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THE CHILD-TO-CHILD (C2C) METHOD: PARTICIPATORY DESIGN FOR, WITH AND BY CHILDREN IN A CHILDREN'S MUSEUM

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ABSTRACT

In this paper, we present the Child-to-Child method (C2C) for co-designing with children for children. The method is illustrated using a design case, where an interactive space for young children in Children's Museum was designed. A three dimensional interactive books are envisioned and explored with children, and consequently embedded into the "Book Nook" exhibit. This interactive environment, intended for young children aged 3-5, was developed and prototyped by an intergenerational design team. The paper reflects upon challenges and opportunities provided by working with C2C method and presents results of preliminary investigation of an interactive space design that employs a novel concept of a 3D book. Further, we argue that C2C method is indeed a participatory design method for, with and by children.

KEYWORDS

Participatory design, design with children, children's museum, co-design, interactive spaces, storytelling.

1. INTRODUCTION

Children's museums are cultural institutions that provide hands-on exhibits and programs to stimulate informal learning experiences for children. The growing world of children´s museums offers experiences in culture, cooperation, critical and scientific thinking through play and creativity, intergenerational and other social experiences, among other offers. These institutions are ideally suited for interaction design and design processes that include children.

Perhaps it was the Exploratorium, a hands-on museum of science, art, and human perception in San Francisco, which started it all. Exploratorium opened in 1969 and was far from being the first in the field (Brooklyn Children's Museum opened its doors as early as 1899). With its over half a million on site visitors per year and over 13 million online, it certainly had a role in popularizing hands-on interactions in children's museums ("Exploratorium - Wikipedia, the free encyclopedia," 2013). In *Something Incredibly Wonderful Happens* Cole (Cole, 2009) describes her first experience with the Exploratorium in the early 1970s: *There were no guides and no path and no right way to go through... Stuff was simply there to mess with. And what stuff! I thought there was nothing like it in the world and I was right. ... One thing I knew for sure: it was not science and it wasn't a museum. "It did not look like a museum", recalled Alan Friedman, a physicist and now the director of the New York Hall of Science. "The look of the exhibits was right out off the lab bench. Rough wood. Things nailed to the table. ... It looked really friendly. It looked like home."*

The idea of "messing with things", as part of the museum experience and the way of learning by "messing with things", was one of the sources of inspiration for this work. Our focus was on exploring and creating a new experience related to books and storytelling in the children's museum that allows for cooperation, creativity and engagement with interactive books in a three dimensional space. Most importantly though, we took a closer look at design methods that foster exploration and also include children in the design of exhibits. We argue that our method allowed us to participatory design for, with and by children.

While designing interactive environments in museums is gaining momentum, e.g. (Clarke & Hornecker, 2012; Danks, Goodchild, Rodriguez-Echavarria, Arnold, & Griffiths, 2007), designing those with children is still not very common.

Including children in the design of interactive installations for children is challenging for many reasons; we provide just a few:

- Children are different from adults both as users and designers, and many of existing design methods do not account for these differences.
- Co-design, or participatory design, with children is a process that takes time. In order to build intergenerational teams those function well, and have a potential to produce truly innovative ideas, require cooperation that extends over time.
- Partnering with children in design processes is often misunderstood by designers. In some cases designers try to hand over decision-making power into children's hands. In others, they include children into design processes as users of their own ideas and prototypes, thus not giving them any real power.
- The design for children's interactive exhibits in children's museums often involves new technology, and this, often, excludes the children from part of the process.

Several researchers have involved children in designing technologies for children e.g. (Dindler, Eriksson, Iversen, Lykke-Olesen, & Ludvigsen, 2005; Druin, 1999; Druin, 2002; Druin et al., 1998; Iversen & Nielsen, 2003; Iversen & Smith, 2012), also in an interactive

space setting (Alborzi et al., 2000; Dindler, Iversen, Smith, & Veerasawmy, 2010). In her paper (Druin, 2002), Druin suggests and describes the four roles children may have in design processes: users (simply using prototypes or similar products in order for a designer to learn about a child's behaviour while interacting with an object), testers (testing prototypes during design processes), informants (children may influence the design by actively informing it) and partners (children become part of the design team). The methods for including children in design teams were similar to methods for bringing adult users into the technology design process. Contextual design (Beyer & Holtzblatt, 1998) cooperative design (Bjerknes & Ehn, 1987) and participatory design (Greenbaum & Kyng, 1991; Schuler & Namioka, 1993) are examples of such methodologies that were adapted to suit design teams that include children and favour equal partnership.

Participatory design (PD) as a design approach emphasizes users' influence in all stages of the design process. Future users are not only given a voice in the process, they are also given power to make concrete design choices (Bratteteig & Wagner, 2012; Simonsen & Robertson, 2012). Their influence impacts all parts of design from problem setting to problem solving, as well as design goals and design form. The design solution thus builds upon and aligns with the logic of its future users. Given that the target user group involves quite young children, PD in this sense is difficult to achieve. Small children cannot speak for themselves adequately, and cannot fill the role of a committed design team member on equal terms. This makes it difficult for them to influence the design process directly. Thus, in order to understand actions and interests of these young children as well as possible, we involved a group of older children to represent the child perspective and interpret the actions of the small children in the design team. The older children were involved in a co-design process (Walsh, Foss, Yip, & Druin, 2013) as members of the design team with the power to influence the process.

