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End Users in Students' Participatory Design Process

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This exploratory case study aims to shed light on how end users were considered in students' design processes and final design products. A three-month participatory design project for students (ages 14–15) was created with the following brief: *"co-design and make an e-textile product for kindergarteners according to their wishes and needs".* We analysed 72 transcribed end-users-related design episodes and the final products from two student teams. The findings indicate that students' end-users-related design discussions concerned various functional, technical, and visual/aesthetic features, as well as aspects beyond functional, such as students' memories and experiences. Additionally, many concrete and abstract features and solutions of the final products were traced back to end users. This study suggests new possibilities for engaging students in empathic and reflective (digital) design and making, targeting design-literate citizens in the 21st century.

Keywords: participatory design, design thinking, empathy, maker education, 21st-century skills

Introduction

Power structures in design have changed toward more participatory and collaborative design practices, and people are included in design as partners (Sanders & Stappers, 2008). To fully participate in society, all people should learn about design and develop (digital) design literacy skills (Nielsen & Braenne, 2013; Smith, Iversen & Hjorth, 2015). Design-based teaching and learning can support the learning of 21st-century skills, such as empathy, creativity, communication, and collaboration (Carroll et al., 2010; Noel & Liu, 2017; Tellez & Gonzalez-Tobon, 2019).

Smith et al. (2015) suggested design thinking as a framework for engaging students in the design of digital technology, and the possibilities of maker education and maker-centered learning have been explored in terms of educating future citizens with capabilities and confidence for actively participating, understanding, and developing a "digitalized world" (Clapp, 2016; Halverson & Peppler, 2018; Konopasky & Sheridan, 2020). Here, schools play an important role, and formal education should democratically offer these new skills and possibilities to children and adolescents (Blikstein, 2013). However, Dindler, Smith and Iversen (2020) argued that issues such as how technology is meaningfully constructed for specific people in a concrete situation, undertaking design research, and developing empathy for users are seldom found in the lower-level school curriculums. How do we then engage students in maker-centered learning, building creative skills, socio-emotional skills, and technical capacity, and enable them to learn (digital) design literacy and other 21st century skills?

Design thinking and its methods and techniques can support student's active engagement in solving wicked, ill-defined problems by trial and error and based on their insight and past experiences (Cross, 2011; Goldman & Kabayadondo, 2016). Design thinking is defined and described in various ways by many researchers and practitioners, especially in design, engineering, and business. Examples include widely known IDEO´s Design Thinking process, Stanford Design Thinking Diagram, or Design Council's Double Diamond process.

Participatory design (PD) "ideology" offers new ways and possibilities for applying design thinking in the fields of learning sciences to develop and transform its practices (DiSalvo & DiSalvo, 2014). Derr (2015) suggested that collaboration with the community is an important aspect of the PD approach, and it can play an important role in school-based PD projects to enhance design skills and empathic development. This exploratory case study aims to shed light on how end users were considered in students' design discussions and final products. By relying on van Rijn, Sleeswijk Visser, Stappers and Özakar's (2011) notion that end-user-related discussion can indicate design empathy, we aim to reach a better understanding of students' design discussions. In the present study, we asked: 1. What kind of end-user-related design discussions did the students have? 2. In which way are the end users or their stated needs, wishes, and feedback acknowledged in the final design products?

Empathy toward the end users in the design

End users' needs and perspectives have to be taken into consideration beyond the functional (e.g., emotional, cultural, or social needs), to design personal and meaningful solutions (products, services, and experiences) for them. 21st century "soft skills" (e.g., empathy, creativity, communication, collaboration) are the core future design skills, as they enable this connection with people and communities (Clapp, 2016; Noel & Liub, 2017; Tellez F. & Gonzalez-Tobon, 2019; Woodcock, McDonagh & Osmond 2018).

