


A Platformer Serious Game with Dynamic Learning Contents

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Abstract. Video Games have always been a point of attraction for many people, especially for those in the younger age groups. Recently, the trend of taking advantage of this engaging field in education, to impart learning in some topics, is growing. Whereas Serious Games are generally designed for a specific educational topic with pre-defined and static learning contents and activities, we propose a serious game for children called “FunHomework”. The game is based on features in commercial games and obtains its learning material from another application called “TutorApp”, where both applications share the same real-time database. The TutorApp can be used for different subjects, giving educators full control over the learning contents of the game, and can also be used to monitor students’ performance. With its dynamic contents, FunHomework will maintain its engagement and increase its usability.

Keywords: Serious games · Game-based-learning · Education · Platformer

1 Introduction

The use of games for learning has developed over several years. Serious games (SGs) are considered an interesting tool that combines entertainment with knowledge transfer. They have a purpose beyond entertainment, e.g., education, training, advertising, or supporting social change [1]. SGs offer considerable potential that can be used to facilitate formal and informal learning experiences in many contexts. Many studies have pointed to the constructive properties of SGs, such as their inducement and stimulus appeal, which can support various learning experiences.

One of the main advantages of using technology in education is producing a personalized learning experience. SGs can gauge the level of the students/players and cater to their learning style. Some students prefer verbal learning style of using words, both in speech and writing, where others may respond better to logical learning style of using logic, reasoning and systems. Such adaptation in classrooms is governed by the availability of time and resources. Due to the evolving learning styles of the Millennials and the way they learn, SGs can be a favourable vehicle to cater to their needs.

FunHomework is a novel game, affording the teacher control over the learning contents, making the game suitable for various subjects. To maintain its engagement and increase its usability, the game is developed using Procedural Content Generation technique, which generates dynamic contents and unique environment, every time the game is played.

2 Background Work

Many researches have described the positive effects of games on child and teen players' learning [2]. Robertson and Miller [3] have empirically supported the constructive outcome of digital games, especially for the less-abled children. Using a game in classroom can motivate all the students, including shy pupils, to participate and contribute in class actively. The nature of games boosts diverse crucial skills for deep learning, such as metacognition, selective attention, etc. [2, 4]. Therefore, SGs can be considered an effective teaching tool that involves various learning principles, not just by virtue of being a game [5]. SGs have to be supported with educational principles and planned with educators, to guide the student through the learning material. Students should be given the opportunity to explore the games and cooperative learning should be encouraged.

Usage of SGs in formal education is making progress; however, most games were designed to achieve a specific learning goal. The games were structured in such a way that the learning goals are recognized and specified in the early stages of game design. SGs generally target specific topics (e.g. Math, Science, etc.). A game that is developed for the science subject in elementary schools will have almost static learning contents. As a result, it cannot be used for another subject, or even other topics within the same subject. Once the students master all the details and tackle the game, their motivation to play the game diminishes.

Despite the presence of games in formal education, it is still rarely seen in the regular classroom [7]. We argue that the reason for that is the gap between game developers and school teachers. A SG that is designed for teaching some curriculum, might not fit perfectly in another classroom that uses a completely or partially different curriculum. To have serious games in the classroom, they have to fit into the existing lesson structures and need to provide appropriate assessment. Currently, games are used often based on the criterion whether it makes the teacher's life easier, because the teacher chooses which game they are willing to use [6]. Teachers need to assess whether the game will enhance their students' learning, which can be time consuming. This is also another reason why serious games are not used in the classroom more frequently.

A study by Husain [8] introduced Serious Game design framework and an example of a Math educational game. Her SG targets Math of fourth graders and is made of three components: the game itself, a social network and a teacher reporting tool. She urged that some teachers are reluctant to use serious games in school and that we can increase usage of serious games as a resource, by involving teachers in game design and address their concerns. In her opinion, SGs should be games and not just drill and practice.

Mathbreakers [9] is a 3-D math exploration video game, where kids experiment with numbers and operations by playing with various toys and puzzles. Adventurers can chop numbers in half with a fractions sword, cast addition spells to zero-out negative enemies, and outsmart swarms of spiky integers, while developing number sense. The first release of Mathbreakers complements the standard math curriculum in San Francisco - USA for grades 1–6, including arithmetic, negatives, fractions, factoring, multiples and powers. The game is also supported by a dashboard, where

teachers can assign lessons and track the progress of their students. However, teachers have no access to the learning material, as the curriculum is pre-set.

