projects in primary schools, where feedback can be shaped in ways that contribute to the development of creativity.

2. LITERATURE REVIEW

In recent years, more and more focus is put on children's ability to behave creatively while taking part in design subjects like Design & Technology (D&T) (Benson & Lunt, 2011). To be able to behave creatively divergent (DT) and convergent thinking (CT) skills are needed (Cropley, 2006). DT entails the generation of novelty, which is commonly thought to go hand in hand with the ability to see many possible answers and interpretations to a problem or issue. CT entails the evaluation of this novelty, which deals with coming up with, or selecting, the 'best' answer to a problem or issue. The ability to separate and alternate between the two

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is considered extremely valuable when developing creative solutions (Guilford, 1967; Howard-Jones, 2002). The Creative Problem Solving (CPS) tradition shows that methods that strictly separate DT and CT modes by phasing them can benefit creative behaviour in the design process (Tassoul, 2009). As the amount of alternations of DT and CT increases, the design process becomes more sophisticated (Mioduser & Kipperman, 2002). Through this alternating process, the design ideas keep on developing. When an idea is being developed and problems arise, these problems need to get solved. This creates the need for new input in the form of ideas (DT) and this in turn leads to the selection of one of these ideas (CT) as the solution that will ultimately become part of the design idea.

Previous research has shown that it's not easy for children to develop their creativity in D&T education. This is due to various external reasons, like available teaching methods, teacher beliefs and examination requirements, and internal reasons, like the children's tendency to get fixated during their design process (Thijs, Fisser, & Hoeven van der, 2014; Nicholl & McLellan, 2008; McLellan & Nicholl, 2009; Nicholl & Mclellan, 2007). Fixation during the design process was first described by Jansson and Smith, which they refer to as design fixation. They describe it 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". Fixation can drive a designer to be stuck in a certain train of thought that does not produce its intended goal. Success in developing a design idea depends on abandoning this train of thought and generating alternative ones (Smith, 1995). Yet people are prone to think along the 'path-of-least-resistance' and therefore likely to form ideas from easily accessible pre-existing concepts from their memory and stick to them (Ward, 1994). Nicholl and McLellan researched the phenomenon of design fixation in secondary design and technology (D&T) students (Nicholl & McLellan, 2007; McLellan & Nicholl, 2009). They suggest that design fixation is widespread among the work of secondary D&T students.

When designing alone, or even in a team, it is easy to get lost in a specific train-of-thought due to the absence of external input. Different strategies can be used to enhance idea development and discourage fixation during the elaboration of the design. Among those are interventions that provide a form of feedback on the design: making a prototype, testing the prototype and receiving feedback from various stakeholders (Crilly, 2015). Feedback sessions, or design reviews, are a common educational practice in design disciplines at a university level to discuss the progress of a student's design project and to gather feedback (Goldschmidt, Hochman, & Dafni, 2010; Yilmaz & Daly, 2014). During these design reviews students get the opportunity to update the instructors, their peers: design students and other stakeholders, such as real or simulated clients and potential users, on the current status of their design project. In addition, questions are asked by the instructor and other stakeholders to the students to clarify aspects of the design project and to guide the design focus. This in turn can encourage the students to take convergent or divergent paths in their design process helping them with the development of their design idea. Feedback sessions while designing in an educational setting have been mostly researched in an academic setting. Here we've put this phenomenon in the context of primary education and we focus on feedback preceding instances of design fixation.

3. METHODOLOGY

In this study we focus on identifying the type of feedback that the children received preceding the fixation moments that were identified during a previous analysis round of this explorative case study (Schut et al., 2017). The goal is to get a better understanding of the type of feedback that preceded those fixation moments and uncover possible feedback patterns.

The study took place at a primary school in the Netherlands, in the area of Zuid-Holland. In this study, one class of a Dutch primary school participated over a period of seven weeks in weekly design sessions of 90 to 120 minutes in March and April of 2016. The class consisted of 24 children, ranging from 9 to 11 years old. The class of children had not participated in any design project prior to this one. The class was divided into 6 teams of 4 children by the teacher, so called design teams. The design assignment of the project was made available by the HALO (sports academy), which is part of the The Hague University of Applied Sciences in the Netherlands. A problem owner from the HALO, who acted as a client towards the children, introduced the

design assignment to the children and was present during several of the design sessions to give feedback on the children's design ideas. The design assignment was presented as follows: "design a game, lesson or sports equipment for the gymnasium of the future that enables children with different participation motives to be physically active together". Three facilitators were present during the design sessions to facilitate the teams. When participating in the design sessions, the design teams were led through different diverging and converging stages via the different design activities. An overview of the design activities can be found in table 1. Different strategies were used during the design sessions to enhance idea development and discourage fixation. Prominent were the feedback sessions halfway in session 4 and at the end of the project in session 7. The feedback sessions were facilitated in a classroom setting in which all the design teams and the problem owner were present. Each design team took turns to present their design idea to the other design teams (their classmates) and the problem owner. After presenting, each team received feedback from their classmates and the problem owner on the status of their design idea.