Our research aimed at finding ways of involving children aged 8-11 as co-designers. Their memories of the time when they were the same age as the target group, aged 3-5, were still very alive. We further wished to explore how to include the children as close as possible to the ideal of the Scandinavian Participatory Design (PD) tradition.

The paper presents an organization of design work with young children, through Child-to-Child (C2C) method by describing a particular design case. We explored a design of an interactive space that we call a "Book Nook", where a book itself has a new form consisting of separate, interactive "pages" that may be joined into a three dimensional structure, allowing for a story to be told in many different ways. The new book form was grounded in young children's story telling activities. The Book Nook is intended as a public space exhibit within children's museum, designed with and for children. Further, the paper argues that the older children did influence the design result considerably through their participation in the design process, as did the young children who tested diverse ideas and concepts.

This paper builds on (Culén, Brattetaig, Pandey & Srivastava, 2013) and is structured as follows: first, we review the main research literature on designing with and for children, as well as design of interactive spaces. There is a large body of research in this field; we present the research most relevant to our case. Next, we present C2C design method and continue with description of a design process with children. We then summarize and present lessons learned from this design case. The final section contains conclusion remarks and reflections on future work.

2. DESIGNING WITH CHILDREN

There are obstacles to PD with young children ranging from difficulties in understanding abstract concepts and verbalizing thoughts, see e.g. (Lincoln, 1985; Markopoulos, Read, MacFarlane, & Hoysniemi, 2008; Piaget, 1973), to a perceived lack of authority as compared to the adults involved in the design process. In order to design solutions aligned with young children's logic, we have built on participatory and co-design methods described in (Druin, 1999; Druin, 2002; Guha et al., 2004; Guha et al., 2005; Iversen & Dindler, 2008; Iversen & Nielsen, 2003; Montemayor, Druin, Chipman, Farber, & Guha, 2004; Walsh et al., 2010), as well other methods and techniques (a good overview and a way to compare methods is given in (Walsh et al., 2013)). In (Walsh et al., 2010), authors describe their teamwork with children designers as follows: "At the University of Maryland, our inter-generational design team meets two times per week during the school year. Design sessions often involve three-dimensional, craft-based, low-tech prototyping materials as well as sticky notes, whiteboards, and journals." With such approach, it is possible to develop ways of representing children's logic in a manner that enables the design team (consisting of adults and children) to design in line with the children's logic. Co-design or partnering with children and designing in intergenerational teams also entails that both adults and children go through a mutual and reciprocal learning process, see (Knudtzon et al., 2003) for some informative lessons learned regarding the organization of work within intergenerational teams.

In some professional design communities, there is a strong disinclination to include children in design processes both because of their non-professionalism and because of doubt in their ability to contribute to design processes (Nesset & Large, 2004). We sought the middle ground, inspired by those who included the children as close as possible to the traditional PD or co-design, while enabling the professional designers on the team to be professional in some areas such as working with technology as a design material during prototyping phases.

Research on design and design methods normally requires the researchers to use reflective practices as an important way to develop knowledge about design processes and methods (Bratteteig & Wagner, 2012; Markopoulos & Bekker, 2003). We have taken an experimental approach: the first version of the C2C method was inspired by some of the above-mentioned literature. Through several iterations C2C was changed to suit our lab possibilities and other work conditions. The later mainly refers to using student projects, both at master and bachelor levels to try different ways of engaging children in the design process. The context we used for these design efforts was related to design of exhibits for the children's museum in the making (Culén, 2010, 2012).

In children's museum field, a user-centered design approach in often used. However, much of the work does not actively include children in their museum exhibit planning and programming, design or development processes. Curators have traditionally documented well and extensively how they envision learning and play in an exhibit to take place, and how they support educational goals and help children develop skills through play. By exploring the ways in which children can be included in the design and development of public exhibits to a larger extent and in a more equal role, our research has a potential to contribute to the children's museum field (Anderson, Piscitelli, Weier, Everett, & Tayler, 2002; Culén, 2012). By trying to understand and appreciate the existing practices in designing for children's museums, we hope to open for the creation of new practices and give voice to children

directly in building and exploring their own future spaces for play and learning. Children's museums can also be seen as a new arena representing a different approach to learning, in accordance with a view presented in (Sefton-Green & Sinker, 1999), fun, collaborative, exploratory and experimental. They aim also to be a "cool" place, full of magic and inspiration (Culén & Gasparini, 2012). It is therefore interesting to research and explore how children can help in forming and defining these spaces.

3. THE C2C METHOD

A technology design method is a coherent set of guidelines for how to carry out a design process from start to end, often called a methodology. A method is characterized by its:

- Application area: a small administrative system requires a different design method than large industrial machinery
- Perspective or worldview: on IT, systems design, design values, and the roles of designers and users
- Guidelines: techniques, tools and organization principles, see (Andersen, 1990; Bratteteig, Bødker, Dittrich, Mogensen, & Simonsen, 2012).

