Math is not only for Science Geeks: Design and Assessment of a Storytelling Serious Video Game

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Abstract— **Educational video games have been employed by teachers in order to make educational software more attractive to students. However, limited research has been made on the design and assessment of the storytelling elements and the educational effectiveness of these games in sciences curricula. For this purpose, we used Scratch to develop a storytelling mathematics video game and then we measured its educational effect to a small group of twelve students. We found that the story-based math video game has captivated the interest of students and it has been beneficial in the improvement of their performance in an assessment test. Most notably, the improvement was higher for students who used to have poor performance in mathematics. In practice, educators should develop similar games for similar science topics (e.g., physics, chemistry, etc), while further research should consider the active involvement of students in the design of serious games.**

Keywords- storytelling, serious, video game, math, performance.

I. INTRODUCTION

Many researchers and educators advocate the use of video games for learning purposes. Educational video games are considered to be an effective learning medium in school context, since they create meaningful contexts in which children have the opportunity to apply higher order cognitive skills [1]. Boyle [2] points out that games can produce engagement and delight in learning; moreover, there are studies that have shown that the use of video games improve thinking [3] and illustrate better students' performance [1]. Within the field of game design, narration is beneficial into a learning environment [4] and provides opportunities for reflection, evaluation, illustration, exemplification and inquiry, especially on arithmetical concepts.

In our study, we designed and developed a math game in "Scratch". The video game with the name "Gem-Game" is available for further improvement by the Scratch community and it has received positive feedback by the community [5]. The game is targeted to children that attend first and second class of gymnasium (13-14 years old).

The purpose of the complementary experiment was to examine whether and how storytelling video games help some categories of secondary school students to improve their skills in mathematics in a more pleasant way than structured exercises and evaluate their effect on students of different skills and attitude towards mathematics. We have elaborated on an experimental procedure that includes pre and post test. The game was given to them to play during a period of two weeks on their own time and the research hypotheses were that: (H_1) there is a significant difference in the performance after the story-based game involvement and (H_2) there is a significant difference in the improvement between good and poor academic performance students.

II. THE STORYTELLING SERIOUS GAME

Gem-Game is a serious game which main purpose is to improve the mathematical skills and numerical competence of players. The main character (Peter) of the game moves up or down dependent on the operation executed by the player. So the students also get a visual idea of increasing quantity when adding and decreasing when subtracting.

Most notably, the game has a plot that starts with a small story and a mission is assigned to the player. The story and the mission are used to stimulate the students' interest and motivate them to play the game. We tried to make the dialogs and the plot funny. We wanted the game on its whole to be interesting and pleasant, so that it wouldn't look like rigid book or computer-based exercises, which usually have a multiple-choice presentation format.

Each storytelling game consists of some common stages [6]; our game's design (Fig. 1) follows this storytelling structure. In the first stage, the hero is situated in the ordinary world; in our game the hero named Peter is in his bedroom and looking for his dog (i). Then the hero is presented with an event that necessitates leaving the comfort of the ordinary world, Peter's dog, Lucky has been kidnapped (ii). Next, the hero meets a mentor (iii) or someone who may offer advice or guidance, the fairy guides Peter to collect 30 diamonds (iv). Once the hero commits to the adventure, he begins the problem-solving process (v). During this process, the hero encounters various challenges that must be overcome in order to progress. In this stage Peter has to play and win the game in order to collect the necessary diamonds. When Peter collected the diamonds, the fairy appears (vi), the fairy calls the witch (vii), the witch appears and gets the diamonds (iix), the witch release the dog (ix) and the moral of the story is presented (x). As we previously mentioned, the ultimate goal of the player is to get back his dog or in other words to collect the diamonds. To achieve the ultimate goal, Peter must win the 3 stages. In particular, Peter must make correct adds/subtracts in order to earn diamonds. For example, if Peter is in the line 6 and the diamond in the line 1, player

must write -5 in order to gain the diamond. In order to complete each stage player needs to collect 10 diamonds.

Figure 1. Gem-Game Storytelling Structure

III. Pilot Deployment and Assessment

The sample of participants in this study was comprised of 12 students. From the total of the participants, 6 were boys and 6 girls. All of them were around 13-14 years old, attended the second grade of gymnasium and they were taught the same syllabus on mathematics. A pre-test was conducted in the course of mathematics.

Following, the game was given to the students to play during a period of two weeks on their own time. After the involvement of the students with the game a post test was conducted in the same level of difficultness. Both (pre and post) tests are structured with the following exercises 10 True/False Sentences, 20 Add/Subtract Integers, 5 complete the correct math sign and 10 compare two integers.

Using a t-test between pre-test (M_1=74.58, SD_1=23.16) and post-test (M_2=89.85, SD_2=10.41), the results showed a significant difference $t(22)= 2.08>2.07$, $p<0.05$. This leads us to the result that the involvement of the students with the video game benefits their performance.

Following, students were split into poor and good academic performance groups based on their pre-test performance (performing a median-split in 75 score). Afterwards using a t-test between the improvement among poor academic performance (M_1=32.00, SD_1=17.20) and good academic performance (M_2=6.00, SD_2=3.07), the results showed a significant difference $t(10)= 3.65>2.23$, $p<0.05$. This leads us to the result that the involvement of the students with the video game mostly benefits poor academic performance students.

IV. Conclusion and Ongoing Work

The results from the evaluation showed that students would benefit from the involvement with the game. Moreover, one important finding is that when the subgroups of students who previously had good and poor performance respectively were compared, it was revealed that the subgroup of students who used to be poor performers had benefited significantly most from the game. The above findings may be explained by the fact that video games are able to entertain, attract and engage students who do not concentrate easily on their studies.

As with any empirical study there are certain limitations. Despite these limitations, the results generate valuable insights which can be used as a part of hypotheses for representative follow-up studies in serious storytelling games. Therefore, in future versions of Gem-Game we aim to improve the environment of the game. Moreover, by encouraging children to make their own game with Scratch, we are aiming to investigate the effect of enrolment in game design and development on children's cognition, motivation and learning outcome. In future investigations, we aim at exploiting a richer spectrum of research methods, including observations and interviews [7] and increasing the sample of students.

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