# An Integrated Approach to Design and Assess Edutainment Applications with Preschoolers

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**ABSTRACT**

The continuous technological progress and the context of COVID-19 pandemic have created the premise and need to use technology much more often in the learning and education process, even for preschool children. However, appropriate educational resources, corresponding to preschoolers' curriculum, are almost nonexistent in Romania. Motivated by the last results of the digital skills assessment of European citizens, especially the poor ones from our country, we have investigated ways of introducing fundamental digital skills to preschool children. In this paper, we describe our child-centered design approach that we have used to develop edutainment applications for preschoolers. We discuss how the children were involved in the design process and in the edutainment application's usability assessment and the challenges we have encountered. We also describe the innovative way we tried to overcome these challenges due to the young age of the children and their limited capabilities. In the end, based on our experience, we give an initial proposal for a competence based approach in assessing digital skills development for children.

**Author Keywords**

preschoolers; participatory design; edutainment; User Centered Design; usability assessment

**ACM Classification Keywords**

K.3.1 Computer Uses in Education, Applied computing~Education~Computer -assisted instruction

**General Terms**

User characteristics; Design; Applied Computing

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## 1. INTRODUCTION

Nowadays, children are born and grow up surrounded by technology. They are called digital natives and it was scientifically proved that they are physiologically different than the previous generations [33]. Presently, most children are used to be surrounded by digital devices from an early age, but when they attend formal education institutions they discover that learning is performed using different methods, that usually do not integrate technology. This discrepancy should be removed, such that learning in the familiar environment and learning in the formal institution become consistent. Furthermore, education should keep up with the technological progress and it should integrate into the learning activities the various advantages technology could bring, like multimedia content, virtual or augmented reality, and stories and movies related to school subjects.

Moreover, in the European Union, it is stated that 90% of the future jobs will require digital skills, while the assessment of digital skills in the young citizens shows that there is a huge difference between the expected level of digital skills and their real situation [17]. These results show again that the development of digital skills should be supported by education to be equally accessible to a large number of children and young people. Besides, nowadays it is considered that digital literacy is equally important to reading and numeracy. Currently, in our country, Information and Communication Technology (ICT) classes are taught in the formal education systems from the primary levels. But, considering the context in which the preschoolers are born and grow, we consider that seeding the fundamentals of digital skills starting from kindergarten is feasible and desirable. The COVID-19 pandemic has also shown us that teaching children how to interact with technology becomes a must, and that educators and children should be prepared for remote learning. The unexpected situation brought by the pandemic has shown that beside the lack of digital skills of the teachers there is also a huge lack of digital resources appropriate for young children (3-6 years) that could be used in the online teaching activities.

Designing educational applications that could be used in the preschool formal educational system is a challenging task, due to the small age of the children and due to the educational goals that should be covered. These applications should be fun, to keep the children engaged and, at the same time, they should be educational. The solution that could ensure both aspects is *edutainment applications* for preschoolers. The success of edutainment applications is composed of the following: children's acceptance and engagement, teachers' acceptance and effectiveness from the learning perspective. The edutainment applications should teach children the same knowledge the classical methods do. We consider that by involving both children and teachers in the design process and by focusing the design on the end users, namely the preschoolers, we can obtain appropriate products.

In this paper we describe our participatory design approach for edutainment applications for preschoolers focusing on the steps where preschoolers have been involved, the challenges we have encountered, and the usability assessment of these applications. We also describe the auxiliary activities that we have performed to help children develop their fundamental digital skills and support the fundamentals of a new attitude toward technology. The contributions of this paper consist in describing a child centered approach in designing educational applications for preschoolers focusing on children and kindergarten teachers participation, presenting the evaluation methods we have used to assess the developed applications from the usability perspective and from the educational point of view, and the auxiliary activities we have proposed (optional ICT classes) to support preschoolers' digital skills development.

