Physical-digital Interaction Design for Children

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ABSTRACT
In this paper, we present the development process of a painting application based on physical-digital interaction. The target group was children with and without special needs.

The design was based on results from fieldwork. The results showed the importance of direct interaction – no mouse and keyboard. We then developed the application and tested it on a group of girls without special needs. This user test showed us that the prototype encouraged a playful and cooperative physical-digital interaction which evolved in to singing and dancing. And we found out that this interaction had an enormously high motivation factor and had potential in development of motor, social and creative skills.

The next step for our project would have been testing the application on a group with regular and special needs children.

Keywords
Depth field, Arduino, Interaction Design, Bodily Interaction and Social Interaction.

1. INTRODUCTION
In this paper we will examine a painting application we developed for children with special needs and regular school children as a mean for social interaction. In the development process we had a special focus on physical-digital interaction, cooperation and social interaction.

Another goal was to help children with special needs to increase their physical movement.

Physical-digital interaction is where one engages with an artifact that responds to manipulation, motion, gesture or state. We can use physical interaction to focus on movement, central to the human body [1]. Physical-digital interaction can encourage physically activeness, collaboration, creativity and playfulness [2].

The painting application was developed using an Asus Xtion Pro camera and an Arduino Board. Asus Xtion Pro creates a Depth field similar to Kinect. Arduino technology is a hardware development kit. The painting application was meant as a platform for normal children and children with special needs to interact and play socially together.

Our research question is: How can the design of a painting application enrich bodily movement, play and social interaction for children with or without special needs?

First we describe the technological platform and the digital prototype. Then we present the methods we used and how we applied them. Afterwards we describe the fieldwork and the user test we did and then we discuss the results. Finally we conclude on our prototype and the results and suggest changes to our prototype in a version 2.

2. RELATED WORK
The Kinect is used for many different purposes; some focuses on entertainment others on education and learning. The BeSound[3] tries to teach children the basic elements of composition through embodied interaction with the Kinect as platform. Kinect allows the user to interact with natural movements which places the technology in the background and lets the user keep attention on the learning.

On YouTube there are lots of examples on entertainment applications for the Kinect, like the puppet prototype[4]. Our prototype is mainly a social, entertainment application but with the possibility for children with special need to learn motor skills.

3. TECHNOLOGICAL PLATFORM AND PROTOTYPE
The technology used for this project is the Asus Xtion Pro combined with an Arduino board, see figure 1.

Figure 1 - Asus Xtion Pro and Arduino board [5, 6]

The Asus Xtion Pro makes it possible to detect movements of body parts or the whole body through the integrated infrared projector and the infrared camera [6]. One lens which projects an infrared pattern and another which captures it and thereby creates a depth field, see figure 2.

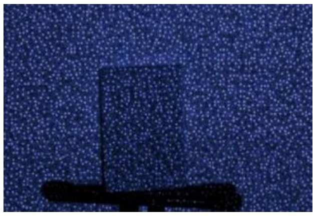

Figure 2 - Infrared Camera Technology [7]

Gestures are managed by two programming libraries called NITE and Simple OpenNI [6]. These are the libraries, which makes it possible for the camera to detect hand tracking and gestures. For the general programming of the camera, Processing is used [6]. Processing has its roots in Java, but with a more simple syntax and a graphical engine build-in.

To manage user input, a single-board microcontroller called Arduino Uno, is used. It allows you to connect all sorts of sensors and actuators [6]. Arduinos programming language connects well with Processing, which makes the combination of the two systems very easy and powerful.

We used the Asus Xtion Pro and the Arduino to develop the painting application. It facilitates playful painting activities for children. The user paints using freehand gestures. The camera detects the hand and paint, where it is placed. The graphical part of the interactive painting prototype was divided into two equal parts, see figure 3 below. The left side shows the painting and the right side shows the camera's viewpoint. This was a representation of the infrared 3D image.

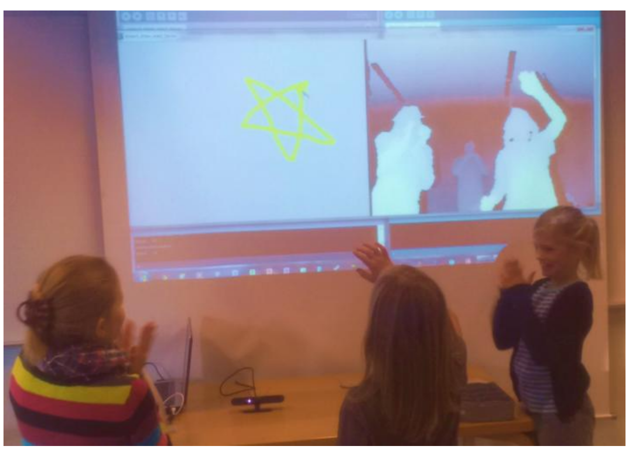

Figure 3 - Screen dump of running application.

The Arduino Board is connected to pc and offers three state switches. These manage the color of the drawing, the size of the pencil and clearing of the canvas.