Table 1. Overview of the design sessions, including facilitation style, design activities and relation to each design phase.

	Facilitation style	Design activity	Relation to each design phase
1	classroom facilitation	Exploring the design problem	- introduction design assignment by the problem owner - experiencing different sport preferences within the class through group activities lead by the problem owner - timeline visualization of positive and negative physical education experiences - brainstorm to shed first ideas
2	Separate team facilitation	Empathizing with the target group	- constructing interview questions - practice interview - homework: do interviews with other children
3	separate team facilitation	Idea generation & selection	- discussing the interviews - 3 brainstorm techniques - categorization of all ideas - idea selection - top 4 selection
4	classroom facilitation	Feedback session	- make a small model/first prototype of 2 ideas - present the 2 ideas to the problem owner and classmates **- feedback from the problem owner and classmates** - selection of 1 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	- build-up for the test - test with other children - get feedback from testers - think of implications for design
7	classroom facilitation	Feedback session	- present design to the problem owner and classmates **- feedback from the problem owner and classmates**

3.1. Data collection

The data collection consisted of several different sources. The seven sessions described above were audio and video recorded and later on transcribed by two researchers. Any materials that the children produced during the sessions were photographed.

3.2. Analysis

Session 4 and 7, in which the feedback sessions took place, were selected for in-depth data analysis. The purpose of the analysis was to understand which type of feedback preceded the previously observed fixation moments of the design teams, therefore the data of this previous analysis (Schut, Van Doorn & Klapwijk, 2017) was used to differentiate between feedback preceding fixation and other feedback. We were particularly interested in the divergent or convergent nature of the feedback. To determine the nature of the feedback, Eris's

question-driven design model was used as coding scheme (Eris, 2004). Eris based his model on 6 reviewed taxonomies of questions, which he adapted into his own coding scheme for the context of questions asked while designing. Although the model is intended, and therefore mostly used, to analyse question behaviour within the same design team while working on a design project (Cardoso, Badke-Schaub, & Eris, 2016; Eris, 2004), instances of its use during feedback interventions, like design reviews, are proven valuable (Cardoso, Eris, Badke-schaub, & Aurisicchio, 2014). In figure 1 Eris's model is visualized. For the purpose of this research 'Compliment' and 'Critique' were added to the framework, so a combination of deductive and open coding was applied by use of Atlas.ti.

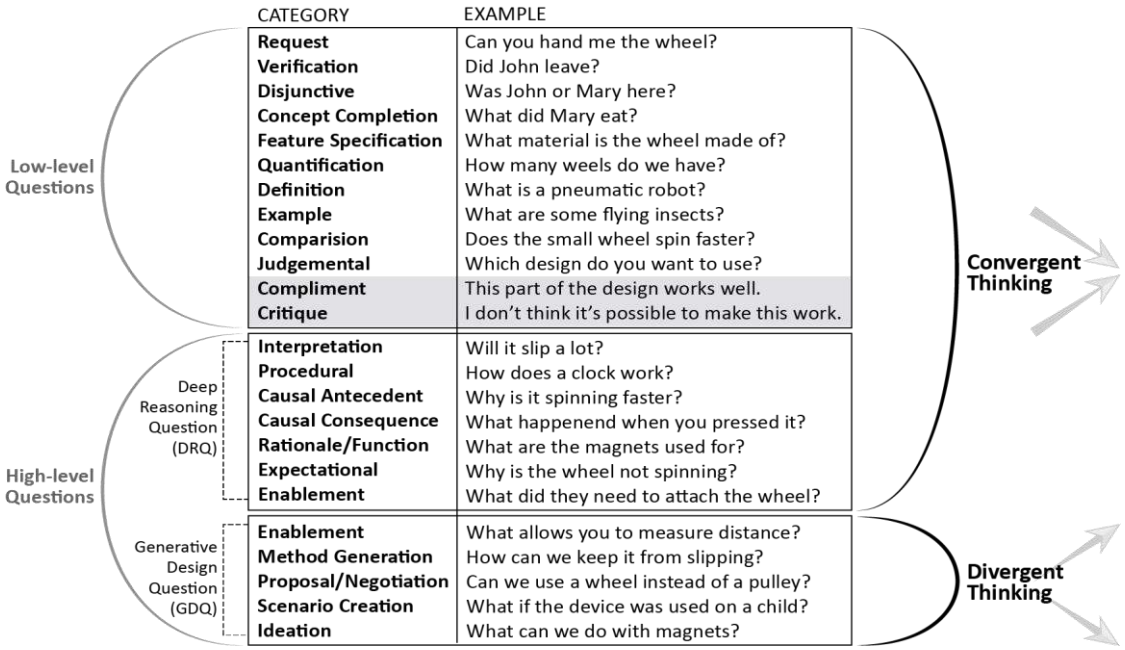

Figure 1. Eris's Question Driven Design Model. For the purpose of this research 'Compliment' and 'Critique' were added to the framework.