The paper is structured as follows. Section 2 describes the details of the participatory design (PD) with children as a particular case of User Centered Design and the roles children can play during the process. In Section 3 we describe our approach in designing edutainment applications, that can be used in the kindergarten teaching activities, with preschoolers. In Section 4 we present a complementary step that we have used to better know, understand and support children in developing digital skills in the form of ICT optional classes for preschoolers. We present our competence based approach for designing the curriculum for the ICT classes and a corresponding assessment method. The paper ends with conclusions and future research directions.

## 2. PARTICIPATORY DESIGN WITH CHILDREN

PD originated in the Scandinavian workplace and promotes workers' control over their work and their lives [4, 20]. Its premise is that users are the best qualified to determine how to improve their work and work life and that their perceptions about technology are as important as technical specifications. PD focuses on finding compromise rather than consensus as an end goal. It follows flexible practices and general guidelines; there is no standard set or ordering of practices, nor is there a preset structure for the time frame of the project. In this approach, users switch between different roles such as observer, approver, knowledge repository but also peer co-designer, design owner, expertise contributor, and self-advocate [28]. Prototyping is integral to the PD methodology since cooperative prototyping involves increased user participation and supports mutual learning by promoting cooperative communication, thus reinforcing the iterative process [5].

Druin and colleagues have pioneered work on involving children within the design team. Their methods have been successfully applied in the design of story board software, digital libraries for children, computer games as well as educational software [15, 14]. Recommendations regarding PD with children include wearing informal clothing, sitting rather than standing, asking the children for their opinions and giving children time to articulate them, using informal language, and taking notes discreetly. In particular, for PD, children aged between 7 and 10 are considered ideal, due to their emerging capacity for reflection and abstraction, and their lack of preconceptions about the design domain.

Druin defines several roles children can play in the process: users, testers, informants and partners [13]. As users, children are observed using technology in order to test design concepts for future versions of existing software or to observe the process of learning. When children are testers, they use prototypes of software designed by adults and are asked for feedback such as, "What did you like?", "What was boring?" or "What was too hard?" As informants, children begin participating in the design process before any prototypes are built. They might be observed using different types of technology, asked to come up with suggestions for the design, or asked for their feedback on paper sketches. Children as informants participate in the design process whenever researchers feel that children will provide some needed information. When children are design partners they participate in similar ways as informants, but, they contribute at all stages, from the initial idea to the final product.

In most of the existing approaches PD is applied with children aged 8-12 years old [15, 3, 18, 2]. When the children are preschoolers (3-6 years old), like in our case, supplementary constraints in participation to design occur, as their communication skills are very limited, their drawing or sketching capabilities are also limited, and their focus span is reduced. Moreover, considering the educational purpose of the applications that we intend to develop we need to also integrate requirements from educational experts and provide enjoyable activities to the preschoolers. Although it may be considered impossible, young preschoolers can be integrated in the design process using familiar activities like playing, drawing, and coloring. In the next section we will present our approach in involving the preschoolers in the design of edutainment applications.

## 3. CO-DESIGNING EDUTAINMENT APPLICATIONS WITH PRESCHOOLERS

In this section we describe our approach in co-designing applications with preschoolers. We have applied the PD approach, involving preschoolers, kindergarten teachers, and parents in different steps of the design process.

### Procedure

The co-design of edutainment applications was organized with the involvement of students from our university. The students were either graduate students following the Software Engineering Master programme or undergraduate computer science students attending the Human-Computer Interaction optional course. They were split in multiple design teams composed of 3-5 persons, and they were coordinated by their HCI teacher and two kindergarten teachers. Each design team has interacted with 5-6 preschoolers, depending on the children's willingness to contribute.

#### *Selection of participants*

The preschoolers have been selected from the children attending the big group (5-6 years old children) in the Albinuta Kindergarten. The authors have presented to the parents and kindergarten management the motivation of the research, the activities that will develop during the study and how the children will be involved, underlining the fact that children will participate to the activities as long as they are willing to. Children could freely decide if they join the design sessions and when they quit our design sessions and return to their classic play activities in the kindergarten's rooms. During the study, 90 preschoolers have been involved with the consent of their parents to participate to the design activities. There were 100 children who participated to the optional classes with their parents agreement, 90 children participated to the design activities, too. Five parents have participated in the evaluation step to improve our understanding of children's attitude towards their experience of using technology.