The application area in our case is a design of public interactive installations in the context of children's museum. Our focus is both in exploring how children can participate in making general contributions to planning of a museum space as well as the design result itself. The perspective is that of co-design, trying to come closer to PD by finding ways to represent children's views as accurately as possible. The guidelines include a set of techniques and tools from co-design and PD, adjusted for use by children. The techniques used were the common ones: prototyping (mainly low-fidelity, both with and without technology), design workshops, scenarios, contextual inquiry, generative tools, mixing of ideas, and brainstorming.

The C2C method is mainly characterized by its principles of design process organization, which distinguishes it from other methods. In order to involve young children and represent them well in decision making in design, we developed a two-step model. The first step is to develop a design team by establishing a core group of school children, all with interest in design and give them experience in participating in design activities with adults as co-designers. The second step is a design process where the design team – which includes the core children group and adult designers – engage in design with children users and testers. This user group of young children participates in design mainly through testing prototypes developed by the design team, but we were always open to include them as informants to design as well. Several iterative cycles of design with both groups of children participating in different parts of the analysis-design-evaluation cycle will typically be needed in order to arrive at a final design. The process may be represented as shown in Figure 1.

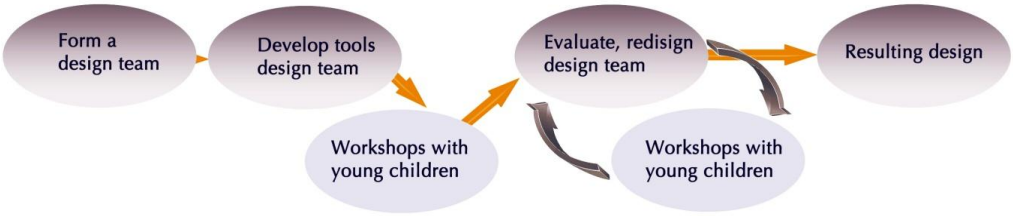

Figure 1. Overview of the C2C process by its organization.

We included children aged 8-11 in a core design group. These children are at the developmental stage when a gradual shift from fantasy to reality occurs, sense of logic and reasoning grows, and they are capable of making abstractions (Markopoulos et al. 2008). Yet, they remember how it felt to be young, usually all the way to when they were a baby. Younger children, up to the age of seven, pass through several developmental stages. We found that for C2C method, children aged 3-5 are the best choice in terms of development. Children younger than three years may be difficult to recruit and engage. Children aged six and seven may be developmentally too close to the design team children. We next discuss how the method was used in practice.

4. DESIGNING THE BOOK NOOK

The Book Nook is part of Children Museum's conceptual master plan. It is situated under the roots of museum's iconic piece, "The World Tree" exhibit, see Figure 2a). The Book Nook is envisioned by Children's Museum as a repose space for parents and young children while the older siblings climb the tree, Figure 2b). As depicted in Figure 2b), the basic planned interaction in this space involves a parent reading a book to a child, or a child browsing books alone. A design brief from the Children's Museum was to make interactions in the Book Nook richer.

Figure 2. a) The Book Nook, a part of the World Tree Climber, as conceived by the Oslo Children's Museum project team, copyright Oslo Children's Museum. b) The Book Nook close-up.

4.1 Forming the Team

Two product designers with specialization in interaction design, an interaction designer with human-computer interaction background and a museum curator were the adult participants in the study. The traditional design practice approach was used to understand the problem space: context mapping and brainstorming. The outcome was the understanding that reading would be difficult in the Nook. With noise from the World Tree climber, and potentially several parents reading at the same time, it would not be a quiet place. Thus, already after the first session it was clear that the concept of the nook would have to change. We needed the children to find out how.

The next task for the adults was to select and include the children into the design team. Since there were four adults, we decided to engage four children. With eight members of the team, we could also work in various group settings, e.g. two adults and two children could form a smaller group under design sessions. The children were aged 8, 10, 10 and 11. The oldest child participated in a single iteration of the process, while the others participated for the whole period of 12 weeks. The team meetings took place in part at home of one of the researchers and in part at the university lab. They lasted around 2 hours (45-minute prototyping sessions, followed by a 30-minute break typically used for tasty snacks thus avoiding the problem mentioned in (Knudtzon et al., 2003) of mixing the work and the pleasure, and then 45-minute evaluation sessions).

4.2 The Design Modules

The design teamwork was organized in modules. One module consisted of a design and evaluation session conducted by the intergenerational team, followed by roughly 2 weeks of developing prototypes and tools for the workshop with young children. Mostly adult team members did this work. The workshop with young children signified the end of one module. Each module built on the key lessons learned from the previous module, key lessons discussed with all members of the intergenerational design team. This process was repeated in four iterations, followed by the final prototype testing. Next, we describe the four modules and the final prototyping session.

