DIGITAL GAMES AS A CONTEXT FOR EARLY CHILDHOOD LEARNING AND DEVELOPMENT

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Abstract - Playing games is a very natural way of self-directed learning during the all stages of human life, especially in childhood, which is the stage of most rapid cognitive, psychomotor, and socio-emotional development. This natural way to learn through play today is supported by new technology, like mobile phones, PDA devices and tablets that are fully integrated into our lives. Many people have explored how new technology can enhance learning during children's play, and how best to support children to develop cognitively through playing activities. Although a lot of research based on developing a conceptual and theoretical understanding of designing of digital games specifically for children has been done, there is still deficient evidence about their effectiveness of children's development process.

In this context, we have decided to develop a serious game for Android operating system, using OpenGL ES 1.0 version, which support all Android devices. This puzzle game, based on a concept of task-based learning, was used for measuring children's enjoyment, engagement, tension, usability and fun. The results of the evaluation has been analyzed and shown in this paper.

I. INTRODUCTION

Play is one of the most important basic needs of children, especially preschoolers, as they learn new things try play. They learn how to deal with new situations, how to interact with others and how to control their emotions. Playing motivates children to stay engaged and concentrate for a long periods. It is also important for intellectual development, so it should be included as a vital part of early childhood education. The significance of play in learning process is strongly supported by established pedagogical theory [1-3].

There is general agreement regarding the five main functions of play in the lives of young children [4].

- Play enables children to use symbols and to represent their world in a variety of forms (Essential Learning: Communication).
- Play promotes creative flexibility in thinking (Essential Learning: Thinking).
- Play assists children to build their knowledge (Essential Learning: Thinking).
- Play fosters language and social abilities (Essential Learnings: Communication, Identity, and Interdependence).
- Play helps children operate above their usual level, by establishing a 'zone of proximal' development, meaning that the child is extended beyond previously mastered learning (Essential Learnings: Futures, Thinking, Communication).

Today children grow up with information and communication technology (ICT) embedded in their daily lives. They are being exposed to technologies at ages earlier than ever before. Many people have explored how technology can enhance learning during children's play, the role technology can and should play, and how best to support children to develop cognitively through augmented play activities [5]. Healy stated that body movements, the ability to touch, feel, manipulate and build sensory awareness of the relationships in the world was crucial to children's cognitive development [6, 7]. The main conclusion of all these researches is that if used appropriately and with suitable media content, new technologies can have a positive impact on children's development and learning. This makes it necessary to employ technologies in meaningful ways.

In the last decade, mobile games have become increasingly popular as a form of entertainment. Mobile technologies offer the opportunity to embed learning in a natural environment and provide motivational effects [8]. Games meet the fundamental needs of learning by providing player with enjoyment, passionate involvement, motivation, ego gratification, adrenaline, creativity, social interaction and emotion [9].

Although a lot of research, based on developing a conceptual and theoretical understanding of designing of digital games especially for young children has been done, there is still a deficient evidences about their effectiveness on children's development process.

With this study, we have tried to contribute in that field, measuring and analyzing different parameters during the children's play.

For evaluation purpose, we have used a puzzle game that has been specifically developed for this research. The game is designed for Android operating system, using OpenGL ES 1.0 version, which support all Android devices. A puzzle game was chosen because it represents a familiar playful activity for preschool children, which requires cognitive effort, utilizes physical manipulation, promotes collaboration and enhances emotional skills.

II. Application Design

There are six key elements that should be included when developing educational games: goals, action space, choice (option), rules, challenge and feedback.

- Goals – achieving some goal is driven by a motivation to reach that goal. The goals must be clearly defined and easy to understand. In our case, they can be divided as minor goals, like raising personal ego after each success or major goals like: introduction to technology in the early years, improving fine motor skills of children hands, gaining confidence, improving cognitive and emotional skills.
- Action space - it describes the overall workspace where the user can operate or perform any actions. In our case, the action space is the screen because a game is designed to work in full screen mode.
- Choice (option) - giving freedom to choose between different options, increases the player satisfaction and enjoyment, especially when he/she encountered some difficulties. In a case of a puzzle game, player can choose which part of the puzzle to try to set. If it does not match, then he/she can choose another part and try to set it again.
- Rules – this element is closely linked to the previous one. The rules are reciprocal to options. What is not defined by the rules of the game, are choices throughout the game. The rules of our puzzle game are:
  - The puzzle is considered successfully done when all the pieces are on their correct positions before the time for execution elapsed. The time for solving the puzzle is 5 minutes. After this execution time, the attempt is considered unsuccessful.
  - If the piece is correctly connected, it cannot move.
  - If the piece is not placed on its correct position, the user can move it until he/she found its real position.
- Challenge – the content of the game itself is considered as a challenge. The challenge of a puzzle game is successfully solving the puzzle to obtain the overall picture. Nancy Maldonado states that, puzzles allow an opportunity for young children to focus on an activity that has an ending - completing the pleasing image [10].
- Feedback – is what keeps players attention and is crucial for getting insight their previous activities. Feedbacks are divided into two parts: short and long-term feedbacks. In our case the short-term feedbacks include successfully set piece of the puzzle (which is presented by a short sound), successfully completed level (presented by animation and sound), expiration of the time for performing particular level (presented by animation and sound). Long-term feedbacks include identifier of a conquered number of stars (points) within a certain level, elapsed time within a certain level, overall points scored, identifier for inclusion or exclusion of music in the game.