The original aim of the empathic design was to understand and make sense of the human experience and to purposely use the knowledge gained for developing successful products. However, in the past decades, users have been more actively involved through co-design and PD methods for building possible alternative futures (Koskinen, Battarbee & Mattelmäki 2003; Tellez F. & Gonzalez-Tobon, 2019).

Even though empathy is seen as an essential part of design, the field lacks a fundamental understanding of what design empathy is: how it functions in the design process and how it can be evolved, supported, and accomplished. Earlier research has focused mainly on developing and utilizing different methods and techniques rather than the more holistic empathic growth of a human (Hess & Fila, 2016; Mattelmäki, Vaajakallio & Koskinen, 2014; Smeenk, Sturm & Eggen 2019).

Smeenk et al. (2019) note that empathy in social-psychological literature is usually divided into cognitive processes and affective experiences, and the ability to attune to or distinguish between self and other. Kouprie and Sleeswijk Visser (2009) created the framework for empathy in design, which integrates these factors, and they emphasized the need for a balance between users' ideas and visions as well as designers' personal insights and experiences. Smeenk, Tomico & van Turnhout (2016) stated that acknowledging different perspectives is valuable in design. Similarly, Hess and Fila (2016) found that designers' reflections and first-hand experiences were an important part of the empathic design process.

Research settings

This qualitative case study was organized at a public lower secondary school in Helsinki as part of an elective eighth-grade craft course. Ten female participants (aged 14–15 years), who had prior experience with textile crafts but no prior experience of PD, design thinking models, e-textiles, or collaboration with kindergarteners, were divided into three teams. Two kindergarten teachers and 16 kindergarteners (aged 6–7 years) participated in the project (later the teachers, as well as the kindergarteners, are referred to as the end users). As the kindergarten was located next to the school, some participants had attended it. The project structure was designed mostly by the researcher/craft teacher/designer (later the researcher), who made the overall planning based on her prior knowledge and experiences of design and craft education. However, the plans were collaboratively discussed and revised on a weekly basis with the responsible craft teacher. The overall idea for the project was formed in collaboration with the kindergarten teacher.

The design brief for the project was to "co-design and make an e-textile product for the kindergarteners according to their wishes and needs." The task emphasized collaboration between team members, taking other peoples' ideas, feelings, and needs into account, and thinking creatively about how technology could be used in the products. Additionally, the students left the school building to take on the role of "participatory designers" in front of the kindergarteners. They connected with the community and considered their roles in it.

The project was carried out over three months in the spring of 2019. The class met 12 times in weekly 90-minute sessions; the last three sessions were dedicated to student presentations and post-questionnaires (see Table 1). The teams documented their processes in the digital SeeSaw portfolio. Both the teacher's and researcher's roles in the process were active yet more facilitative than authoritative. The students were supported in finding their own paths to contribute to the design process.

*Table 1. The design process steps, and activities (*not included in the analysis)*

Sessions	*Design process steps*	*Activities*
1	Discover & empathize	Memories and reflections in a post-it note. Filling up the pre-questionnaires.
2	Discover & define	Visiting kindergarten. Observations of the space. Direct interaction with end users. Collecting needs and wishes.
3	Define & develop	Forming the small groups (ice breaker). "How might we…" questions. Ideation in small groups. Defining the challenge.
4	Develop & deliver	Ideation in small groups. Making the fast mock-ups. End users visiting for presentation and feedback. Collecting feedback.
5	Develop & deliver	Developing the concepts ready according to the end user feedback.
6	Manufacture	Manufacturing the products.
7*	Manufacture	Open day: parents visit. Manufacturing the products.
8	Manufacture	Manufacturing the products.
9	Manufacture	Finalizing the project and poster.
10*	Deliver & present	Delivering the outcomes. Presentations for the end users.
11*	Share	Sharing for a wider audience at the UH Invention Fair.
12	Reflect	Filling up the post-questionnaires. Reflecting the overall process.

