


Improving learning in mathematics through 3D digital game play

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Improving learning in mathematics through 3D digital game play

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Abstract— Teaching mathematics is a challenging goal for primary and secondary math teachers. Learning through game has been proven to increase kids desire to acquire new knowledge.

This paper presents the design and implementation of a three dimensional (3D) educational game that aims to help pupils to improve their mathematical skills. The game is simple to use and easy to navigate, but at the same time the kids feel rich game environment, which makes the experience better. To increase availability, the game requires simple installation and can be played directly on the web browser.

Game evaluation was made in elementary school environment. Results of the evaluation showed that kids that played the game have shown interest in learning math with this educational game. Their experience was positive; they liked the learning through game playing, which made the learning process more competitive and fun.

Keywords— *Game-Based Learning; 3D Education Game; Digital Game-Based Learning; Mathematics; Primary Education; Secondary Education*

I. INTRODUCTION

Most of the kids have difficulties in learning particular mathematical concepts. In order to learn and master those concepts, a lot of practice and dedication is needed, which is hard to be accomplished. Children quickly lose interest for solving mathematical problems and want to do something else, something easier and more appealing. On the other side, children spend most of their free time on their tablets, smart phones, or in front of their computers, playing their favorite games.

There are different ways to stimulate learning. For student at university, project based learning has been proved to increase students' interest for the learning course material, especially for engineering subjects [1]. Project-based learning is learner centered. Students have a significant role in selecting the content areas and nature of the projects that they do. There is considerable focus on students understanding what it is they are doing, why it is important, and how they will be assessed.

Recently, there has been an ongoing interest in the use of computer games for educational purposes. The studies found that video games can impact positively on problem solving skills, i.e. they can improve engagement and motivation. This

learning approach, which combines digital game-based activities and educational content, is often referred to as Digital Game-Based Learning (DGBL) [2].

Video games are powerful tool for teaching, especially with their interactive nature [3]. They create virtual worlds that cannot be done in reality, and allow us not only to tell the story, but also to experience the story and learn from it. Hence, creating and designing video games is not a trivial task. Moreover, generating game that is educational and entertaining at the same time is a challenging task. DGBL constitutes a relatively recent and still evolving learning approach that needs more empirical evidence in order to be applied more effectively.

The goal of our project was to combine mathematical problems with something more entertaining like playing video games. We aimed to find and show solution that will help kids to solve mathematical problems or review mathematical problems learned in school while spending their time on video games.

The most challenging problem was to make the smooth experience transition from educational to entertainment game, i.e. to make the academic content integral to the game rather than an add-on. Solution for that question is important because that is the way how kids can accept educational game, which have to give them fun experience that they are used to while playing entertainment commercial games. When we are trying to solve this problem, we should explore how to include educational content and activities in the games so they will remain fun and attractive. If the transition is fast, for example, simple implementation of educational methods in entertainment games, kids will recognize the game as educational math game and will discard it as unattractive. Therefore, it is very important the transition to be done correctly, to be slow and not noticeable by the players, i.e. the kids.

This paper presents the design and implementation of 3D digital game which helps pupils from elementary and secondary school to increase their knowledge in mathematics. In this paper we propose a slow transition approach that uses already existing game mechanics and adapts it for educational goals for learning mathematics. Game mechanics [4] are usually methods, actions and rules which motivate the player

to play the game. Collecting items (coins, diamonds, etc.), players' health, magic power, avoiding obstacles, etc. are only a few examples of game mechanics. This approach were used to create our educational game for learning mathematics.

The paper is organized as follows. The second section provides an overview of different solution for learning through game play. The third section provides implementation details. Section four evaluates the game. This paper is concluded in section five.

II. RELATED WORK

Part of this idea is not new and there are other educational games for learning math as well. The major problem with most of the existing educational games for learning mathematics is that the graphics, story, game content, details of the characters and other details, which are very important for keeping the attention and the interest of the player, are not done correctly. That is the reason why kids who will start playing that games lose their interest after short period of time and start to play more appealing entertainment commercial games. Kids always choose better graphics, details and games with better story.

Most of the games for learning mathematics are web based short games. Some of them are Cheese Capers [5], Bus Math Multiplication [6] and Feed Fribbit Addition [7]. Most of the other web base games for learning mathematics look very similar to the abovementioned games.

There are many mobile applications for learning mathematics. Graphics in those games are better than graphics in web based games. Still, there are a lot of improvements that can be done in order to make them more entertaining and with better functionalities. The content of these games should be improved, enhanced with better and more useful math's problems and examples that are synchronized with the lessons from school. Examples of popular mobile math's games that worth looking at are Math Training for Kids[8], Dinosaur Park Math[9] and Mathly Hollows[10].

Other interesting game for learning mathematics is Timez Attack [11]. This game is a good example how a fun educational games should look like. However, the story and the graphics for Timez Attack need to be improved in order to match the quality from good entertainment games.