### Our approach

Involving children in the design process has already been studied [15, 14, 13, 26], but new challenges arise when the design product is an educational one (edutainment) because of its educational goal, wrapped in an entertaining envelope. The educational content and the games used to underlie the knowledge are decided by the educators. So, children's opinions and vision are restricted to the objects, situations, and stories that will create the context for learning. Thus, in PD of edutainment for preschoolers we have two separate roles that are involved in the design: the preschoolers, that provide information, feedback and ideas for the presentation, and the kindergarten teachers, that provide information and feedback regarding the content, navigation and the presentation of the edutainment application. The role definition matrix used to synthesize the participation of children and kindergarten teachers contains two underlying dimensions when defining children's participation: the phases of the design in which they are involved and the way in which they are involved during each phase [2]. In the requirements step children have discussed with the members of the design teams about their interests, their favorites characters and games, but they have also been represented by the kindergarten teachers who have introduced the design teams the main characteristics, limits and capacities of the preschoolers (see Table 1). Also, children provided feedback during the design alternatives step whenever this was possible (represented in an understandable manner for the children) and during the prototype's evaluation. Preschoolers were also directly involved in the evaluation step, by using and providing feedback on the developed applications.

| **Activity in relation to designer** | **Requirements** | **Design** | **Evaluation** |
|---|---|---|---|
| Elaboration | | x | |
| Dialogue | x | | |
| Feedback | | x | x |
| Indirect | x | | |

Table 1: The role definition matrix for preschoolers

The kindergarten teachers actively and directly participated in each design step. They provided information during the requirements step, they provided feedback on alternative designs and suggested ways of improving the proposed designs, and they evaluated the created prototypes, as Table 2 shows.

| **Activity in relation to designer** | **Requirements** | **Design** | **Evaluation** |
|---|---|---|---|
| Elaboration | x | x | x |
| Dialogue | x | x | x |
| Feedback | x | x | x |
| Indirect | | | |

Table 2: The role definition matrix for educators (kindergarten teachers)

In the following we will provide details on how the design process has been organized. The design and development steps were performed during a university semester (14 weeks). The time constraint forced us to schedule each step of the design very strictly.

### Requirements

The first step in designing edutainment applications was a meeting between the kindergarten teachers and the students during a lecture class. Kindergarten teachers have presented to the students their need for proper tools to integrate technology into their regular teaching activities. They have mentioned the poor results obtained in Pisa Assessment by the Romanian children and their need to keep pace with the technological progress. They have described their regular activities underlining the fact that every activity is conceived as a game, the domains studied during the teaching activities in the kindergarten mentioning that everything is taught in an integrated manner, how the new knowledge is introduced to children and how evaluation is performed. They have also mentioned the kind of equipment (desktop computer and video projector) they possess in the kindergarten's classroom. The applications will be used by children individually, so no collaborative features were required. This activity was conceived as an open discussion, with the students addressing questions and the kindergarten teachers answering. There were questions like what operating system runs on the computer in the classroom or if the kindergarten can provide hosting for the applications, that the kindergarten teachers could not answer. Instead, they invited the students to visit the kindergarten and gather the required information.

In the next step of the requirements gathering phase, the design teams explored the environment and the activities of the end users, the preschoolers. For this purpose, members of the design teams visited the children during their regular activities in the kindergarten and spent approximately two hours with the children. For this meeting, members of the design teams used the recommendations from [15, 31]. They got involved in the children' activities such as solving puzzles, or playing with wooden cubes or Lego pieces (as shown in Figure 1). The scope of this meeting was for the children to become familiar with the members of the design teams. Children have been informed that the students will create games for them and that they need their help. During this interaction, students have tried to discover the subjects of interest of the children, their favorite activities and their favorite heroes by open discussions or games. Students also tried to find out the level of children's knowledge related to the proposed sub-

Figure 1: Getting to know the real users.