This paper proposes a serious game for elementary school students, called “FunHomework”, where learning contents and questions are set dynamically by another application called “TutorApp”, used by teachers. Each time the student plays the game, he/she finds new questions and challenges set by their teacher. Using TutorApp, teachers can add their own learning materials, which are then integrated into FunHomework and can be viewed and tackled by students during gameplay, which puts the game under the full control of teachers.

3 Game Components

FunHomework is a framework that consists of two applications; a Game “FunHomework”, and a mobile application “TutorApp” for teachers. The basic goal of this framework is to provide for students an encouraging learning environment to submit their homework/activities results, and for teachers a simple and easy tool to manage students’ activities and evaluate their performance. Both applications share the same Firebase real-time database to save, retrieve, update and exchange students’ data and homework/activity reports. Firebase [14] provides a real-time database and backend as a service. The service provides an API that allows application data “TutorApp” and game data “FunHomework” to be synchronized across clients and stored on Firebase’s cloud. Firebase also provides client libraries that enable integration with Android, iOS, as well as Unity3D game engine applications.

3.1 TutorApp

TutorApp is a mobile application to help teachers managing the learning contents of the game FunHomework. Using TutorApp, teachers will be able to organize students into groups according to their age/class or subject (Fig. 1a). They can also assign homework/activity questions to be done by students using FunHomework game (Fig. 1b). The application will be used by teachers and have the following functionalities:

1. Create a group for students to join, identified by a unique identifier GroupID.
2. Create a homework with a name and a description. Specifying the homework deadline is optional.
3. Add questions to homework, specifying the right answer for each question, as well as the mark associated with that question.
4. View the results of students within each homework and within the group as a whole.

3.2 FunHomework

FunHomework is 2D game developed using Unity3D game engine. The game can be classified as a Platformer game - one of most popular genres of video games. Games

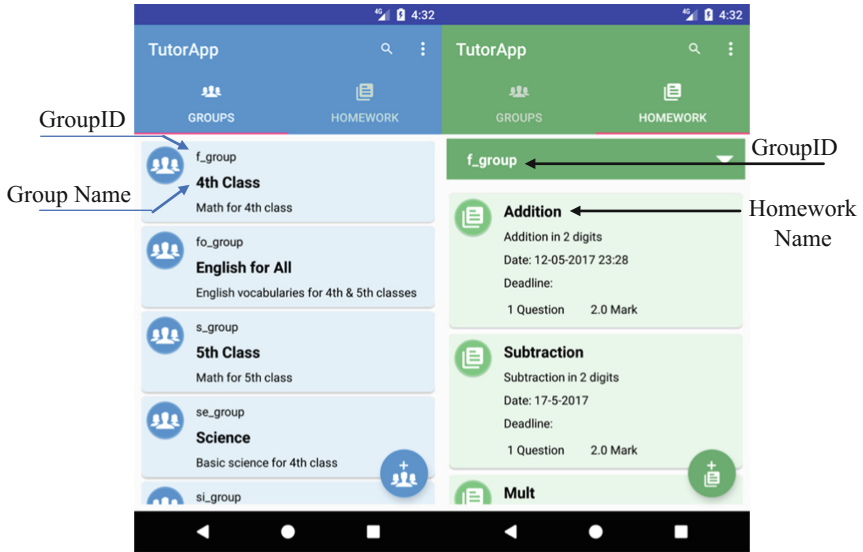


Fig. 1. TutorApp application; (a) Groups view (b) Homework view for group “f_group”

like Super Mario and Sonic, considered as the best-selling games of all time, are Platform games [13].

In the game’s main menu, the players have to fill in their profile with data to be shared with TutorApp, which includes name, age, and student number if available. To view available homework/activities, the player has to join active group(s) created by their teacher. The group can be found by its GroupID as a unique identifier. (Fig. 2)

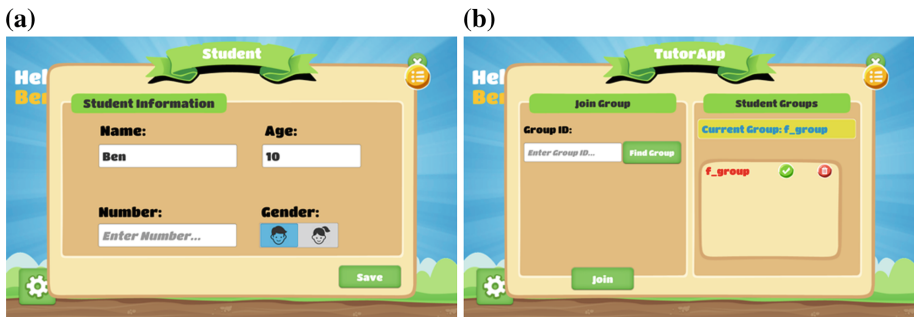


Fig. 2. FunHomework student’s details; (a) Basic information (b) TutorApp details

The teacher shares the GroupID with their students which will enable them to find and join a specific group by that GroupID (Fig. 2-b). Once the student successfully joins their group, he/she will be able to view homework/activities assigned by the teacher (Fig. 3a). By selecting the “Play” button, the game starts (Fig. 3b) and the questions of the homework/activity are integrated into gameplay.