There is nice, carefully created, educational project from Rovio, the company that is the creator of the globally successful Angry Birds[12], called Angry Birds Playground [13]. This is a good example how a popular entertainment games can be used in education.

The difference between our game and other games for learning mathematics is that we let the player to experience the fun like playing entertainment game. At the same time, the part of the game where the player solves math's problems is nicely integrated with the story of the game, so it feels like it's part of the game story. We also tried to adapt the educational content to be more useful, i.e. math problems to be more similar to those learnt at school. We believe that it will

increase the motivation to solve the math problems in the game.

III. GAME DESIGN AND IMPLEMENTATION

This game fits in the category of small games and can be played on browser with Unity player and standalone on Windows, Mac and Linux. When playing the game on browser, there is a background image that fits in the mood of the game play, providing better playing experience.

More details about the design of this game can be obtained from Fig. 1, which actually presents the activity diagram.

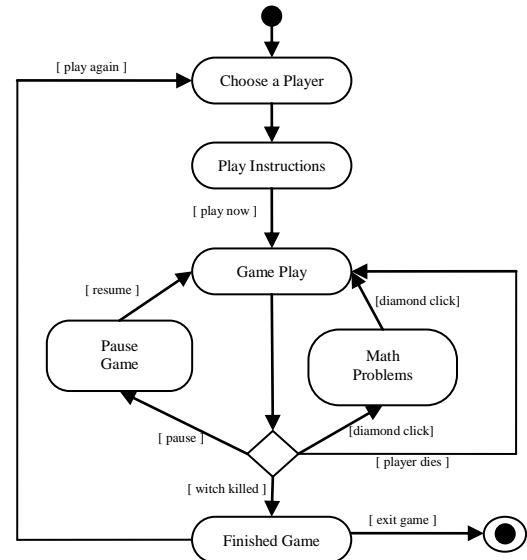


Fig. 1. Activity Diagram

For creating this game, Unity3d [14] game engine was used to bring all together and to build the final application. Photoshop [15] was used as a supporting tool for image editing, while 3ds max was used for creating 3d models and animations [16]. Most of the techniques we used are extensively described in [17].

Type of this game is platformer, i.e. it involves guiding an avatar to jump between suspended platforms (or over obstacles) to advance the game. The player controls the jumps to avoid letting the avatar fall from platforms or miss necessary jumps. This game is a 3d game, but the camera is positioned like 2d platformer to make the game easier to play and navigate. For this game we created simple story so the kids have motivation to play the game. The story is about a wizard who fights against an evil witch using magic powers. Hence, the game has a goal that need to be accomplished.

The first option that shows up when the game is started, is to choose a type of player. There is an option to choose to play as a boy or as a girl (Fig. 2). Characters in the game are very important as game mechanics. Allowing players to choose different type of game characters and customizing them makes players engaged and identified with the game character. This is a small detail which helps player to get more attached to the game.



Fig. 2. Game start screenshot

After choosing the game character, simple explanation is provided in order to introduce the players with the game rules. Only few controls are used while playing the game, which makes the game easier for playing.

After the game starts, the player can enjoy playing nice designed game and feel like any good entertainment game. There are standard game options for pause and restart the game. The player can enjoy special effects sounds. Background classical music makes nice ambient and helps player to feel the quality of classical music.

In order to defend from the enemies, the player uses magic power to attack and destroy the enemies. Each time the player uses magic, the magic power goes down and the only way to get more magic power is to click on the diamond icon, which brings new state where player can focus on solving a math's problem (see Fig. 3), and for reward gets a magic power. With current settings of the game, player gets 10 magic power for each solved problem which allow him/her to use the magic for 10 times. This setting can be adjusted.

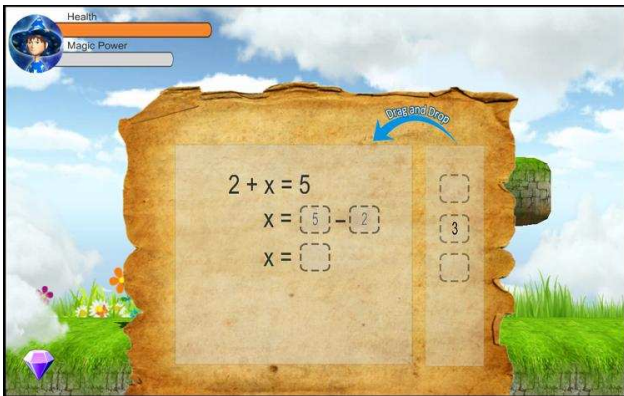


Fig. 3. In-game Math Screenshot

In this way, the player discretely is forced to solve the math's problems in order to achieve the game's goal. It is also important to mention that the appearance of the educational content and activities in our game is very similar to the game mechanics in entertainment games and they are connected smoothly with the story of the game. Educational contents should be included in that way so the player feels like they are part of the gameplay.