Figure 2: Assessing children's initial interaction skills

jects of their edutainment applications. They also invited the children to use some interactive games on the computer to get an initial idea on their digital skills (as shown in Figure 2). As such, the children participated in these activities as *informants*. Four groups of students entered at the same time the kindergarten group and sat at a kindergarten table and started to interact with the interested children that came near their table. If the children were too shy, then students asked the permission to join their games to build a relation. Each students' team interacted with 3-4 children at a time, but children were moving from a students' team to another at their choice, exploring different teams' approaches. Students created field notes based on this meeting conclusions, while pictures have been taken by other team's members. Although the time spent with the children was short, it provided valuable information for the future design related to children's vocabulary, activities, subjects of interest, preferred characters and/or games. A challenge of this approach was the continuous movement of children from one team to another anytime they wanted. Sometimes, by continuing the dialogue with the children at a distance determined the children to return and continue the conversation, other times children would not return to the same student's team again. Although focusing on a small group of children to extract information was not possible, it provided a larger variety of information, from multiple children. We consider that the best approach would be to work with smaller groups of children (5-6 children at a time) and one design team in a room. Unfortunately, this was not possible in the kindergarten's building, as there are not sufficient rooms to accommodate each students' team at a time. To add more knowledge about the young users by spending more time with them, most of the students teams decided to get involved in the ICT optional classes activities and get to know them, as will be described in Section 4.

## Design

After identifying the main characteristics of the end users, the design teams have started to explore the solutions' space to determine the most appropriate approach. The kindergarten teachers (the clients) have stated some additional constraints on the edutainment applications to meet the educational goal, too. Every application should contain a presentation part which introduces new knowledge and a fixation part which provides tasks to support knowledge gathering and understanding. Moreover, the edutainment should be conceived as a story (narration) [37], with a character that acts like a tutor during the interaction, in order to be entertaining [34, 25]. The applications should contain gamification aspects, like rewards for tasks accomplishment or ranking of the participants [27]. The teams' design ideas have taken various forms, from drawings or wire frames to executable prototypes.

### *Designing with preschoolers*

Feedback on the proposed designs have been gathered from both children and teachers during another meeting. Drawings and executable prototypes have been successfully used to gather feedback from children (see Figure 3). Children have been actively involved in this step by providing design ideas which were more related to the characters and objects appearing on the interface. Boys have frequently asked the replacement of objects on the screen with cars, asking for "a game with cars", while girls were attracted by sparkling, colourful objects. When children had the opportunity to interact with executable prototypes, the design teams have identified some interactions that haven't been implemented but the children were expecting them, like drag and drop for moving an object from one position to another, instead of sticky drag and drop, which the literature shows is preferable for children [6]. Although literature on designing interaction for younger children shows that mouse interaction is preferable to keyboard interaction [12, 21], we have observed that children are used to moving objects using drag and drop, but they are not able to perform double click as fast as needed. These findings have been discussed with the kindergarten teachers and double click have been replaced by pressing the ENTER key or by click.

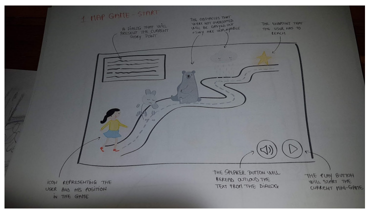

Figure 3: Design example.

#### *Designing with kindergarten teachers*

In the case of wire frames, children's feedback could not be taken, due to their high abstraction. In this case, only the kindergarten teachers have been involved in the design by providing feedback or by providing new tasks ideas or narration threads. During the interaction with the children we have applied interviews to explore their vision on what they think should happen next in the story or if there are other characters they would like to see in the game. We have redesigned the interaction considering the actions the children tried to perform on the interface and which were not supported (double-click or drag and drop). This way, children can be considered as playing the *designer* role in our participatory approach. To ensure better participation of children in the design step we should force the design teams to create design alternatives as executable prototypes, such that children could easily understand and interact with the proposed alternatives.