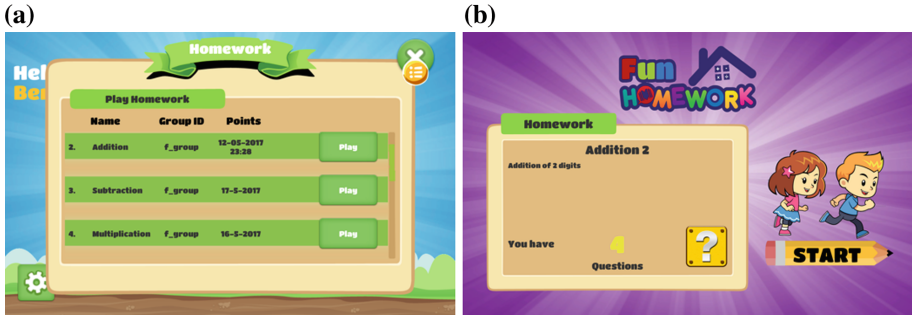


Fig. 3. Homework/Activities; (a) Available homework for group “f_group” (b) Homework “Addition” description

FunHomework involves guiding a player character to jump between suspended platforms and over obstacles to traverse their environment. The player controls the jumps, to avoid letting their character fall to their death or miss necessary jumps. During gameplay, the player has to fight and jump over enemies which launch projectiles. With their pencil weapon, the player can shoot enemies and gain more points. Along the way, the player can collect stars, before reaching a point where he/she is blocked by a wall, asked to hit a question block before he/she can go further (Fig. 4a). Once the question block is hit, question interface appears and the players can write their answer to the displayed question – which is loaded from TutorApp (Fig. 4b). Upon completion, the player can view their result which shows right and wrong answered questions accompanied by their marks and percentage out of total possible marks. The result screen also shows the points the player has collected by gathering stars and shooting enemies. The players can also see their position in a standings table of all students within their group, based on the average marks of all attempts. With two different player characters, one for girls and one for boys, the players can choose a character which represents their gender. The game presents the possibility of choice in character selection, which can be considered as a means by which the players could extend themselves into the world of the game.

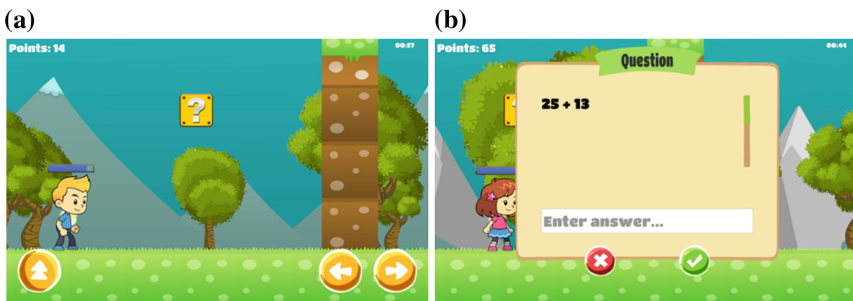


Fig. 4. FunHomework game; (a) Question point (b) Question user interface

4 Procedural Content Generation

Procedural content generation (PCG) is the programmatic generation of game content, using a random or pseudo-random process that results in an unpredictable range of possible game play spaces [10]. Due to the increasing cost of content design, we used PCG technique that can supplement design skills to rapidly populate the environment with randomly generated content. Using dynamic Instancing of In-Game Entities, we varied the parameters of in-game entities, to create a large possible number of entities with a small chance of repetition [10]. The dimensions of the environment depend on the number of questions of the activity/homework to be solved. The building unit we used to generate game contents is the question. Before and after each question, we generated an enemy selected randomly from a set of enemy entities (Fig. 5). Mountains and trees are also instantiated with Background Parallax effect from a set of entities, and placed with random spacing among question points and according to the dimensions of the environment. The same principle applies to walls, platforms, obstacles and stars to be collected. After generating the environment and its contents procedurally, the players find activity/homework questions spread evenly across their path.