The design of our application is made to attract children's attention, while following the design rules and principles, which have been proven in practice [11]. Pictures of the puzzles that are used are appropriate to the age of the children (Fig. 1). There are different levels of the puzzle game: puzzles that consist of 3x3 components, or overall 9 components, puzzles that consist of 4x4 components, or overall 16 components, and puzzles that consist of 5x5 components, or overall 25 components. At the beginning, the child starts with the easiest level, and continues to the heavier levels, thus allowing constant progress of various children's skills.

The game takes advantage of touch screen technology, as a standard way of interaction used on new mobile devices. This way of interaction is very intuitive for children, as they used their fingers to drag and drop the pieces of the puzzle directly on the screen.

The competitive character of the game is achieved by winning different number of stars (points) depending on the time for solving the particular puzzle. The maximum number of stars that the player can win is three, and this number

decreases with each elapsed third of the total time. If the player is not satisfied with the winning number of stars, he can go back to the same level and try to complete in less time.

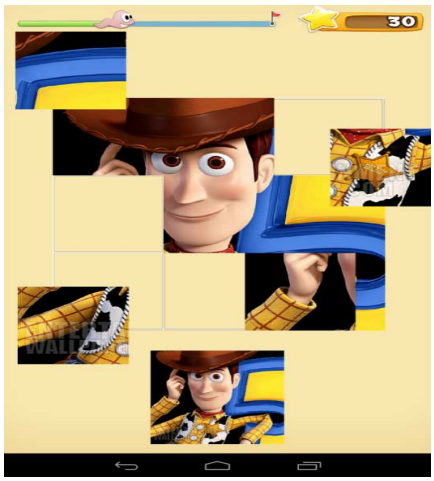

Figure 1. User interface of a developed puzzle game.

III. Evaluation With Children

A. *Elements of effective learning*

When conducting a research study with children, special evaluation methods are required. This is because children differ from adults; they have their own likes, dislikes, needs and requirements [12].

Children find informal learning fun when they enjoy and are engaged in the activities. Enjoyment and engagement are integral and prerequisite aspects of children's playful learning experiences [13-15] Prensky indicated that a combination of twelve elements make games engaging [16]. Fun and enjoyment are the most important elements of all these twelve elements. Being actively engaged in a learning activity has repeatedly been shown to be beneficial for learning [17].

Enjoyment has been found to be positively related to a desire to continue participation [18], and where the effort to increase intrinsic motivation has been widely accepted as a desirable educational practice since it leads to long-term motivation, and hence continued participation [19].

On the other hand, engagement comprises cognitive engagement, which involves attention to the activity and concentration and promotes 'useful' learning [20]. This conceptualization is relevant for children's play since a dominant function of play is learning. Learning requires engaged attention.

In our study engagement has been measured through the time recorded for the first and second completion, number of successful attempts, number of failed attempts as well as a number of moves. While enjoyment was defined and measured according to a questionnaire of the IMI (Intrinsic Motivation Inventory) model.

B. *Methodology*

IMI (Intrinsic Motivation Inventory) model is a validated multidimensional measurement instrument based on SDT (Self-determination theory) [21]. It relates enjoyment with intrinsic motivation. The IMI model includes questions divided into six subscales, which assess participants' interest and enjoyment, perceived competence, effort, value and usefulness, felt pressure and tension, and perceived choice while performing a given activity. The questionnaire is easy to modify to fit specific activities and interpret for children. In our case we have used only four of them (Interest/Enjoyment, Effort/Importance, Pressure/Tension, Value/Usefulness) with the slightly modified statements, suitable for children.

Standard IMI questionnaire utilizes a 7-point Likert scale, but in our case it was modified and a 3-point rating scale based on smiley meter was used. The smiley meter uses pictorial representations of different kind of smiley faces to represent the different level of satisfaction [22]. It has been used in different situations to measure one or more of the fun dimensions and has been proved easy to use by the children. Children were asked to circle one of the faces for demonstrating the truth level of each statement in the questionnaire.

Another model that was used in our study was Technology Acceptance Model (TAM). This model is used for measuring player acceptance of information technologies. It is also a questionnaire model that includes six constructs: perceived ease of use, perceived usefulness, attitude, intention, anxiety and satisfaction. Like the IMI method, a smiley meter scale was used with TAM model too, but with two responses only ("true" or "false").

C. *Participants*

The experiment was conducted in one kindergarten, where 20 children, aged 4 to 6, were participated in the study. The children selection was done randomly, assuming that subjects have a similar capability of completing the puzzle tasks

and a similar understanding of all the questions that were presented in the study.