### Evaluation

The evaluation of the edutainment applications was a complex process, as it was composed of at least two elements that had to be considered: the usability of the final product and the educational experts' acceptance based on the product's relevance for the subject it is intended.

### Usability evaluation

To assess the usability of the edutainment applications, based on ISO usability definition [23] we have tried to identify metrics for the efficiency, effectiveness, and satisfaction. Moreover, we must not forget that our end users are young children, aged 3-6 years. Their cognitive characteristics make most of the methods used with adults impossible to apply. Their communication skills and abstract thinking are limited, so interviews or surveys cannot be used. Also, their focus span is very limited, such that discussions about their experiences cannot be very relevant. Observation remains an appropriate method for gathering information on children's performance and subjective satisfaction. Still, the presence of an expert may influence the children's behavior, if the expert is an unfamiliar person. Because we consider that involving the children in the evaluation is the most relevant method in our case, we decided to use observation, interviews and an adaptation of smileyometers [35]. The observation was organized in the kindergarten classroom with six children staying over their usual kindergarten program for the usability testing session, based on their parents' agreement. Children had the choice of participating in the interaction with the edutainment application or playing with the toys. The children were informed that they will participate to test the "games" that they have seen before. One of the children used the words "try on" for the action of testing the application. They were informed that the decision of playing with the game is their own and if they preferred doing something else in the kindergarten classroom they were allowed to. The usability assessment sessions were organized as play-testing sessions (see Figure 4). Children were allowed to explore the applications at their own pace, and the kindergarten teacher and one observer, a member of the design team that was already familiar to the children, were accompanying the children. Ad-hoc peer tutoring sessions occurred, as children have started to give support/instructions to their peers.

Figure 4: Play-testing sessions with real users.

At the end of the interaction, children were asked to select how they feel after the interaction using a *dragonmeter*. Our previous experience with using the smileyometer has shown that children do not really understand how it should be used, such that they have selected more than one smiley face for an edutainment. The dragonmeters are used in their everyday kindergarten activities to assess their emotions. The dragonmeter has the following emotions: brave, calm, sad, happy, bored or angry. We have observed that all the children have chosen the happy or the brave dragon, although the observation revealed the existence of some difficulties in their interaction with the edutainment.

Due to our desire to objectively evaluate children's emotions, we have organized short post-interviews with the preschoolers. Children had to answer one of the following questions:"Would you like to play the game again?" or "Would you like to show this game to your best friend?" addressed alternatively. All the children participating in the post-interview have affirmatively answer to the addressed question. Knowing children's willingness to satisfy adults, we have considered that we need to further investigate methods that can be used to obtain an objective assessment of children's experience with the edutainment application. The next approach we have used was to organize workshops with the parents of the children participating in the testing sessions. Parents mentioned that children have reported their interaction experience as "play" and some of the children have mentioned different objects that were presented in the edutainment: geometrical shapes, objects from a house, and so on. A child's mother has said that her main concern is that her child would never stop playing if he had the chance. In our observation sessions we have seen that none of the six children have sat in front of the computer for more than 10 minutes. Anyway, the applications have been designed to run at most 15 minutes, taking into consideration the time needed for multiple trials of answering a question or performing a task.

#### *Adding insight into young children's emotions*

The progress in the Artificial Intelligence domain creates the premises to gather more information about children' emotional states while they interact with edutainment. Emotions have been defined as physiological reactions to significant events and can be easily recognized universally [10, 9, 16, 29, 30]. Emotions are a component of children's academic readiness and achievement [11, 22, 24]. A class of *academic emotions* have been identified and their relation with the learning process has also been determined [32, 36]. Some emotions can be automatically detected from sources like facial expression, voice, physiological signals, body posture. For the purpose of automatic emotions detection on preschoolers the most appropriate method is the use of information from their facial expressions while interacting with the edutainment.