The project followed the Double Diamond design model (British Design Council, 2005) and started with empathizing. Students made empathy maps, visited the kindergarten for needs observations, and interacted with the end users. Based on those observations, needs, wishes and discussions with the end users, the researcher put together different HMW questions, and students brainstormed solutions for the design challenges and voted for the favorite concept to work with. Then, concepts were developed (Figure 1), and rapidly constructed mock-ups were presented to the end users. Concept designs were developed based on the end user feedback in Session 4, and the manufacturing phase started. In Session 7, there was an open day (extra school day on Saturday), where parents were invited to visit; some of them even helped students with the making phase. Lastly, the functional needs-based design products "Season Tree" and "Strength Crow" were brought to the enthusiastic preschoolers, and a toast was made to celebrate the big accomplishment. Later, the students and the teacher presented the project (Session 11), the city-center "Invention Fair," organized by the research team from the University of Helsinki.

Figure 1. Student designers from Team 1 working with the design challenge.

Data and analysis

In this study, we focused on analyzing the processes of two student teams (*names pseudonyms*). Team 1 (Emmi, Sofia, and Sara) designed a "Season Tree" to help preschoolers learn about the different seasons. Team 2 (Iina, Senja, and Rosa) designed and manufactured a soft toy "Strength Crow," a popular figure in

Finnish early childhood education for supporting positive pedagogy and strength-based education (Vuorinen & Uusitalo, 2015). It also functions as a noise level meter. The two teams were chosen according to students' willingness to participate in the study.

Research permissions were obtained from all participating students, and versatile data were collected during the project. The primary data consisted of approximately 18 hours of video recording, photos of the sketches, mock-ups, observation and ideation notes, and final design products. The secondary data consisted of the researcher's field notes, students' pre-questionnaires and post-questionnaires, and other pedagogical material. Some sessions (7,10,11) were left out of the analysis because they did not offer any new design aspects to the design process. In some of Team 1´s sessions, we had technical problems capturing students' voices as they actively moved around the classroom. Altogether, analyzed video data consisted of approximately 10 hours of video recording.

The qualitative data analysis was done in several cycles and levels, adapting the model proposed by Derry et al. (2010). The first phase consisted of making a rough content log of the whole video data to obtain an overall picture and reveal the main contents and various activities of the sessions in the design process. Then, we systematically identified all those episodes in which students' teams had discussions related to end users, e.g., the user environment, or possible future use of the design. We utilized MAXQDA software for qualitative data analysis, and the identified episodes (n = 72) were transcribed verbatim. By analyzing the students' team discussion relating to end users, we were able to reveal the kinds of motivations, concerns, experiences, and reflections the students' team exposed through their design process. The overall analytical process was accompanied by the writing of memos, which included, for example, definitions of categories, preliminary analytical notes, and questions of analysis. Whenever the transcriptions did not offer the full picture of the moment, we returned to the video data to strengthen the analysis.

In the second phase, we created a process table (similar to the flow chart; see Ash (2005) to support the analysis. To this end, we added versatile basic information (e.g., session, phase of project, data collected, assignments) next to end-user-related transcriptions. We also included photos of the sketches, mock-ups, notes, and design products to keep better track of the overall process.

To answer the first research question, we utilized data-driven analysis to identify the main functional and beyond functional aspects related to different kinds of end-user-related design discussions. Functional aspects consisted of functional features or solutions (how product functions or what it is meant for, e.g., what does it teach for children?), technical features or solutions (how the product can be produced, e.g., which material fit or what kind of digital functions can it have?), and visual and aesthetic features (what the product will look like, e.g., attractiveness and shape).

Beyond functional aspects included other-oriented and self-oriented categories. Students' other-oriented end user considerations were derived from end users (e.g., based on the observations) or their needs, wishes, and feedback (e.g., kindergarteners learn about seasons or end users preferred some color). Students' self-oriented experiences and knowledge included, for example, their own experiences from kindergarten, experiences of the topic at hand, or the kindergarten visit from Session 2 (e.g., how was it in kindergarten or during a previous experience of making).

