Co-Design of Edutainment Applications with Preschoolers. Is it feasible?

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ABSTRACT
Children of nowadays are exposed to technology from their early childhood, thus becoming technology consumers. Creating the appropriate content and interaction for children will determine a better quality of the time they spend with technology. When designing for adults, the participation of the end users guarantees the success of the final product. But is it possible to reproduce the process with small children (3-6/7 ages)? In this paper, we present our approach in involving preschoolers in the design of educational software. The design teams are formed by Computer Science students attending the Human-Computer Interaction optional course.

Author Keywords
Participatory design, user centered design, preschoolers.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Human Factors; Design.

INTRODUCTION
Nowadays, children are exposed to technology from their very early childhood. Thus, they are technology consumers and must be taken into consideration in the design process. The User Centered Design approach requires a focus on the user on every step of the product design and development, while the Participatory Design requires active participation of the users in the design. Many guidelines on both approaches exist, but they consider only adult users. Although designing for children is a subject largely discussed in the literature, the age range considered in these studies is 6/8 to 12 years. Few research paper on involving small children in designing technology exist. Moreover, there are no references to designing educational software with children participation. In this paper we describe our approach in designing and developing edutainment applications that can be used as a teaching support in the public formal kindergarten educational system. A case study is presented to show the results of applying the proposed approach. The case study is performed on children aged 4-5 years (middle group in the Romanian educational system). The design and implementation teams are formed by Computer Science undergraduate students attending the Human-Computer Interaction optional course.

CHILD-CENTERED DESIGN
Involving preschool children in the design of technology is a challenging task, as children of preschool age are in the Piaget's preoperational concrete development stage. Although a large number of design guidelines for children have been proposed [3, 5, 7, 15], little attention is given to designing for preschoolers. Recent studies [3, 10] show that most of the applications consider the children aged 0 to 8 being a homogeneous group. They also suggest that the interaction techniques and content are not adapted to children development. In an effort to provide the design teams with relevant information about children development, Bekker et al. [4] propose the Developmentally Situated Design (DSD) method that uses cards that synthesize the main capabilities and limitations children of certain age expose. The method is intended for children 5-6 years old. An approach in extending the DSD method regarding the spatial learning features to smaller children (3-4 years old) is discussed in [2]. Cooperative Inquiry is another method intending to provide guidance in involving children aged 7 to 11 years [6]. Adaptation of the method can be used for children of age 4 to 6, but it requires the participation of many adult experts [9].

The number of studies on preschoolers is relatively small, as there are many constraints on the physical and cognitive abilities of such young users. The main differences between preschool and school children are that preschool children cannot read or write, they cannot complete adults stated tasks without being rewarded, and their main activity is playing. All these differences add new constraints on the design of interactive applications for preschool children: the applications should be conceived as games or at least they should expose games-related characteristics in order to be suitable, they should not use written output and they should not require written input. The interaction of the children with the applications should require basic (fundamental) computer skills: pressing a key on the keyboard (space, enter, arrow keys), moving the cursor on the screen or clicking. Moreover, if we consider that the main goal of

edutainment applications is to teach children new things, new constraints on children participation arise.

EDUTAINMENT APPLICATIONS FOR PRESCHOOLERS

Edutainment software possesses educational content and an entertainment model, being a promising perspective in education support. The benefits of appropriate computer experiences for young children are:

- It provides opportunities to acquire and construct knowledge through active participation.
- It provides a holistic learning environment in the sense that by exploring virtual environments they acquire knowledge and skills in different domains of development.
- It promotes intrinsic motivation to learn by providing children with challenge, control, fantasy and feeding their curiosity.
- It provides children with scaffolding that enables them to acquire skills faster [8, 14].