4.2.1 Module 1: Exploring the Concept of a Book

The first design team session had as an agenda getting to know all the design team members and discuss the concept of the Book Nook. We used an iPad as a tool to talk about books and interactive books with children. We tried the ICDL application based on (Druin et al., 2003), an interactive version of Alice in Wonderland ("Alice for the iPad," 2013) and, finally, Puppet Pals ("Puppet Pals HD," 2013), an application that enables children to direct a puppet theater piece with preset character sets with the possibility to make one's own characters and scenes. The children participants were familiar with these applications from before, but not all the adults. We discussed what kind of "reading" is more fun: browsing a book, using an interactive book like Alice, or actively creating a story with Puppet Pals. Our older children team members gave us the following insight: Alice gives fewer interaction possibilities and modalities of interaction than Puppet Pals, therefore was less interesting after a while. In Puppet Pals, the voice, the movement, different backgrounds and objects of their choice could be combined, which encouraged more active and creative story making. Thus, the first research question was formulated: how to inspire young children aged 3-5 to engage in story making?

The children's input in this session was significant. It helped raise questions around what makes a story-book vs. what makes a story and how children's stories can be "captured" and shared, given that they still cannot write. If a book is a collection of pages bound together, could we build entirely different books, whose pages occupy space in a different manner than in traditional books? As a consequence, the adult part of the team designed a generative tool set, inspired by (Sanders & Stappers, 2008; Sanders, 2000) and shown in Figure 3, that could help us research these questions.

The next step in the module was to hold a workshop with young children and collect empirical data on young children's experiences and interactions with the artifacts of the domain (books and stories) and the overall domain understanding. Further aim of this workshop was to gain an idea about the interests and skill set of children of 3-5 years of this age, belonging to a particular cultural setup. The design team wanted to gather information about the nature of activities that the children of this age group found interesting and engaging. Additionally, how the children brought the experiences from their home to their play.

Keeping in mind the behavior patterns of young children (Montemayor et al., 2004; Sanders, 2000), we allowed the tools that were carefully chosen to open for creative involvement and open-ended activities, to work their magic and show us the young children's play patterns, story building and storytelling behavior.

Figure 3. The first workshop with young children: connecting the dots, boxes with generative tools, children making props and finally, playing with them.

The initial workshop with young children was not very different from what is described in literature, e.g. (Alborzi et al., 2000; Montemayor et al., 2004). The workshop took place in the kindergarten. Two boys and a girl were selected by their teachers to participate. Since the children were meeting part of the design team, three adults, for the first time, an icebreaker was used to make the children comfortable. As an icebreaking activity, everyone sang a song together where each person had to tell his/her name and which animal the person thinks he/she is and then make the sound of that animal. This icebreaker was effective, names were remembered and children seemed comfortable. The first activity with children was a simple "join the dots", see Figure 3a). This activity was based on Munari's Flight of Fancy (Munari, 1998), where joining the dots was open ended and allowed each child to connect the dots into any form they wanted to. The design team prepared a set of sheets with dots printed on them at random. Thereafter, generative tools designed specifically for this workshop were given to the children. Each child received a personalized box, designed to give the participant a sense of ownership and create interest and curiosity towards its content. The content of the box was chosen to promote creative and expressive play, engaging the children in production of characters and consequently, bringing out behavior patterns related to story-making. Each box contained materials such as colored sheets of paper, felt, yarn and some re-used articles with unique textures such as egg boxes, a hand-shaped piece of velvet, plastic eyes, crayons, etc.

Everything was easily recognizable and instantly usable, no instructions or tools needed. The choice of the material was guided by an aim to incorporate a multitude of textures into the toolkit, inspired again, by Munari and his workshops on educating children regarding the tactile sense (Munari, 2004). The workshop and the activities were exploratory and open ended by design. First thing the children did with their boxes was to write their names on them. The textured material in the box fascinated all the children, but none chose to play with colored sheets of paper they received in the box.

The children explored the content, while the team observed passively for approximately 30 minutes. After that, the children were handed additional tools: hobby scissors and glue. They were asked to make a character and then tell a story about that character.

As expected for their age, each child made his/her own character, without any collaboration with other children. One of the children made two objects: a character and a spaceship. When done, the children spontaneously began to play with their characters and each other, speaking for the character they made. The children lost interest in answering questions or telling us stories about their characters. Instead, they became very engaged in making environments for their characters, possibly inspired by the spaceship. They used the remaining materials to make these environments. We found this behavior pattern to be of interest and wanted to explore deeper how characters might move through the story, physically in this case.

4.2.2 Module 2: Design Team Building and Tool Improvement

During the second meeting with children co-designers, we discussed what went on in the workshop and showed the video and the pictures from the workshop. Sitting around the table, we used an iPad again, plus several additional paper representations of the iPad. We all started playing with making scenes on the iPads. The children used two paper iPads for which they created different backgrounds, kept them next to each other, and then used real objects to move them from one iPad to the other. This extension across space was another key factor that shaped the 3D storybook. It led to the design of connectable boards. The next workshop with young children was to test how these work for storytelling.

