

Mobile Games for Children

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Abstract. This article presents a study on the use of educational games on mobile platforms, with touch screen, for children with ages between 2 and 3 years-old. The evaluation of the use of the games is based on the PLU model that proposes a three vector approach: Play, Learner and User Requirements. Hence, a set of paradigmatic games was selected that fulfil those three vectors defining the model. Experiments were carried out including the observation of the interaction of children during the use of selected games. The results show that the use of mobile technologies is extremely well accepted by children, and it was possible to reach a set of meaningful and relevant conclusions concerning the relationship between play / learning / user.

Keywords: Mobile platforms, learning, children, games.

1 Introduction

The use of computers and mobile platforms by children at home and in school environments is nowadays common in several countries. The exposure of a child varies according to the type of computer technology available, the child's age and sex, as well as the family social group [7]. Technologies like tablets and iPads have currently high rates of dissemination. Therefore, children are frequently exposed at an early age by their parents, relatives or teachers, using them with some frequency to work and entertain. In fact, measure of exposure of the impact of these devices is related to how parents and teachers present or implement strategies for using these technologies [9].

A potential consequence is that technology is rapidly changing the way children learn and have fun. Thus, the development of applications for children should consider the factors that affect children's cognitive abilities and take an active role in the realm of the methodological process of the design of the interaction [8].

The study presented in this article aims to evaluate the use of games in children aged 2 and 3 years-old. Although there are several studies with older children [10, 11, 13], our purpose is to effectively focus on younger children, since they are being increasingly exposed to this type of technology [12]. To clearly define the evaluation criteria, the work is underpinned in the PLU model, proposed in [2], defining different tasks from a set of selected games, paradigmatic of the three vectors that constitute the model: Play, Learner and user Requirements.

The study involves the observation and further analysis of the behavior of 14 children aged between 24 and 40 months while playing different games. The analysis and conclusions presented here are extracted from the results of the interaction with a selected game set that attempts to span over the three PLU vectors, as well as the insights gained by observing the interaction of children.

In the next section we present some of the most significant work carried out with children and interactive technology, which fall in the area of this work, including some that make use of the PLU model. In Section 3 we describe in detail the proposed approach and experimental setup. In section 4 we describe with the implementation of the proposal, in Section 5 we present the results that we analyze in Section 5, and, in Section 6 we discuss the results of the interaction with the children. Finally, Section 7 presents the conclusions and some possible lines of future research.

2 State of the Art

We start by analyzing the abilities and skills of children in this age group, as well as their interaction with touch screen devices. Children of this age are said not to have yet refined skills in the use the mouse [8]. However, children realize that they can have an effect on the objects on the screen. As a consequence, touch screens are most suitable since interaction is performed directly on the screen [1] [4].

2.1 Children's Learning

Jean Piaget's theories were of great importance for understanding how children think and learn; therefore they can be very useful to frame the development of children's software. Children between 2 and 3 years-old generally have limited attention span, they acquire numerous skills, among which we highlight [1]:

- Place individual shapes on “form board” type puzzles;
- Use a pencil to replicate a vertical line;
- Match objects by simple shapes;
- Enjoy taking things apart and putting them together again;
- Ask "why" and "how" questions;
- Anticipate consequences and understand the impact of their own actions;
- Answering simple questions;

Although children acquire these skills at these early ages, competences acquired in the physical world may not have the same effectiveness with touch interactive devices.

2.2 Children and Games

All children love to play, but there are games that bring more interest and more motivation. Therefore, when developing software for children, the evaluation evaluation must take into account not only children's capabilities, but also e principles of children's motivation. Hence, we can make use of these principles as follows [1]:

- *Enjoyment* - children choose activities that they like to do, and avoid activities that are frustrating, static or boring
- *Control* – children avoid activities where they have no control. Software should increase children’s sense of control with scenarios where their actions have impact
- *Interest* - children are more likely to engage in an activity when their interest has been sparked
- *Feeling of Competence* - children develop feelings of competence if they think they have a reasonable chance of success

2.3 Children and Touch Screen Devices

As children between 2 and 3 years-old love to play, learn easily, but have a natural difficulty handling the mouse, whilst understanding that their actions can have an effect on a screen, touch screen devices are a good alternative regarding computer interaction. These devices are now quite disseminated, so they can be used as learning tools. We must take account some relevant aspects regarding their use by children [4]:

- In general, all children are excited by such devices, but only this enthusiasm does not guarantee the interest on learning;
- Application interface is as critical as the platform and need to be intuitive to allow easy access to the child;
- Young children explore and learn in ways that are natural to them through touch, repetition, and trial and error;
- The evolution from novice to master is often achieved in the first experiment.