Developing edutainment applications means focusing on two aspects: the educational aspect and the entertainment aspect. To do this, the participation of two categories of users is needed: the kindergarten teachers that will guide the content design, and the children that will guide the entertainment aspect of the products and will tailor the educational part. We have previous experience in involving kindergarten teachers in the design of educational applications for preschoolers [11, 12, 13]. Still, some aspects that we have identified while performing evaluation with real users (preschoolers) showed us that the participation of only the kindergarten teacher during the design process does not cover all the relevant aspects of little users' characteristics. For example, some task statements haven't been understood by children although they seemed very clear for the adults: *Find the objects that have the same color* resulted in children pointing with their finger on the screen. As such, the task has been reformulated into: *Select with a click the objects having the same color*. To overcome similar situations, we decided to involve preschoolers in the design process as early as possible.

PARTICIPATORY DESIGN WITH PRESCHOOLERS

Method

Participatory design, cooperative-design or co-design is a design approach where the users are invited to cooperate with designers, researchers and developers during an innovation process. They participate in several stages of an innovation process: during the initial exploration and problem definition in order to to help define the problem and to focus ideas for solution, and during development in order to help evaluate proposed solutions [16].

Because of the educational goal of our applications, in the initial exploration step we have involved only the kindergarten teacher. It was a necessary step to understand how the required products should be used, and the problems in the current situation, where there is no interactive support for teaching activities in the public kindergartens from Romania. Also, the subjects of the edutainment applications, the goals of the interaction with the applications and the tasks children should perform were initially stated. In order to create suitable solutions for our little users, the design teams participated in field studies in the kindergarten. Each design team has observed and interacted with the children for 15 minutes (see Figure 1). The goal of field study sessions was to really understand the knowledge children possess on the domain of each application, to assess their digital skills and to understand their capabilities and limitations. The members of the design teams were recommended to consult the Curricula for preschool children and Bloom's taxonomy of learning objectives. In this step, children have been involved as informants (they gave information on their knowledge, preferences, digital skills).

Figure 1. Field-study at the kindergarten

In the next step, the design alternatives, only the kindergarten teacher participated. The teams have presented their design ideas as sketches, sometimes very abstract and difficult to understand even for the kindergarten teacher (see Figure 2). Children aged 4 have difficulty in taking part to participatory techniques, including drawing, that is why methods as Cooperative Inquiry [6, 7] and Mixing Ideas [9] cannot be applied without modifications. Still, we have required the teams to generate three different design ideas that have been presented to the kindergarten teacher. Mixing Ideas has been applied for the proposed design alternatives, and after the discussion with the kindergarten teacher the selected design idea incorporated parts of the proposed designs and the kindergarten teacher feedback.

In this step, the process is still child-centered by using a *surrogate*. This surrogate for the preschoolers should be an education expert like a kindergarten teacher or psychologist that knows their capacities, limitations and interests. Involving children in this step would be possible if all design teams would have the talent and availability of

presenting their design idea in an appropriate fashion, as in Figure 3. Still, it would require a lot of time to explain the children the role, intent and interactions with each element on the screen mockups.