Another important thing to mention is that educational game should contain fun, entertainment part of a game play, because if the game is full of activities for solving problems, it may not be appealing for the player. So the fun part of the games must exist and as addition to it, educational activities to be included. This is the strategy we used in our game.

The graphics for games are very important, because graphics are first things that player sees and according to them he/she decides whatever to play the game or not. No matter how good the game mechanics are, if graphics of the game are with low quality there are big chances that the player will quit the game. Keeping that in mind we tried to create nice graphics for our game (Fig. 4 and Fig. 5). Graphics are combination of 2d and 3d graphics. Most of the environment (clouds, grass, flowers, etc.) is 2d graphic, while the platforms and the characters are 3d graphic. For the magic spell actions we used 3d particle system.

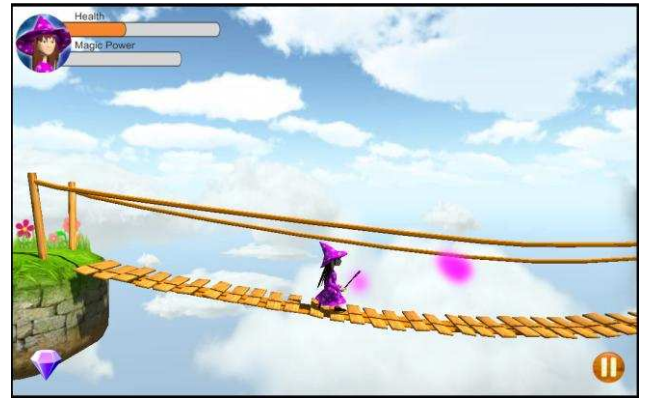


Fig. 4. In-game screenshot for female player

Two different animations were used in the game. One type is the environment animation like "dark clouds disappearing" animation and "witch explosion" that happens in the end of the game. Other type of animation is the character's animation [18]. We tried to work on details on these animations, because they are what players see most of the time while playing the game. Character animations were split into smaller animations like character actions (run, jump, magic spell, attack, etc.). Each of these parts were carefully animated and imported into the game engine with an appropriated sound, i.e. when the animation is active, the corresponding sound is played.



Fig. 5. In-game screenshot for male player

IV. EVALUATION

In order to validate the actual educational value of our game, we performed a simple evaluation.

The evaluation was done in two schools, one private (QSI International School) and one public school (Vera Ciriviri Trena) in Skopje, Republic of Macedonia. In order to evaluate this project, 45 students (22 males and 23 females) were asked to play the game for 15 minutes. Only one student, a girl, refused to play the game. All students were enrolled in fifth and sixth grade in primary school.

The first impression of the students about the game was positive. They were excited about the game and the idea. All students had the opportunity to play the game and after that, they were asked to fill a questionnaire.

Students have answered the following questions:

- 1) Do you like the game?
- 2) Is the game easy to play?
- 3) Can this game help in studying mathematics?
- 4) After playing the game, do the math's problems like that in the game look more fun and easy for you?
- 5) Do you have some ideas to make the game better?

The results of the evaluation (see Fig. 6) showed that kids who played the game have shown interest in learning math skills with this educational game. Their experience was positive; they liked the learning through game playing, which made the learning process more competitive and fun.

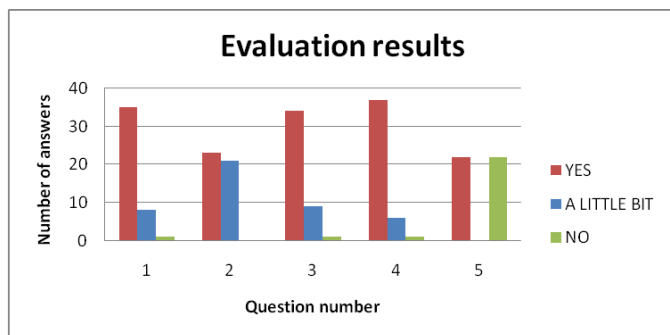


Fig. 6. Results from the questionnaire

V. CONCLUSION

This paper presents the design and implementation of 3D digital game which helps pupils to increase their knowledge in mathematics. We adopted existing game mechanics from commercial games to make slow transition from entertaining to educational game.

In the future, we plan to improve and extend this game with: diversity of rewards and achievements, implementation of timers, levels, multi-player gaming, etc. These extensions should be carefully integrated within the game, in order to keep the amusing component dominant in the game.

Additionally, we intend to implement educational games for high school pupils and university students. In this case, the mathematical concepts must be explained correctly and without hiding details. This process should include extensive consultations with math teachers. Moreover, the game should be frequently updated to take pace with the changes in the course syllabus.

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