2.4 PLU Model

Conducting evaluations through questionnaires with children is a difficult job, since they often tend to respond in order to please the adults who interact with them, rather than on the question. The various models of product evaluation for children we have analyzed are all based on the observation of children's behavior. This work is underpinned in the Play-Learner-User model (PLU) [2], as this presents a metric with several vectors in an interactive application.

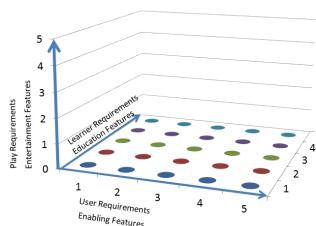


Fig. 1. PLU Model [5]

Almost all evaluation models are intrinsically subjective, while in opposition in this work we propose to define and use a more accountable approach. The PLU model was designed to help understand how children interact with technology. The first version was proposed in 2004 and later updated in 2008 [2] and in 2011 [5]. This model, depicted in Fig. 1, attempts to map the approximate relationship that children have with technology and with three types of interactive products. To reach this goal, technologies are classified according to their features: as entertainment, education and qualification. Each set of features map to one of the three vectors to evaluate:

- Play – Dimension fostered by the entertainment capabilities of the application. In this relationship, the child sees the product as a toy, therefore to fulfill its purpose the product should amuse or entertain. Examples of technologies include games and electronic pets.
- Learner – Dimension that corresponds to the educational component of the application. The interactive product is seen as a "teacher" who teaches, challenges and rewards. Examples include educational software (e.g. arithmetic or writing).
- User – Dimension given by the capabilities to produce results. The child sees the product as an interactive tool that, to be useful, must allow to "do" things. Examples could include drawing applications or calendars.

Based on these ideas, an evaluation framework can be put forward based on the PLU model, named PLU-E (Playing for Learning and Using Evaluation):

1. Decide on the purpose and focus of the product, to project goals and PLU targets;
2. Identify basic users and expert users;
3. Based on steps 1 and 2, set PLU weighs representing the product;
4. Define the moments in the development process evaluations should be done;
5. Based on steps 3 and 4 and on the design constraints (e.g., time and availability of users) evaluations can be planned and carried out.

3 Proposal and Work Plan

Based on the analysis of existing studies, this paper analyzes 3 types of educational games for children between 2 and 3-years old. We used a memory game, a paint game, and a puzzle. We modified both PLU and PLU-E models [3] [5], in order to introduce flexibility and easier results' analysis. Instead of using a normalized weighting (0%-100%), we implemented a qualitative value-based range from 1 to 5 for each vector ("Very Low", "Low", "Medium", "High" and "Very high").

3.1 Assumptions and Expected Results

Taking into account the studies and theories presented in the previous section, we defined several hypotheses to be verified experimentally:





- H1.** Children that have not yet had previous contact with touch screens devices, will nevertheless have ease in grasping the concepts of touch and drag;
- H2.** Children will have natural curiosity about technology and games and will take part in the experiment without any external compensation;

- H3.** Children that are more agitated are more likely to give up when difficulties arise. Given the short duration of the concentration ability at this age, most time consuming tasks may also be the cause of dropouts;
- H4.** Children prefer games with more game component;
- H5.** The time that each child spends gambling reflects the interest in the object of the game.

3.2 Selected Games and Tasks

Since the objective of this study is to evaluate children's exposure to technology, "traditional" games were adopted since the rules of the games were already familiar to the children. The types of games considered were memory game (joining pairs), puzzle, painting, search (identify something "hidden" in an environment), association (match or group related elements), and target acquisition (e.g. a game for "smashing balls"). Since the concentration span of children is reduced, only three sets were considered to limit the change of context of children. Physical versions of the chosen games were already present in the children's kindergarten. Several implementations of these games were installed and tested, and the following versions, available on Google Play, were adopted: Animals Memory (Task A), Kids Painting (Tasks B and C), Noddy Puzzle (Task D). In the definition of the tasks the PLU model was used, with the amendments referred in the previous section, as shown in Table 1.