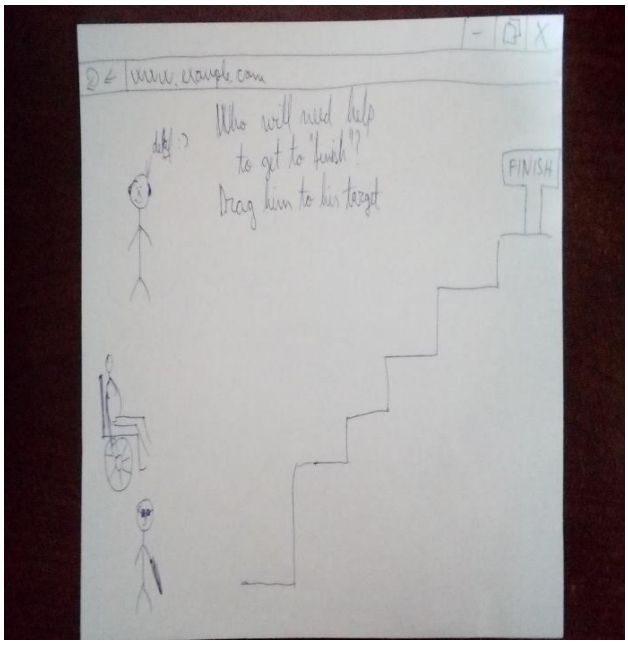

Figure 2. Abstract alternative design sketch

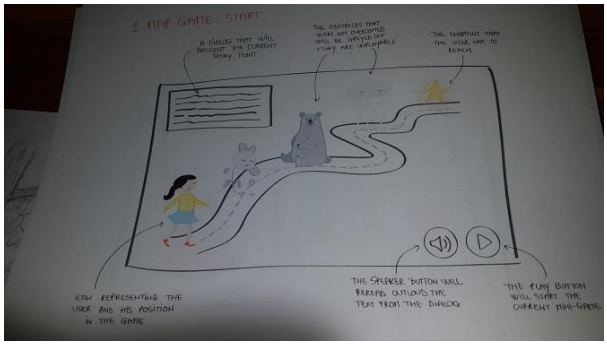

Figure 3. Children appropriate alternative design sketch

The prototyping step benefits the participation of the preschoolers, playing the testers role. In this step, high-fidelity prototypes are assessed by the children. The relevant information acquired from this step is related to the difficulties the children have while interacting with the applications, their attitude toward the built products (e. g. having fun, being curious, getting bored). In this step they play the users' and testers' roles, providing information on the content, interaction and engagement while using the product. Preschool children can participate in this step only if high fidelity prototypes (executable versions) of the products are presented to them.

In the evaluation step, the children act as testers of the products. They participate in play-testing sessions, peer tutoring and post-interview sessions.

Figure 4. Play-testing session for Sailing on the Sea application

This way, preschoolers participate in every step of the product design and development, except the design alternatives step, where they are represented. In this step, their cognitive limitations pose limits on the co-design process. Even they are not actually involved, they can be successfully represented by educational experts.

Case study

We have applied the presented co-design method in the development of edutainment applications for preschoolers aged 4-5 years, attending the middle group in the Romanian public formal educational system. Applications on the following subjects have been developed: *the autumn, the tree through all seasons, fairytales heroes, the human body, fruits, insects, discovering the cosmic space, sailing on the sea*. Each application has been developed by a team using the above presented co-design method. The tasks children perform in these applications are related to counting, sorting numbers and geometrical shapes, choosing objects with a certain property (color, size), and maze solving. The evaluation of the developed products focused on two aspects: the educational part of the applications and the engagement of the children. Each application has been assessed by 3 to 5 children of 4 to 5 years. All children attending the middle group have participated in this step. Each child has participated in the evaluation of any application they liked. The evaluation took place in the kindergarten classroom. Members of the design team and the kindergarten teacher observed the children while interacting. The children had the freedom to join the evaluation when other colleagues were interacting. Thus, spontaneous peer tutoring took place and we have encouraged children collaboration to get knowledge about their understanding on the goal of the application.

Children engagement was evaluated through play-testing sessions with individual children (see Figure 4). Each application was assessed by two children, in individual play sessions. Some applications have been assessed using peer-

tutoring such that think-aloud protocol has been simulated (see Figure 5). Smileyometers have also been used to assess the children satisfaction (see Figure 6), followed by post-interviews. The post-interviews contained questions like: *would you like to show/play this game with your best friend*?

Figure 5. Peer tutoring session for the Fairytales heroes' application

The educational part of the application has been evaluated by twelve kindergarten teachers using a heuristic approach. We have chosen to use an adaptation of HECE [1]. We have asked the experts to evaluate the heuristics sets from the CUH and LUH components related to children appropriateness and learning support of the final products. Each application has been evaluated by two kindergarten teachers. All applications have successfully fulfilled the heuristics from the CUH and LUH components.

The NUH heuristics set has been evaluated by the master students attending the Design of Interactive Software Systems classes. Groups of 3 to 5 students have assessed each of the before mentioned applications. The most frequent problem in all the applications was the lack of consistency (widgets on the screen placed in different positions from one screen to another). Other problems that have been revealed were related to the lack of clear exit options, the lack of control on the navigation (children can't navigate back or forward in none of these applications). However this was a requirement of the kindergarten teacher to train the discipline and patience (children have to listen the stated tasks and go further only after completing the tasks).