Participants were divided into two groups (each group consist of 10 participants). The first group was testing the developed application of the tablet PC (Fig. 2), while the second group was performing the classic way of playing puzzle (Fig. 3). This way we wanted to make a comparison of the gathered results, in order to make a comparative study.

Figure 2. Experiment using a developed Android application

Figure 3. Experiment using classical puzzles

D. Procedures

To test the puzzle game initially, a classical puzzles from the toys store in 3 different complexity versions (3x3, 4x4 and 5x5 cubes), were selected. Then, based on the images from the purchased puzzles, the puzzles on Android application were made. This was done in order to have a small as possible differences while performing the experiment.

During the training phase children form the group that work with Android application, were briefly introduced with this new technology, because there were children who have not been used tablet PC previously. The touch screen interaction with the tablet was explained, as well as the way of moving puzzle parts in order to solve it.

The training phase for the second group, working with classical puzzles, was omitted, because the children were familiar with this issue. Instead, this group was passed directly to the testing phase.

During the testing phase, participants were working on randomly selected puzzle, but it was taken into account, each child to get puzzle of varying difficulty and to try to solve it. The time required for solving the puzzle, the number of correct and incorrect attempts, as well as remaining time, was measured during this phase.

After the twenty-minute play session, children were asked to complete questionnaires (according to IMI and TAM model that were previously explained). The survey was conducted with the help of the teachers, who verbally explain each question to the participants.

IV. RESULTS

Results obtained during experiment were summarized and the mean value and standard deviation were calculated, for both groups (Table 1 and Table 2).

From the results it can be observed that at the beginning children need more time to complete the puzzle, but after several unsuccessful attempts their memory improves, they remember the shapes, forms and colors of different pieces of the puzzle, so in next attempt the process of solving puzzle becomes faster and the number of movement for making the whole puzzle decreases. During the experiment, it was observed that children who played a classical way get easily bored (after several unsuccessful attempts) and they wanted to switch to play on tablet PC. They did not even want to play the same puzzle again. On the other hand, participants playing on the tablet PC were much more engaged to complete the puzzle.

This coincides with the results obtained from the questionnaire according to IMI model (Fig. 4). From these results, we can observe that the children interest and enjoyment were higher in the group that was playing on tablet PC. At the same time, pressure and tension were lower in this group, compared to the group who played a classical puzzle game.

TABLE I. RESULTS OBTAINED FROM ANALYSIS OF THE DATA ACQUIRED PLAYING A DEVELOPED GAME.

	Mean value	**Standard deviation**
Total Executing Time in first trial (TET1)	0.982	0.518571114
Total Executing Time in second trial (TET2)	0.728	0.522698258
Time Remaining (TR)	1.018	0.518571114
# of Successful Trials (ST)	11.8	3.42928564
# of Failed Trials (FT)	21.7	8.283115356
Total Number of Trials (TNT)	33.5	10.08216247

TABLE II. RESULTS OBTAINED FROM ANALYSIS OF THE DATA ACQUIRED WITH A CLASSICAL WAY.

	Mean value	**Standard deviation**
Total Executing Time in first trial (TET1)	3.697	2.398370488
Total Executing Time in second trial (TET2)	\	\
Time Remaining (TR)	\	\
# of Successful Trials (ST)	12.4	3.611094017
# of Failed Trials (FT)	28.6	27.55793897
Total Number of Trials (TNT)	41	27.17719632

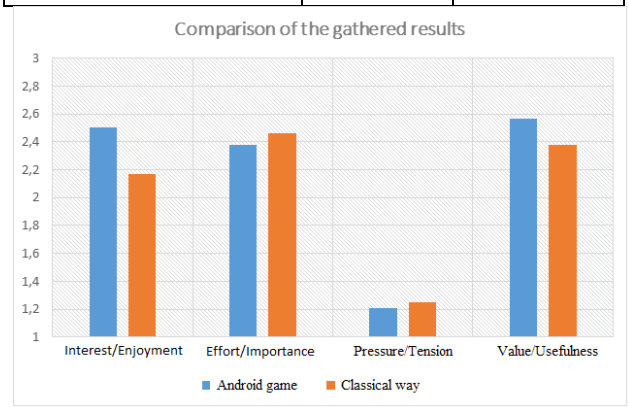

Figure 4. Comparison of the results gathered from the survey according to IMI method

Results about the children's acceptance of new technology were gathered from the questionnaire according to TAM model. About 90% of all participants answered affirmatively that playing game on tablet PC using touch screen technology was easy and fun, even for those children who have not been used this technology before.

V. CONCLUSION

There is no simple and unique answer to the question: What is the best way that young children learn? However, one thing is obvious, living in the era of digitalization, interactive mobile games should have more practical role in the learning process, because they are fun, engaging and motivating for young children.

For the purposes of this study, an Android application was developed according to the standards required for preschool children. The game was tested for various parameters as children's enjoyment, engagement, interest, tension, value, usefulness. The results of the evaluation showed that when designed appropriately games can encourage and motivate children and thus positively affect the learning process.

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