Table 1. Selected games and characteristics

Game	Image	Task	PLU
Memory game with pictures of animals.		A. Identify the pairs of identical pictures and find all pairs;	P = 4 L = 3 U = 1
This game a puzzle of 6 pieces with images from the world of Noddy.		D. Build the puzzle according to the displayed image;	P = 3 L = 5 U = 3
Game to paint designs preexisting, where you can choose the colors or pencil "magic" that paints the correct colors.		B. Paint with the pencil "magic";	P = 5 L = 1 U = 5
		C. Paint with other colors chosen by the child;	P = 4 L = 4 U = 5

The memory game is a game that, in terms of interaction, involves simply the touch in the card to make it turn. It's an easy game to play, with immediate reward (pairs made disappear). For this reason it is considered to have a "high" (4) play value (P). Being a memory game, the game's success involves the use of related cognitive memory, so it was assigned the value "Medium" (3) in learning (L). At the end of the game the child does not get any significant result, therefore the User (U) component has a value of "Very Low" (1). The painting game involves touch (to choose the color) and drag (to paint), and can be played in two completely different ways. The choice of a "magic pencil" allows the "discovery" of the original design, as if the drawing becomes transparent. The choice of colors implies a fine motor coordination, since the lines can go over the outlines. As painting is an activity very well accepted by children the Play (P) value assigned to the game was "Very High" (5) for the game with the "magic pencil" and "High" (4) for the game with pencil paint colors. Learning (L) in the case of the magic pencil is "Very Low" (1) since the result is always the same while in crayons is "High" (4). As at the end of the game, the player has a painted design we considered the usefulness (User) as "Very High" (5). To the puzzle game we assigned a value of Play (P) of "Medium" (3), since it is a game where there is only "movement" as a result of interaction of the child by moving a piece. On the other hand, it is a game that requires observation and comparison of the different parts and fittings of identifying the location of the tiles (learning "Very High"). At the end of the game the child gets the complete picture and, therefore, it was assigned a utility value "Medium". Table 1 presents the games adopted, describes the tasks associated, and summarizes the PLU values adopted.

4 Developed Work

The work was composed of two stages:

- (i) A questionnaire to parents and educators to know details about the children, e.g. previous contact with interactive touch devices or their usual reaction to given tasks;
- (ii) Experimentation with a group of children aged between 24 and 40 months, 6 girls and 8 boys. Children played the selected games using a Samsung 7 inch tablet.

4.1 Questionnaire to Parents and Educators

In a first step surveys were conducted with the parents of the children, and we found that none of the children had regular previous contact with the type of devices. The main personal characteristics of each child were also registered, in terms of curiosity, calm or agitated behavior, shyness, social behavior, and difficulty in concentrating, based on information obtained from the educator. Of the 14 children that completed the test, based on information from educators: four are reported to have some difficulty in concentrating, which may be considered normal for children under 2 years of age. Two children are also identified as particularly shy and can be a barrier to interaction that accompanies the test.

4.2 Games with Children

In the second phase, there were several sessions of observation of children playing with a 7-inch tablet. This phase of experimentation was conducted in a quiet room, with no other children, but accompanied by the educator. During the session, each child was asked to play each of the games mentioned in the previous section, starting with a brief explanation of how to play each one. Each child has had contact with only one game at a time. During the child's interaction with the game the reactions of the child were recorded on paper, the time s/he took to understand what was asked and the time taken to reach the goal of the game. Additionally, the difficulties encountered by children were also registered.

Given the limited attention span of children at this age, individual sessions took about 15-20 minutes to complete the four tasks with the three games. However, some of the sessions lasted a bit more when the child's interest so justified. The same adult and the educator accompanied the execution of all the tasks. The interaction between the adult and some children was hampered by timidity and/or by the difficulty in concentrating on the requested task. During the experiments the following observations were registered:

- All children answered affirmatively when asked if they had previously known the game. However, none of them had used a tablet before and their knowledge was related to the physical game (cards, paper and pencil to paint and puzzle);
- The shyness in girls and difficulty in concentrating in boys influenced negatively the performance, leading some to give up;
- In the puzzle game, the greatest difficulty was the fact that the pieces placed in its final position may leave the place with an accidental touch, which forced them to put them back;
- The tablet device aroused much curiosity.

5 Results

5.1 Identify Pairs of Images (Memory Game)

In this game, of the 14 children involved, only one gave up, having identified only one pair after more than 1 minute. Fig. 2 shows the time each child took to complete the memory game. On the x-axis, the children are ordered by increasing age. The graph also includes a trend line to aid on the interpretation of the values obtained. One observation that can be made of the results is that the trend line is very flat, reducing only 20 seconds when the age increases by 16 months.

5.2 Paint with the “Magic” Pencil

The ease with which you paint the drawing with the "magic" pencil, where one only needs to swipe the finger, led the authors of this study to suspect that this would be one of the preferred forms of interaction. However, regarding the level of enthusiasm, the children showed a greater interest in the game where they were able to choose the colors, even with a resulting image distant from the original.