Figure 6. Smiley-meter example for the Sailing on the sea application

Results

The results of the play-testing sessions showed that the children enjoyed using the applications. At the end of the applications testing they were always asking to play again the "game". The use of smileyometer was new and exciting for the children. Although they were instructed to use the smileyometer to assess only one application, they have used the same smileyometer to assess more than one application, but using different marking symbols. The peer tutoring sessions convinced us that children understand the goal of the application and that the behavior of the application is consistent and predictable.

The heuristic evaluation has revealed the power of co-design with the kindergarten teacher participation. All kindergarten teachers fully agreed and successfully evaluated the CUH and LUH components of the heuristics.

The problems revealed in the NUH component of the heuristic are due to the lack of experience of the design teams in applying Norman's heuristics and also the lack of more development time.

We can conclude from our case study that co-designing with preschoolers is possible and effective. The need of support from an educational expert is obvious in some design phases, if we think about the capabilities of 3-4 years children, but the children remain on the center of the design process.

DISCUSSION

We have presented an approach in designing edutainment applications for Romanian preschoolers aged 4-5 years. The applications are intended to be used in the formal teaching activities from the public preschool educational system. We have focused only on the process of building the interactive applications and we did not assessed the educational impact of the developed applications yet. This work can be used as a guide for other researchers intending to develop educational applications for preschoolers and for instructors that intend to teach interaction design for children to Computer Science students. In our approach we have used influences from Cooperative Inquiry in the sense that field observation has been performed in the users' environment (kindergarten classroom). In the design alternatives step we have used Mixing Ideas approach, first by requiring at least three alternative designs from each design team and then, with the help of the kindergarten teacher we have chosen a design theme that was further implemented by the design team. There are many aspects that have constrained our approach. The first and most important one is related to the amount of time students are attending the Human Computer Interaction course, which is a one semester course (14 weeks). The other constraint is related to the amount of time the design team had to meet their users, and this is restricted to a three hours interval (from 9:00 AM to 12:00 AM), due to the kindergarten program. Field study has been organized in two sessions (two consecutive weeks, one day per week) where multiple design team members have observed and discussed with the children at the same time. Each team had allocated 15 minutes to observe and interact with the children, such that each team had the chance to meet the end users. The design teams have met the kindergarten teacher for guidance and feedback three times at the faculty and two times in the kindergarten. During the evaluation step, we have also had time constraints for the same reasons mentioned before. We consider that more relevant results on our approach would be obtained if a smaller number of design teams will apply the design process at a time. At this moment, we could solve this problem only by involving more than one kindergarten teacher in the process and more supervisors for the design teams. Involving more kindergarten teachers in the process is difficult as there are many reasons they are reluctant to our proposal:

- They consider they are not smart enough to guide the students;
- They consider it is a very time consuming task;
- They are not confident that students will accomplish their tasks and deliver a usable product.

Based on the above presented arguments, we consider our approach being time-effective and at the same time child centered. Involving the children in the design alternative step is desirable, but at the same time, in the current context is impossible. Taking into consideration the fact that the children are very small, they do not have extended drawing capabilities and neither extended communication skills, it would take a lot of time to make them generate and express design ideas. Moreover, the educational goals of the application restricts their participation with design ideas. Also, the componence of the design teams (unexperienced members both in interaction design and children development) brings new constraints. The design ideas are expressed using paper based sketches, or mockups of the screen with abstract representations, such that it would take a lot of time to present them to a 4-5 years old child. If the members of the design team possess design skills, then the alternative design step could involve the children in an enjoyable manner (see Figure 3).

The limitations of our study are: the lack of experience of design teams, the limited amount of time when the children can be visited by the design teams and the constraint to design, develop and evaluate the applications during only one semester, and the participation of only one kindergarten teacher. Improvements could be obtained if many kindergarten teachers accepted to participate in case studies and guide the design process.

CONCLUSIONS

In this paper we have presented an approach in developing edutainment applications using a co-design method with preschoolers. We have validated our approach by a case study on eight edutainment applications that benefit the acceptance of children and kindergarten teachers also. In the future we intend to evaluate the results of our approach in terms of educational outcomes and in terms of digital skills acquisition.

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