The second workshop with young children was again exploratory in nature. The goal this time was to closely observe the relation between the environment story characters live in and their movement across different scenes, one scene corresponding to one page. The generative tools for this workshop were connectable boards, images, crayons and glue. The boards were brightly colored, see Figure 4. The boards came with a packet of images that the children could use and arrange on boards in various ways in order to tell a story. These packets were personalized for each child. The pictures were showing objects that are easily recognizable by children e.g. houses, trees etc. They could be glued onto the boards. We were interested in finding out how these tools were to be used, along with the characters they made previously, to tell a story. We imagined that they would be making a story as they connected the blocks. The lesson we learned from this workshop was that the connectable boards were used fully in the spirit of Lego blocks: to build. The pictures were not at all used for storytelling. As can be seen in Figure 4, some images were placed upside down. The hand drawings on the boards were not connected to any story either – they were simply used as decoration.

Figure 4. The children built environments for their characters. However, the pictures were used as decoration on structures and not to support the story.

4.2.3 Module 3: Exploring the Concept of a 3D Book

In the third session with the design team, after discussing the workshop, Munari's book (Munari, 1994) was used as a prop to bring the discussion around the book form further. The book consists of many loose pages with differing levels of transparency, so that one could add elements to the story by placing an opaque page at the bottom and then adding other transparent pages on top in order to create a scene around which stories may be told. Subsequently, the mixing of ideas approach (Guha et al., 2004) was used and the design team was split into two groups. One group included two children and two adults, and the second included two adults and one child. Both groups got the same tools as were used in the workshop. The only difference was that the majority of the boards for our discussions were plain cardboard, not very colorful. The task was to turn boards into "book pages" that may be placed in three dimensions, but at the same time, represent parts of the story. We wanted to encourage using fewer boards, yet enabling richer content.

Open-ended play was used as a method to get everyone involved in a brainstorming process. The older children, quite like the younger ones, found the connectible cardboards very interesting and began playing with them. One child found scissors and started cutting through the boards to make movable parts like doors and windows. Suddenly, the characters could move within the structure, adding new interactions to the play. The whole team recognized this as the next key improvement to the generative tool, see Figure 5.

Figure 5. a) The team, discussing the group work. b) The detail of the witches' house

Taking inspiration from pop-up books, the design team decided to make story elements using origami. Origami was chosen as the medium for story elements since it is three-dimensional and could be moved across the blocks. Origami could easily be placed on and taken off the board. Together with movable parts such as the doors of a house or the tail of a dog, richer interactions with of the board could be enabled. This time, connectible boards were given a neutral color in order to bring attention to origami. The neutral colored connectible board and origami story elements were the generative tool for the next workshop with young children.

Testing this approach with young children was carried out in two workshops; the second one just continued where the first one stopped, as we simply needed a bit more time with children. We started by observing how young children use plain boards with detachable origami as 3D storytelling elements. The change in the way children played was significant. None of the children attempted to build houses and all included origami as elements of the story, sometimes drawing things in addition, see Figure 6. The boards were connected so that their stories could unfold naturally. Also, the way the children connected the boards in three dimensions was different. This time, the placement of the boards followed the spatial logic e.g. a board with an airplane was placed highest conveying that the airplane was high in the sky. Or, the board with a monster was placed behind the board with a house, indicating that the monster was inside the house. The children were starting to create book pages, creating physical connections as the story required. Yet, pages were not connected linearly but placed in three dimensions.

The data gathered and behavior observed at this workshop led us to believe that the concept of creating books in three dimensions might be an exciting direction to take.

Figure 6. a) The third workshop, children starting to tell stories using the boards. b) Trying out different connectors for boards during the additional hour with children.

For the second workshop with the same tools, we slightly changed the boards, making them a little more complicated to connect but allowing for a greater variety of connections. Rubber bands were used as connectors, see Figure 6b). The children were able to do this, but it took a bit more time and required greater focus. As a result, the interest weakened. This session helped to understand how complexity of the form directly influences the play.

4.2.4 Module 4: Concept Development and Technology Prototyping for the Nook

The module 4 started as usual with review of the workshops. The task for the design team this time was a concept development for the exhibit, more specifically, shaping of the "book pages" and interactions they would allow. Up to this point, story elements used in the workshops with young children were elements from their environment, a house, a dog, a sun and like. Throughout the length of the project, prototypes of different levels of fidelity and interactivity were integral to the concept development. After successfully testing the use of boards with origami with young children, a workshop was conducted with the team to further develop the concept. One of the strong directions that emerged in this workshop was to evolve the dimensionality of the boards by adding detachable characters that could 'speak'. In addition, it was noticed that detachable characters would need to be sturdy.

To test the new ideas about the added dimensionality and layering the characters with unique behaviors, higher fidelity prototypes needed to be built with functional technical elements. The new high fidelity prototypes consisted of two parts: interactive boards and character props. Adding the electronic circuits to the boards had a natural side effect of increasing its size and weight. The boards were re-built as cardboard enclosures, re-used chocolate boxes, and a new connection mechanism was developed for these boards considering its new form and weight. Strong neodymium magnets of opposing polarity were used on each edge and the back faces of boxes. The detachable character props were built out of felt with an RFID chip and a magnet inside them to make them more durable and completely wireless. The magnet was used in conjunction with a wire-mesh placed inside the storyboard's face, allowing the children to stick the characters on the boards if they wanted to. The mesh allowed the RFID signals to pass through and allowed the board to detect the characters and react to it. The components used to build these initial prototype boards was a ID-20 RFID reader, a Lilypad Vibe board, a programmable RGB strip and a SOMO 14D

audio playback module, allowing the character props to 'speak and light up' the boards. They were all connected to the Arduino micro-controller platform on a temporary breadboard based circuit. Appropriate sounds were chosen for the on-board and off-board characters and stored within the SOMO 14D module. The sounds were linked to specific RFID tag IDs. Lighting and vibration patterns were also designed for each on-board and off-board character and linked to specific RFID tag IDs as well. The housing for the circuit was made using customized cardboard boxes using neodymium magnets as connectors, see Figure 7.