Lastly, to answer "In which way are the end users or their stated needs, wishes, and feedback acknowledged in the final design products?", we focused the analysis on the photos of the sketches, mock-ups, and final design products and listed the main end-user-based features and solutions. Next, we went through the listed features and solutions next to the process table with all the transcriptions to reveal the process and connections between the needs, wishes, feedback, and the final product.

Findings

We analyzed what kind of end-user-related design discussion did the students had. Furthermore, we analyzed how the end users were acknowledged in the final design products. Next, we present the findings for our research questions.

RQ 1. What kind of end-user-related design discussions did the students have?

This first level of analysis revealed that students considered many functional, technical, and various visual/aesthetical aspects or solutions. Table 2 provides the frequencies of these main aspects of the episodes. Since we were not interested in the frequency of each functional aspect (e.g., how many times Velcro was mentioned in one episode), we present our findings from a wider perspective, relative to the episodes. It is important, however, to notice that these five categories were not exclusive, and most of the time, the students' discussions related to many categories within the same episode.

In both teams' processes, the most common end-user-related design episode was related to the functional and other-oriented aspects. In Team 1, 27 of 39 episodes dealt with functional aspects, and 32 with other-oriented aspects. Of all the analyzed episodes, Team 1 also dealt with technical (26/39) and visual (24/39) aspects of the proposed product more often than Team 2 (16/33). The findings suggest that other-oriented end-user-related considerations, as well as students' own self-oriented experiences, played an important role during the design process, even though Team 1 referred to experiences more often.

Table 2. Frequencies of the main aspects of the episodes.

Team	*Total number of episodes*	*Functional*			*Beyond functional*	
		Functional	*Technical*	*Visual /Aesthetic*	*Other-oriented*	*Self-oriented*
Team 1 Season Tree	39 episodes	27	26	24	32	21
Team 2 Strength Crow	33 episodes	23	16	18	25	12

The functional category included various considerations of the purpose of the product or the kinds of intended functions it might perform. Team 2 (Strength Crow) pondered, for example, whether the Strength Crow could play a sound when the noise in the class is too loud, thereby functioning as a noise warning system. Team 1 (Season tree) discussed how children could decorate the tree by themselves, and how snowflakes could represent the wintertime, and green leaves the summertime. Technical considerations related mostly to material choices, for example, whether Velcro should be used to attach the strength cards to the Strength Crow or whether real (wet) branches should be used on the Season Tree. Considerations of the water resistance of the programmable board, the strength of the material, or issues of coding were also included in technical considerations. The visual and aesthetic aspects were also actively considered by both teams. Team 1, for example, pondered whether the sketch of the Season Tree looked scary and how to make the tree more attractive with bright colors. Team 2 considered whether capital fonts were easier to read, or rainbow colors well liked.

The other-oriented category consists of notions derived from or concerning the end users or their situations, needs, wishes, or feedback. This category represents the clearest end-user-centric considerations during the design process, for example, statements recalling what the end users had expressed earlier. These needs and wishes were especially discussed during the ideation phase, where the students ideated different solutions, for example, by proposing a "dressing-up game" to motivate the children to dress up layers of cold weather clothing faster or to make dressing funnier. Later, the student teams considered what kind of feedback they could request from the end users, or how teams could include user wishes into the design of the artifact.

The self-oriented category consists of notions during which students brought up or memorized their own prior experiences in kindergarten, the kindergarten visit, or making. Team 2, for example, discussed what they played on the kindergarten field trips. They also referred to the experiences collected during the kindergarten visit and used personal emotions as part of the design. Earlier experiences of making were also in this category as if they were connected to making for the end users.

RQ 2. In which way are the end users or their stated needs, wishes, and feedback acknowledged in the final design products?

The second analysis concerned the way the end users (both preschoolers and their teachers) or their needs, wishes, and feedback were acknowledged in the final design products (Figure 2). We analyzed the photos of the sketches, mock-ups, and final design products, and the main features and solutions derived from the end users were listed (see Table 3, right column). Then, we compared those features next to the process table to reveal connections between the end users' stated needs/wishes/feedback and the final product. The findings show that many concrete or abstract features can be traced to the end users' needs, wishes, and feedback. Next, we explained in more detail the different end-user-derived features and solutions of both products.