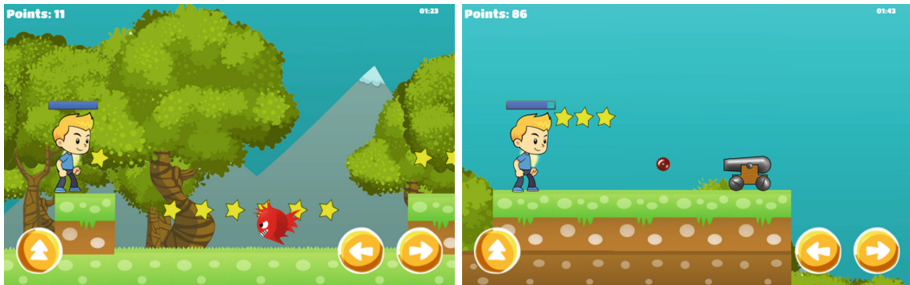


Fig. 5. Sample enemies

The result of PCG will be an almost completely different play environment, each time the player starts the game. The changing positions of mountains and trees and the different types of enemies settle the player in a new level, by restarting the game. This has not only saved design and development time, but also reduced the chance of player frustration, and maintained game engagement.

5 Reward System

The term reward system refers to the structure of rewards and incentives in the game that inspire intrinsic motivation in the player, while also offering extrinsic rewards [11]. Reward systems can be viewed as player motivators or as compromises for easing disappointment. In modern video games, reward systems also provide a social meaning within and outside of games [12]. In FunHomework, we tried to create a reward system that maintains game engagement and increases the healthy contest among students to play and do more homework. Listing students in a standings table kindles the

competitive spirit in them, whereby they are stimulated to keep playing and solving problems, to improve their ranking. The reward system of FunHomework depends on three factors:

1. Number of right/wrong answers that the player make. The final grade of each homework is presented as a percentage and then added to the average of previous attempts.
2. Number of collected points. The player can collect points by grabbing stars, or shooting enemies and projectiles. Points are accumulated in the student's score and then used as a second factor, in case of a tie in the marks.
3. The time needed to finish the homework/quiz. The faster the task is finished, the more are the points to be got.

Once the player reaches the finish point, the result screen shows the outcome (Fig. 6a), where he/she can also view his/her position in a ranking table (Fig. 6b). The ranking table displays the players within the same group ordered by (a) their average result for all homework in this group (b) the sum of points collected during the play of all homework. For more motivation, badges are given to the first 3 players within the group. The first player wins the trophy, while the 2nd and 3rd places enjoy silver and bronze medals respectively.

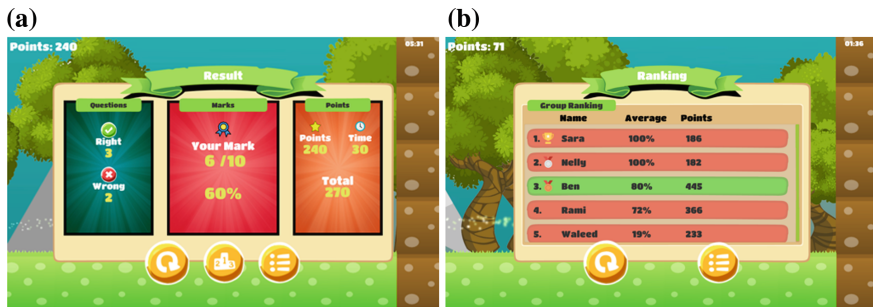


Fig. 6. FunHomework game; (a) Results Screen (b) Students' Ranking

6 Conclusion

Serious games are used in various domains; however, in the formal education sector, there are a lot of factors to be considered, as they might change the fundamentals of the current educational process. The teachers play an important role in this process, as they have the authority to choose the learning method. They also have the experience of the current learning process. For using serious games, they need to be able to adapt to a different learning process and be able to manage the reflection of new methods.

In this paper, we introduced FunHomework, a platformer game that gets its learning material from another application TutorApp. The game provides full teacher control over the learning contents, making it suitable for various subjects. FunHomework

maintains its engagement and increases its usability, by using the Procedural Content Generation technique, which generates dynamic contents and a unique environment, every time the game is played. Providing a healthy, competitive environment, FunHomework can be used in formal education for students within the classroom or at home. The game should be published for personal computers as well as for mobile devices, to be available for students everywhere. While the initial feedback received from students, teachers and parents is promising, the game should be tested in and outside the classroom, to measure its educational impact on students' attainments.

As a suggested refinement for future work, Speech Recognition can be employed within the gameplay, to ease user input. This should convert the player's voice into written text and can help the player in submitting the answers with his/her voice more quickly, especially where answers contain long texts.

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