Upon testing the initial setup with younger children we realized that the added layers of interactivity and the ability to move the characters across boards was extremely helpful for children in identifying the characters used in the story and aided them in building richer stories and increase collaboration. The primary issue we noticed was that the magnets were not as effective in connecting the blocks as our earlier connection mechanisms. Magnets allowed the blocks to be connected in a specific manner only since any other orientation would lead the magnets to repel each other. Also, the connections formed out of linking the blocks together using magnets was not as strong as we had expected once the forms of the boards became complex. This was causing the blocks to fall off and topple and hence frustrating the children. Second, the breadboard-based circuit developed was not stable and durable enough to be used by young children and one of the blocks given to the children was rendered completely un-functional.

Figure 7. a) Law fidelity prototype of a block: inside the box and details, blocks with fixed elements such as the cauldron, witch's house, etc. b) The inside of a fixed element.

After the initial prototype tests, a follow-up workshop was conducted with the older children, our design partners. We realized that since the main component of the concept are story books, the content needs to be carefully designed in order to enable learning about stories and allowing collaborative and creative story generation on their own. The older children suggested that each set of boards could "belong" to some well-known story, e.g. Hansel and Gretel. Extending the same concept to three dimensions, we realized that blocks could be treated as metaphorical theatre sets, with the off-board character props acting like the actors. The on boards props help create background for the story to happen.

4.2.5 Content Development

The concept allowed for the mixing and matching different stories. Cues from different, well known stories were present as pre-recorded sounds embedded in the boards. They were triggered allowing a character to interact with a board. Each board was designed to have a unique and relevant response to characters (using light, sound and vibration).

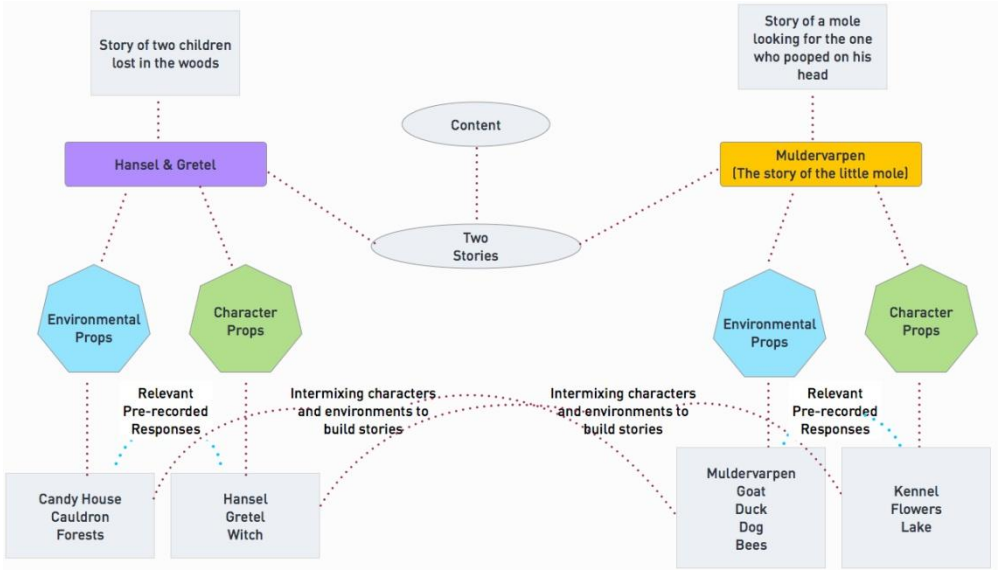

Figure 8. Concept and content for the two stories that were prototyped.

The older children assumed the role of storytellers in a subsequent design team session. All of them told their favorite stories and drew their favorite characters from those stories. Their eagerness and enthusiasm contributed to decision that the final concept for the Book Nook should use such hybrid stories and characters they were familiar with. The team chose two well known stories "Hansel and Gretel" and "The Mole" to work with further, and develop prototypes for those two stories, Figure 8.

Figure 9. a) Wooden "leaf" blocks with better connectors and b) how we envisioned them hanging from the tree.

Once the concept and content design was in place, the second iteration of the higher fidelity prototypes was built using a custom designed shield that could give durable plug and play operability with any Arduino board. The enclosure was rebuilt as well using a custom made wooden housing n the shape of a leaf, see Figure 9, using cylindrical connectors which would allow the forms to be connected to each other in 3 dimensions in any orientation and also rotated along one. The on-board artifacts were designed using felt, foam and Velostat - a conductive fabric used for packaging of electronics. This allowed the on-board artifacts to be made in the form of soft, fabric-based switches - allowing them to be interactive as well. Functionally, there was no major issue that was noted with the off-board artifacts and hence they were just redesigned keeping in mind the content framework developed with the same technical components.