Although automatic emotion identification has been successfully performed on adults, applying the same approach to such young children brings new challenges. The first challenge is the lack of datasets needed to train the algorithms, the imbalanced representation of emotions in datasets, and the fact that different emotions may generate similar effects on children faces. For our applications we have tried to also perform usability evaluation using automatic emotion recognition techniques. For our study, we have first created a dataset with photos and video recordings of preschoolers aged 5-6 years. The photos and video recordings were taken during play-testing sessions in the kindergarten classroom. Different Machine Learning techniques have been applied to automatically identify children's emotions on images/videos, using SVM[7] or CNNs [19]. The emotions that we looked for were happy, sad, fear, anger, disgust and surprise. A face detection step based on Haar [38] or by HOG [8] features have been initially applied. When trained and tested with adults and children, the obtained accuracy varied between 50% and 81%. When trained and tested on children images only, the obtained accuracy varied between 68% and 70%. The most frequently identified emotions were happy and angry. To adapt the edutainment applications we are more interested in identifying very accurately the angry emotions which will determine an adaptation decision, to change the child's emotion.

Although there is place for improvement in this approach, we consider it a good starting point in supporting children's emotions identification. We underline that we do not intend to fully automate the satisfaction assessment, instead we could use the automatic emotion identification as complementary to the previously presented classical usability evaluation methods. Moreover, when a better accuracy of emotions identification will be obtained, it could support the adaptation of the edutainment applications based on children's emotions.

### Validation by Educational Experts

In order to ensure that the developed edutainment applications are not only entertaining for children, but also useful for kindergarten teachers too, we have tried to evaluate their attitude towards the developed applications. In this context, we have considered that the most cheap and effective method of evaluating the usefulness of edutainment applications is the heuristic evaluation. We have adapted HECE [1] method to our specific context. HECE considers three dimensions when evaluating e-learning for children: Nielsen Usability Heuristics (NUH) - the traditional design heuristics concerned with general user interface design, Child Usability Heuristics (CUH) - concerned with children's preferences and abilities, and E-learning Usability Heuristics (EUH) - concerned with learner-centered design. We have omitted from HECE the questions related to reading and writing capabilities of children. The CUH and EUH dimensions have gathered best rankings from kindergarten teachers, considering the content and the learning strategies appropriate. Regarding the NUH dimensions, some of the kindergarten teachers have considered that some tasks are too abstract or that there are inconsistencies in objects' locations on the screen.

We consider the evaluation step as the most complex and demanding step due to the different aspects that need to be evaluated. Evaluating with children is very relevant but time consuming and sometimes is very difficult to draw a conclusion because the information gathered from various resources (observation, dragonmeters, interview questions) may provide contradictory information. Evaluating with kindergarten teachers lacks an appropriate method. Adapting methods intended for school children provided additional information, but we consider that the method should be refined to be appropriate for our approach.

Overall, we consider the proposed designs and implementations successful based on children, kindergarten teachers and parents assessment.

## 4. DESIGNING ICT OPTIONAL COURSES FOR PRESCHOOLERS

Our experience in integrating young children in the design of edutainment applications has shown that young children need support in developing their understanding of technology. First, children should build a basic vocabulary related to technology and computers, and then, they should start the digital alphabetization by learning the basic interaction actions. In the current curriculum for preschoolers from our country there are no Information and Communication Technology classes. Still, optional classes can be proposed for preschoolers. We have conceived a syllabus for an optional ICT class for preschoolers called "A computer to learn!" that is addressed to children in the older group level, aged 5-6 years. The educational approach in our country is competence based, so together with the kindergarten teachers we have defined a set of behaviors that could predict the development of basic digital skills. In Table 3 are presented the intended elements of digital competences and the learning activities organized to support their development. LOU and MOUSE are two friends that support each other in learning to interact with the computer.