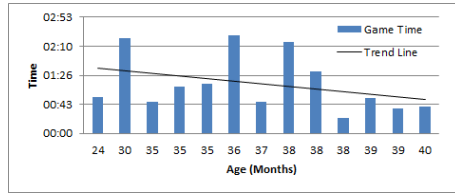


Fig. 2. Times of conclusion of the memory game ordered by age

5.3 Paint with Other Colors Chosen by the Child

Unlike the game of paint with the "magic pencil", the drawing with chosen colors is final only when the child so considers. Since there was no stipulated time for completion of the task, it would be acceptable that this task would take significantly longer than the "magic pencil". However, such scenario only occurred expressively in one of the children, while for all the others the times for both painting activities was similar. Fig. 3 shows the times that the children took in both painting tasks. Notice that the trend line exhibits a reduction of almost 1m30s corresponding to an increase of 4 months of age. Additionally to the playing time during the painting activities, the children’s accuracy motility was also registered: a high motility results from caution when reaching contours and also from applying the right colors to specific areas; on the other hand, low motility results from scratching with colors without giving importance to the contours. More than half the children had not yet these skills (nine exhibited better motility skills, while four had still some challenges to overcome). The small difference between the times of painting in these cases can be explained by differences in the resulting paintings (less motility resulted in less accurate paintings).

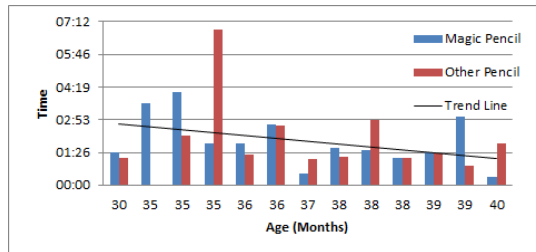


Fig. 3. Times for conclusion of the painting game ordered by age

5.4 Build the Puzzle

The puzzle game is the most cognitively demanding: it requires the identification of the location of the part in the final image and dexterity to put it in that position. Since the pieces placed in the end position can also be moved, sometimes the child inadvertently moved a piece out of place. Given the cognitive demand, it is normal that the trend curve is much more pronounced. As shown in Fig. 4, this line falls almost 3 minutes in 10 months.

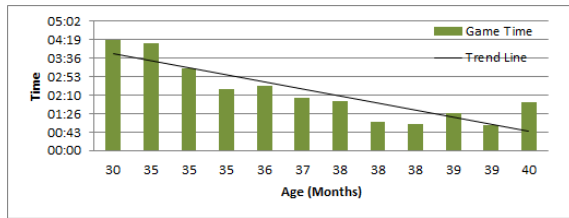


Fig. 4. Times for conclusion of the puzzle game ordered by age

Table 2. Children that gave up each task organized by gender (Withdrawals marked with X)

Game	Female		Male		Total		%
	X	√	X	√	X	√	
Memory	0	6	1	8	1	14	7
Painting A	0	5	0	8	0	13	0
Painting B	1	5	0	8	1	13	8
Puzzle	0	5	3	8	3	13	23
					5	53	<10%

6 Analysis of Results

After the experimentation phase, we reach the following analysis:

- The great majority of children has poor fine motor skills, natural given their age;
- In the memory game, it can be seen that neither gender nor age influenced the child's comprehension of the purpose of the game (see Fig. 3);
- In the painting game we see that age was not relevant to the comprehension or the skills needed (although final drawings were extremely variable). Analyzing completion times by gender, we can see that the completion time varied slightly;
- In the painting game, most children were more interested and thus preferred the task of choosing the pencils of various colors instead of the "magic pencil";
- In the puzzle game, we can observe that children older than 36 months had a better performance than younger ones (Fig. 5);
- We can also observe that while the puzzle game has a higher drop out percentage than the other games, the final percentage is less than 10% (see Table 2).

7 Conclusions and Future Work

Based on the work and analysis of the results obtained, we can draw a set of conclusions. Almost all children, despite having no previous contact with touch devices (H1), learned with ease the concepts of touch and drag. The child's gender did not affect the capacity or the ability to understand the goal of the game, but the preferences of each child were determinant. On the other hand, shyness influences the demonstration of skills and understanding. The difficulty in concentration reduces the acquisition of skills and understanding the purpose of the game. Another interesting finding is related to the age of the children. There are games where age is

not a determining factor, e.g. the memory game or the painting game. It would be expected that the older children would have the memory more exercised, but it was found that the performances of smaller children were identical. On the other hand, the age factor has an influence on the puzzle games, since they need more understanding.

Future work includes the use of performance measures in the game to evaluate more objective hypotheses, to make them richer, more reliable and easier to obtain. It is also our goal to develop a game, based on the results with balanced PLU values, considering age and capacity characteristics of children in the specific age group.

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