4.3 The Final Concept and its Evaluation

The final concept for the whole exhibit was named "Footprints". It is an interactive exhibit that explores the book in its ephemeral, text-less form. "Footprints" views a story book as consisting of two strong elements. The first element are characters of the story, and second, the environment in which the story takes place, e.g. the cauldron, the forest, witches house. All the characters in a story book move through this environment at the story progresses and interact with different characters or the environment itself. For example in the story of "Hansel and Gretel", the characters are Hansel, Gretel, their father and the witch. Whereas the environment elements consists of the "trees from the woods", "the witch's cauldron, "the candy house". The connectible blocks are metaphorical pages of a story book which become a collection of environmental backdrop of a story. The analogy come from that of the plays in theatre with different sets prepared for different scenes. Each block has one or more environmental elements attached to it, giving it a meaning. The characters from the story books are kept free. They can stuck on any of the boards and light and sound feedback received on doing so will be according to the environment and the character. The intention behind keeping the character separately was to facilitate intermixing of different characters with environments from different story blocks kept in the museum installation. The installation aims to enable children to make their own version of stories from the ones they have read or heard before. Additionally, parents can be involved in the installation telling some of the old stories through these blocks and characters which the child might not have heard before. This installation consists of a series of blocks that function like the pages from a book. These pages have connectors that enable the child to connect them in three dimensions. Each page has a "fixed character" that is permanently attached to the block. However, the orientation of these fixed characters can be altered, they can rotate. In addition, a set of "free characters" was made. The free characters could be moved anywhere on the board, as well as between boards. All these (free and fixed) characters are based on popular children's stories. For the purposes of prototyping, the stories, as mentioned, were "Hansel and Gretel" and "The Mole". The ability to add pages in three dimensions allows the children to position elements of the story spatially. For instance, the sun can be positioned on top of a house while a tree can be positioned next to the house.

The circuit inside the boards is designed so that it can identify the character placed on the surface of the board and when the character is moved around on the surface, the board generates unique sounds specific to the character and in some cases light and vibration as well,

adding to the overall interactivity and engagement of the child in the system. When the child pokes the fixed characters, they trigger a sound and light response specific to them as well.

Upon completion of the prototypes, we organized a workshop with the adults, older children and one young child.

Figure 10. a)Testing the prototypes with team children and a target group child. b) Tangible interactions surface.

The purpose of this final high-tech prototype testing was to make a quick evaluation whether the added interaction improved the user's experience while playing. Also, we wanted to see if interactive characters from different stories would be used together to make stories that expand/build upon existing stories. Footprints prototypes consisted of two parts: interactive storyboards and character props.

The prototypes were given to the young child. The child was surrounded by our team members who engaged the child in story-making and demonstrated the features of the system. All of the team members started to connect the boards like they did with the low level prototypes and make stories in three dimensions. Sound and light responses added to the play for the youngest child. The child thought that the effects were cool and repeatedly played the sounds and recreated the scenes over and over again. Other children playing with prototypes (Figure 10) narrated the stories and increased the effect of their words with sounds. For example, one child said: "It was raining hard, and you could hear the lightening" – at this moment, the child pressed on the cloud with lightening and the sound played for a few seconds. Cross narratives between the two stories were made instantly and spontaneously.

The final concept for the Book Nook is shown in Figure 11. We envision an immersive environment that will stimulate creative and engaging storytelling, both by children and adults.

Figure 11. The exhibit as the intergenerational team conceptualized it. The blue surfaces of the tree trunks are actually surfaces for tangible interactions as depicted in Figure 10 b).

5. DISCUSSION

The C2C method is designed as a PD method (Bratteteig et al., 2012; Bratteteig & Wagner, 2012) utilizing PD techniques and tools aimed at involving children as co-designers. Our approach is different from other approaches also called C2C, where the point is that children designers make artifacts (e.g., games) for other, younger children (Kafai, 2003). In C2C the principles of organizing the design work were inspired by Druin's long-term work with children as design partners (Druin et al., 1998; Walsh et al., 2010) but with a more pragmatic and shorter term approach. Workshops were arranged with young children, involving the same children in subsequent workshops, to provide for the possibility of deeper commitment to the design result. As related to Druin's roles of child-designers (Druin, 2002), the older children in the C2C method had the role of design partners. The older children in the design team played a crucial role in the process and contributed major insights. Some examples of such insights are movement of objects across pages (interactive surfaces) providing a novel way to structure the story, the interest in better kept with objects that are self-constructed etc. The younger children in the user group mostly played roles as testers and users. The younger children's design ideas had to be "translated" by the design team into solutions. All of the children, however, influenced design decisions. A good example of the younger children-users influencing the process was their rejection of the "improved" board design shown in Figure 6b). The "design decisions" that this age group makes are much more embedded in their actions and attitudes than in their words; nonetheless, their message was very clear. As users and testers in the design process, their participation was invaluable for the project. They gave us first-hand experience of how they approach storytelling and which elements could be used as design elements, leading to the decision to make a story character-based – a concept based on the children's current undeveloped reading ability. Careful anchoring of the visions with our children design team, and the sharing of visions throughout the project was crucial for making a Book Nook that fit with the logic (and abilities) of the young children.