Both teams' solutions were developed to offer tangible, concrete products to support kindergarteners' learning. The main function of the Season Tree was to demonstrate different seasons in a more realistic and motivating way, as children could change the leaves, flowers, and snowflakes by themselves. The Strength Crow was developed for playing and supporting strength-based education and measuring the noise level. During the kindergarten visit, Team 2 noticed that the space was small and noisy, and it triggered the idea of utilizing the programmable e-textile board for this purpose.

Presentation and feedback sessions between eighth graders and end users were very concrete by nature. The main kindergartener feedback noticeable in the final products was the size of the Strength Crow and its bill, as well as the larger size of the Season Tree compared to the sketches and mock-up version presented to end users. Further, the end user feedback offered some new ideas for the material and functional aspects, but the wishes were rather contradictory or were not included in the final design due to the very limited timeframe or other technical challenges.

Figure 2. Season Tree and Strength Crow: Products designed and manufactured by the students.

The end users were acknowledged in both final products in many ways (see Table 3). For example, when the students discussed how the strength cards should be attached to the Crow, they first considered the usability and safety issues between using pins or Velcro and then chose Velcro, thinking of the end users. This view was supported by end user feedback, as preschool teachers supported it. In the same vein, Team 2 considered the materials to be strong enough to prevent Crow from breaking in children's hands.

When selecting the font size, type, and color for the strength cards, students paid attention to the visibility. They pondered what type and size of the font the end users (kindergarteners) might be able to read or what type of font color the end users might like. Furthermore, visibility was also considered in terms of LED lights and programmable boards, and different color LED lights were considered suitable for the end users. All these points were visible in the final Crow.

The Season Tree team considered Velcro fastening an easy and safe way for end users to use, but also changing the batteries and hanging the tree on the wall was considered for better usability. Bright, colorful flowers and colorful LED lights were considered for a livelier and more attractive look for the Season Tree, which end users would appreciate. The form of the tree was developed to be a softer and nicer bushy tree, so the kindergarteners would not get scared of it. In general, the team was trying to make the tree look impressive and beautiful by making the Season Tree rather large (around 1 m high) and filling up the tree with flowers and leaves.

Table 3. End users and their needs, wishes, and feedback acknowledged in final products

Team	*Needs and wishes stated by the end users* *Feedback from the end users**	*End users acknowledged in the final products*
Season Tree	• Tangible and more attractive season tree • To support learning about seasons • Size of the tree bigger than in mock-up version* • Not necessarily real branches*	• Educational function (support learning, recognizing the seasons) • Different kinds of flowers, leaves, raindrops, and snowflakes demonstrating the seasons • End users can decorate themselves • Bright colors for a more attractive look • Nice, friendly-looking, and soft bushy tree for end users (not scary) • Size of the tree fairly big, impressive • Appearance lively and attractive (e.g., led lights, a tree full of leaves) • Usability (e.g., battery change, Velcro binding, no real branches)
Strength Crow	• Tangible, concrete Strength Crow • To support strength-based education • Size of crow and its bill adjusted according to end users' feedback* • LED lights for eyes* • Velcro for binding*	• Educational function (support learning, recognizing the strengths) • Noise level meter (sound & light) • For playing • Chosen weekly strengths can be attached • Velcro binding (for safety & easier usability) • Visibility for the end users (e.g., fonts & colors) • Usability (e.g., change of battery, the strength of the material, can stand on its own on a table) • Appearance-friendly and colorful (e.g., LED lights)

Discussion

This exploratory case study aimed to shed light on how the end users were considered in students' design discussions and final products. These eighth graders were able to practice participatory and empathic design by acknowledging end users in multiple concrete and more abstract ways. It was visible in various end-user-related discussions and considerations, which materialized in the final products.