4. METHOD, PLAN FOR FIELDWORK AND DESIGN PROCESS

4.1 Methods

User-centered design means that you, as a designer, not only create solutions for users, but also in cooperation with them. Users are actively involved in the research-, design- and evaluation-phases and the result usually gives a targeted product, increases the quality and reduces the risk of having to redesign the final product. We had to adapt our method to our target group; their way of understanding a system, workflow, skills, vocabularies etc. [8]. The project group made use of an iterative design process; we generated, formalized and then tested our ideas on our users. Thereafter we evaluated our test results and when problems occurred, we would start the process over again until solutions had been made [9].

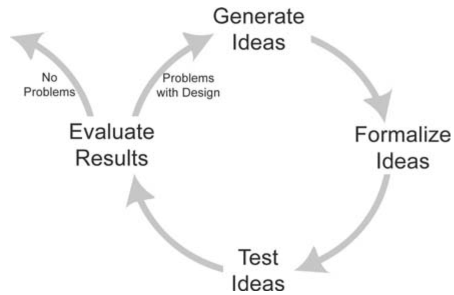

Figure 4 - Iterative process diagram [9]

Initially we used two methods for the field research: unstructured interviews and participant observation [10].

4.2 Plan for Fieldwork and Design Process

First we did field research, then we designed our prototype and did a user test: The field work was done in Pilehaveskolen; a special needs school, age 12-18. The user test was done at the Faculty of Engineering, where we had a visit from four girls, age 10-11.

We made the following plan for the field work: We had to create an alternative approach to the research because a "question-answer"-interview (structured interview) would be too difficult for pupils with special needs. We therefore chose to put more attention on observing the children and subsequently do an unstructured interview with their teachers [10]. The topics for the teachers were:

- Special needs children's way of playing and learning.
- The motivation of children with special needs

We wrote down notes and videotaped throughout the process. The project group also had physical interactive games ready for the field research [10].

Based on the analysis of the fieldwork we developed the painting prototype.

We then tested the prototype on the four girls without special needs. They were aged around 10 years. We chose to test children without special needs at this age because their maturity and ability corresponds to the special needs test group. This was gauged by the special needs children's teachers. We wanted to see how they responded, how quickly they got tired of the painting activities, how physically active they were and how much they cooperated. After the test, we did a short interview on what they thought of the different features and what kind of changes should be made.

5. FINDINGS

In this section we describe our findings from the preliminary field work and the user test of the Painting Application.

5.1 The Initial Field Study

Through the initial field study, we found that technologies without direct feedback was to abstract for them, e.g. a stationary computer, where the mouse controls the curser. The direct interaction with a tablet was easier for the children and according to the teachers; the pupils could keep focus much longer then with other learning material.

From this field study we found out that:

- They need a technology with direct feedback
- The prototype should be playable without the requirement of moving too much

This made some constrains to the project, which meant that full body gestures were excluded. We learned that they were all able to handle a tablet, in this case an iPad, which meant that they had the motor skills for hand gestures.

5.2 Testing the Painting Application

The users were very excited from the beginning and quickly learned how to interact with the interface through hand movements. They used their creative skills to draw dogs, stars and movie characters. In the beginning of the test, one of the project members had the control of inputs through Arduino, but after a couple of minutes, when the group seemed to understand the basic of the application, they were introduced to this as well. They quickly organized whose responsibility the different tasks were and then kept on playing. They began to make their own roles in connection with the game, one was painting, one managed the switches on Arduino and the rest were singing and dancing as the painting evolved.

After the test we interviewed them altogether and they suggested the following improvements:

- Basic functions like an eraser, an undo button and more color choices
- Templates for drawing different kinds of figures
- Coloration of predetermined images
- A competition to get the most points by painting the best animal or person
- Being able to draw with the feet

The feedback gave very useful answers that helped further our process on the prototype. An interesting and important fact was how long the test group could keep their interest in the prototype. Even after half an hour they were still very focused and excited.

6. SUMMARY AND CONCLUSION

Our goal was to create an application that could be used by kids with or without special needs equally, and that could also facilitate social interaction between them. We did fieldwork with special needs children in their normal school environment. Then we developed a painting application that worked by hand gestures based on knowledge from the fieldwork. Finally we tested it on a group of girls without special needs. The feedback from the test was used to refine the prototype. Our next step would be to introduce it to a mix group with both regular and special needs children. We haven't been able to do this yet.

The special needs children often benefitted from direct interaction as done in tablets.

The user test with the kids showed us that the interaction patterns developed naturally and that the application was quickly embedded in their play. Physical activity came very naturally while they ended up creating a game that incorporated both song and dance, behavior that wasn't intended in the design process.

All in all, this type of interaction has an enormously high motivation factor and it allows children to develop not only their motor skills, but also their creative and social skills. Our test with kids without special needs showed that the application could serve as a tool that facilitates a playful environment.

7. PERSPECTIVES

We see a future for this type of physical-digital interaction, also in this specific painting program format. The prototype still requires much more development before it is ready for launching. The painting program needs more content and functionality to be interesting enough for end users. Through our user tests, we found some areas to further develop functionality in. To paint in freehand without a predetermined goal is a good creative exercise, but you could also add special educational and didactic purposes, like color mixing and physical training programs. The program will have to become adjustable since our audience has very different physiological and mental baselines. These development opportunities, and many more, have we discovered through this process and we believe that there is great potential in applications like this.

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