4. RESULTS

Overall *convergent* feedback was most prominent preceding the fixation moments of the design teams. The classmates of the design teams took a leading role in giving this type of feedback, although there were some instances in which they shared *divergent* feedback with the design teams. In general, most of the divergent feedback that preceded the fixation moments of the design teams was given by the problem owner. Repeated patterns were observed in the manner in which the feedback was given to the teams, by their classmates and the problem owner preceding fixation moments. The following sections will elaborate on these observed feedback patterns through several dialogues that took place between the children and the problem owner. The children that are a part of the design team the dialogue is focused on, will be indicated as 'child' and, if necessary, a number. The children that are not a part of the design team the dialogue is focused on will be indicated as 'classmate' and, if necessary, a number. The problem owner will be indicated as such.

4.1. Expectations and assumptions about the design ideas

Expectations about the presented design idea appeared to be prevalent in much of the feedback that was posed by the classmates of the design teams. Through convergent feedback the classmates 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.

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…
Child1: But we don't offer handball.
Classmate: Okay. Then soccer, if you then kick the ball then you don't know how fast you will kick.
Problem owner: Well, the computer would be able to measure that. You can make that happen.
Child2: 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 classmate then repeats the expectation, prompting the problem owner to step in and contradict the expectation of the classmate, which is quickly embraced by the team. The first reaction of the team to feedback of the classmate was to parry it, showing little intention to evaluate the feedback and possibly using it to improve their idea. This, almost wary, behaviour could have been promoted by the classmate sharing expectations about the idea without any verification towards the team as to whether these assumptions are indeed correct.

In a few instances, classmates intertwined convergent feedback with divergent feedback. This divergent feedback consisted of either a new addition to the design idea, a small idea proposal, or a question intended to spark idea generation regarding a specific feature of the design idea. This behaviour is illustrated by the following 'scorekeeper'-example.

Scorekeeper
Classmate: Maybe it would be fun if you would also have a scorekeeper.
Because maybe the children will keep their own score, but you can also lie
that you have 20 points while you only have 15 or something.
(Design team directly starts mumbling in disagreement)
Child 1: No that's not possible, because you have to throw your objects in a bucket
and if you don't, well, then you just don't have any points.
Child 2: Yes, and uhm… there will be a referee that checks if there are no weird
things going on and he will also count the points in the end of the game.
Classmate: Okay…

The example dialogue starts with a classmate sharing a new addition to the idea of the design team: a scorekeeper. Additionally, the classmate explains that the proposal stems from the expectation that players might lie about the number of points they have collected during the game. In theory, the proposal has the potential to kick-off a new process of DT, yet here the design teams did not engage in any new DT behaviour. Instead, they listed all the reasons why the classmate's proposal would not fit their design idea. Yet similar to the previous example, the expectation of the classmate - that the players might cheat - is an assumption which again is not checked with the design team. From the reaction of the team it is clear that the possibility of cheating, which the classmate assumes to be problematic, is not viewed as a problem by the design team.

4.2. Proposing new additions

Similar to the 'scorekeeper'-example, there were other instances when fixation moments of the design teams were preceded by divergent feedback. This occurred on several moments when the problem owner gave feedback to the teams. The following example dialogue showcases how one of the design teams reacts to the divergent feedback of the problem owner, who proposes a stream of new additions to the team's design idea.

New proposals
Problem owner: What might be nice is something you can see in some playgrounds.
That you get points if you hit something. You know?
Child: Yes, this game is that you can shoot and then you get points.
Problem owner: 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.
Child: If you stand there the sticks will fall and then you can get them really fast.
Problem owner: 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.
Child: [silence...] Maybe…

The problem owner 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 problem owner 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 problem owner. Although the feedback of the problem owner 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 problem owner 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 assumption that the game needs to get more difficult over time. Yet this assumption is only communicated at the end of the conversation, keeping the team in the dark of the problem owner's true intentions for the most part of the dialogue. The 'new proposals'-example showcases the use of divergent feedback without it leading to DT behaviour in the design teams. Although proposals are a form of divergent feedback and could lead to DT behaviour, the example shows that this is not necessarily the case. It appears that only the divergent nature of the feedback is not enough to guarantee the start of a new DT processes and that something is still missing.

Our preliminary analysis of the feedback on other occasions – not preceding the fixation moments – indicates that hidden expectations and assumptions were less prevalent. Further comparison is however needed.

5. DISCUSSION

The results of this explorative case study show reoccurring patterns in the feedback preceding the fixation moments of the design teams. Firstly, most of the feedback was convergent in nature and, additionally, the feedback that could be considered divergent did, for the most part, not spark any new DT processes within the design teams. We presume that one of the factors that hindered that the start of any new DT processes within the design teams was the presence of the expectations and assumptions the classmates and problem owner had about the design ideas, which were implicitly present in the feedback. Due to this implicit nature within the feedback, there was an absence of mutual understanding between the design teams and their peers and problem owner regarding these expectations and assumptions. If there is no mutual understanding, disagreement occurs and the openness, which is needed for a new DT process, is lost.

We suggest that, firstly, the 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 and it's clear for both parties what the feedback relates to, there is again room to regain openness and follow with a form of divergent feedback in order to spark a new DT process. We will explore these possibilities in our following case studies.

6. ACKNOWLEDGMENTS

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