Following Woodcock et al. (2018), we acknowledge the need to consider features beyond functional to design personal and meaningful products for people; thus, we based our analysis on various types of user-related design process data, and eight graders' memories and experiences. Our findings show that beyond functional features can bring us closer to design empathy, and end-user-related topics were discussed repeatedly during students' design process.

As earlier research suggests (van Rijn et al., 2011), direct contact and interaction with real end users have proven to be an effective way to increase students' motivation and engagement for the students. We surmise that, with adolescents or younger children, direct contact and students' previous own experience from the context were crucial for motivational reasons, as well as for making the whole design thinking process more concrete and being able to apply different perspectives in design. Everyone had an experience of kindergarten and its practices (as kindergarten is obligatory for children in Finland), and that was the important connector between the students and the end users.

The motivation and engagement grew especially in contact with end users, and data from students' post-questionnaires supported this view. For students, collaboration, interaction, and hearing kindergarteners' opinions about the products were inspiring. Moreover, some students mentioned that recalling memories of their preschool times at the beginning of the process helped in thinking about what preschoolers are like and which things are important to them.

The eighth graders' ideated concepts were to be manufactured by the students; thus, during the process, they referred to their previous experiences with sewing or coding. This might have affected the design process, as certain skill or material constraints were there. However, students also drew inspiration and knowledge from their experiences, which is considered beneficial in the process of learning.

Limitations and reflections

This study was a small case study on applying empathic design in the eighth grade PD project with real end users. The sample size was small but suitable for this kind of pilot project. Due to the gendered division in Finnish craft classes, all students participating in the project were girls. To increase trustworthiness, we offered the overall picture of the aims, goals, and process implementation to the full extent and described and justified the data collection methods and analysis as precisely as possible.

A small student-teacher ratio enabled time for instruction when two adults were all the time supporting three teams. It was necessary for the narrow time restrictions given to the project, and we noticed the small pressure of the students in trying to complete the products. Due to the small size and situated nature of this study, the findings cannot be generalized, but these findings pave the way for new studies of empathic PD with a wider group of attendees in different schools and grades. Students gave permission for data collection; however, as this project was part of their formal education, the project itself was not voluntary for students. This and the fact that the project class was at 8 AM every Friday and the students were teenaged could have affected some students' active participation.

The researcher being familiar with the setting and school and being present and co-designing all sessions with the teacher have supported the analysis. Additionally, this familiarity led to honesty, trust, and openness between the teacher, researcher, and students and increased the positive and open atmosphere for sharing experiences and risk taking.

Even though the PD process was a dialogic process between teachers and students and other stakeholders, this study focused mostly on students' verbal design discussions. However, it is good to keep in mind that in many moments, the researcher and teacher might have been starting the end user talk by asking a question, proposing an idea, or giving a design task (such as HMW questions). We have not separated these moments in this analysis. Further, end users' needs and wishes mostly came from the preschool teacher, not the six-year-old children themselves. We focused strictly on what the students said; therefore, the idea and the design concept were considered their own. Nevertheless, teachers' role in this kind of open-ended process is significant.

Conclusion

The findings of this small-scale study broaden the knowledge of how lower secondary level students can practice participatory design and include end users in their design processes. These small local PD projects can offer new possibilities and directions in engaging students in critical and sustainable design and making in formal schooling, targeting active and design-literate citizens of the 21st century. However, this novel field requires further studies on educational contexts other than higher education, which currently has the best research coverage.

Future studies could address, how these community-based participatory and empathic practices can be supported in formal education, e.g., how teachers can scaffold and balance the process with structure and freedom and offer certain tasks to feed implicit learning goals (such as different 21st-century skills) into the process.

By scaling up these local design projects first to a greater number of schools at different levels and contextual places and areas of living, developing the practices and teaching materials together with the teachers and school leaders, we can build new frameworks and ways of working with participatory design in educational settings and activate young students to take part in community development.

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