This design brought about major changes compared to the initial concept envisioned by City Children's Museum from Figure 2b).

Some of the contributions by the design team children, such as cutting windows and doors on the witches' house (Figure 5b)), were key contributions to our final design. The true test of how well the design team children interpreted and represented younger children's logic was very visible in the first workshop in Module 3. The result was a full success, encouraging further investment in the 3D book idea. Another very important, direct contribution from the design team children was the sound and light effects on the boards. The children and the adults worked well together, showing mutual respect during the entire project.

Our work demonstrates that it is feasible to engage children in real exhibit design processes. The two-group organization of the C2C design method provided important contrast, balance and confirmation in the design inputs from the two groups of children. We believe that children were more adequately represented in the Book Nook design process using the C2C method, than they would be with any other method given the time constraints and without a well- established lab or school-like setting. One of the major themes in this project has been whether it is possible to engage young pre-school children in PD as co-designers – or are they too young? Our two-group organization is a method for involving less articulate or more vulnerable user groups who do not fulfill the preconditions for standard methods or organizing principles. Young children are one such user group, who cannot read or write, and whose cognitive development is different from the abilities presupposed for most tools and techniques for systems description and presentation. The translation and representation made by the older design team children enabled the design team as a whole to get a better grip on the young children's logic and perspective, hence "translating" the visions into forms and functions that small children could understand and use.

In the introduction we described PD as "a design approach [that] emphasizes users' influence in all stages of the design process" emphasizing that future users are given a voice in the design and that "they are also given power to make concrete design choices". Do these definitions fit the C2C process we have described? Yes and no: We will argue yes because the process as well as the result can be characterized as participatory, and no because the process did not give all the children "power to make design decisions" in a literal sense. In the Book Nook design process, the design team and all its members (adults and older children) represented the smaller children and took design decisions on their behalf. The smaller children were given a voice in the design through techniques and tools that were designed for exactly this purpose. But having a voice is not the same as having a say: the small children did not make design decisions themselves. However, the way that the design process was organized gave the smaller children a say even if they were absent in the design decision-making situations of the design team. The design result: the interactive 3D book space was designed for small children following their logic of interaction. A book nook that works for smaller children would not be possible to design without their participation, hence their influence is possible to recognize in the final result. (Bratteteig & Wagner, 2014) argue that these two elements: 1) a design result that gives a weak group a stronger voice, which 2) had not been possible to achieve without their participation in the design process are sufficient and necessary for the design to be characterized as participatory. In this view PD does not have to include users in all decisions as long as their voice is visible and taken into consideration in important design decisions, and that their views and contributions are recognizable in the final design result. A PD process results in a design result that shifts the power in the use situation in favor of the weak group (Bratteteig & Wagner, 2014). The design of the book nook is

participatory in this sense – and includes design "for, by and with the users" (Briefs, Ciborra, & Schneider, 1983). In this paper we have argued that the organization of the design process in the C2C method with older children as full members of the design team and acting as mediators and translators for the smaller children is a way to give the smaller children a voice as well as a say in the design process.

We therefore argue that C2C is a PD method that enables the participation of less articulate groups – in this case very young children – to participate in and influence design on more equal terms and within a reasonable time frame. The two-group organization strengthens the represented logic of the primary user group by having a secondary group with more articulate users representing the primary group – this is a way to give both voice and decision power to such groups. We believe that the same organization of the design process can support the participation of other vulnerable user groups, e.g., ill, disabled or elderly people, such as for example for cases as described in (Culén & Velden, 2013; Karpova & Culén, 2013).

6. CONCLUSION

In this paper we have presented the Child-to-Child (C2C) design method for designing for children with and by children based on PD guidelines and principles. The method employed two different age groups of children: one, the target group of young children, and the other, a group of older children, representing the younger children and acting on their behalf. Design and evaluation were carried out by a team of adults and the older children where the adults and children were nearly equally represented in number as well as in influence and input to the design process. The group of young children was primarily involved in testing and using prototypes and ideas. The two groups of children in the C2C method strengthened the design result by recognizing and building upon the inputs of the other group. The young children from the target group are often not able to represent themselves as design participants on equal terms with older children or adult designers. Ensuring that end-users having a say in the design process increases the possibility for a useful – and even participatory – design result. C2C is an effective design method for increasing the influence on design results for typically underrepresented user groups such as young children. The method is particularly well-suited for design of interactive installations for children in the context of children's museums. We would like to end with quoting Cole (2009) again, as she illustrates very well why it is so difficult for adults and older children alone to design for younger children: *There were no guides and no path and no right way to go through... Stuff was simply there to mess with... One thing I knew for sure: it was not science and it wasn't a museum"* adding Friedman's comment that *"It looked really friendly. It looked like home."* Home is the safe and well-known logic of its inhabitants. Implementing the logic of small children requires their help.

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