The activities in the optional classes were organized in two steps: the first step introduced new knowledge about computers and interaction with computers, while the second step was intended to practice the new taught information. The presentation of new knowledge was organized using a game based approach. Specific children activities using paper, pencils, balloons and role playing games have been created to integrate the new knowledge in an enjoyable manner.

To evaluate the effectiveness of performing teaching activities for digital skills development support, kindergarten teachers used an observation grid and checked the relevant behaviors

| Digital Competence | Learning Activities |
|---|---|
| Recognize and differentiate the components of a computer: screen, keyboard, mouse | LOU shows us the computer<br>LOU helps MOUSE understand how each component works |
| Interaction basics: turning the computer, closing the computer,<br>Mouse actions: click, double-click,<br>right click, drag & drop, selecting objects using the mouse,<br>Keyboard elements: ENTER, SPACEBAR, ESC<br>Actions: opening and closing an application | LOU shows us what a on and off mouse can do<br>LOU invites MOUSE on a screen trip<br>LOU uses a computer mouse for exploring the screen |
| Recognize WIMP elements (windows, icons, menus, pointers) | LOU is a professional already<br>MOUSE helps in difficult situations by acting on the right element with the right action |
| Using drawing tools (paint editors) to draw, choose colors, fill in geometric forms, select screen regions, copy, paste | LOU teaches MOUSE how to draw<br>MOUSE is the supporting partner<br>LOU and MOUSE draw their favorite animal |

Table 3: Preschoolers' behaviors and learning activities to support digital competence development

performed by the preschoolers without support. For each behavior the kindergarten teachers marked if it is an independent behavior, performed by the children without any support, or if it is a behavior that needs support. Twenty children participated in the evaluation and all of them were able to independently identify computer components, and they express the desire to interact with computer applications. Sixteen children were always following the interaction steps from the edutainment applications correctly, and 13 children have demonstrated perseverance in performing tasks (were willing to try again even after a wrong answer has been given). Eight children were able to perform a multitude of interaction actions like: turn on/turn off the computer, perform click, double-click, right click, drag & drop, mouse selection, press ENTER, SPACEBAR, ESC, open an application, and close an application without any support. However, none of the children verbalized the actions they were performing without support from the kindergarten teachers. As far as we have found, there is no similar initiative on developing an ICT curriculum for preschoolers and no tool to assess the results of the instructional activities in this domain. The proposed approach needs to be refined in performing the evaluation, with a more flexible approach in assessing children's behaviors.

## 5. CONCLUSIONS AND FURTHER WORK

In this paper we have presented our approach in applying PD with young children (preschoolers) for developing edutainment applications. We have described the roles the children have played during each design step, the challenges we have encountered, and the solutions we have envisioned. Depending on their age, children can be involved in most of the steps of design, with challenges in alternative design where sometimes the abstractness of the design could be an obstacle. Using appropriate design alternatives (like drawings, sketches), children can successfully participate in this step. Evaluating the edutainment applications with children is also a subject for deeper research, as it is difficult to evaluate the satisfaction of children based on an objective approach. Introducing an automatic approach that could assess children's emotions while interacting is a promising approach, but with limitations determined by the constraints of the Artificial Intelligence algorithms, which need a proper training to perform accurate emotion recognition and, as a consequence, large datasets of children images.

Complementary to the design steps, we have organized ICT optional classes for preschoolers where members of the design teams have tried to support children in understanding computers and the interactions with them. In the future we intend to extend our research in the following directions: identifying solutions to involve children in the design alternative step as designers - this depends on the age of the preschoolers and we consider it is doable for children in the older group (5-6 years old); include emotion recognition modules to the edutainment applications to adapt the interaction according to children's emotions - in this case the challenge is to identify an architecture for the edutainment applications to allow efficient interaction between the emotion recognition module and the edutainment application module; validate our approach in more case studies - this requires the use of the developed edutainment applications to new generations of preschoolers and organize groups of children that learn in the classical approach and children that learn using technology and assess the outcomes.

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