MATH RAIDER: ADVENTURE MATHEMATICS

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Abstract

Although video games, especially serious games, can be a great way for students to have fun while learning, they are often not really integrated into conventional teaching. Instead, they tend to stand on their own and may therefore be less accepted by some students who do not want to participate in school activities during their free time.

This paper addresses this issue and presents a concept for a learning package that combines a serious game with a traditional analogue teaching tool and also includes a web platform for teachers to be able to better track their students' learning progress. The goal is to obtain greater engagement from students by tighter integrating the game into regular teaching.

Keywords: e-learning, maths education, game-based learning, gamification.

1 INTRODUCTION

Serious games can help school and university students learn by increasing their motivation to learn and achieving voluntary involvement with educational materials. It is obvious that teenagers often play computer games [1]. It makes sense to carry out learning in a playful environment, especially when it involves more abstract concepts such as mathematics. The potential of students in serious games, especially in this subject area, was recognized early on [2]. To generate a flow, some aspects play an important role [3], of which the most important are taken into account in the application presented here: Challenge, immersion, thematic and Visual Appeal, Clarity of goal, feedback, and Rewards.

Another strength is the location and time independence of learning with serious games as a subcategory of e-learning.

However, instructors often have no way of tracking learners' progress, apart from personal monitoring during lessons or class tests and exams.

In addition, with the former, the advantage of being time and place independent is lost, and class tests and exams are a moment when it is already too late to identify any deficits.

To remedy the problems described above, a learning package was designed as part of this work, which, on the one hand, gives teachers the opportunity to gain an overview of the learning progress of their learners, and, on the other hand, enables learners to learn in both analogue and digital form. For this purpose, the package includes an analogue teaching aid - be it a workbook or textbook - to convey the learning content, as well as a serious game to practice and consolidate what has been learnt. In addition, a web service is linked to this serious game so that the teacher can obtain an overview of the learners' progress. The components of this learning package and how they interact with each other are shown in Fig. 1.

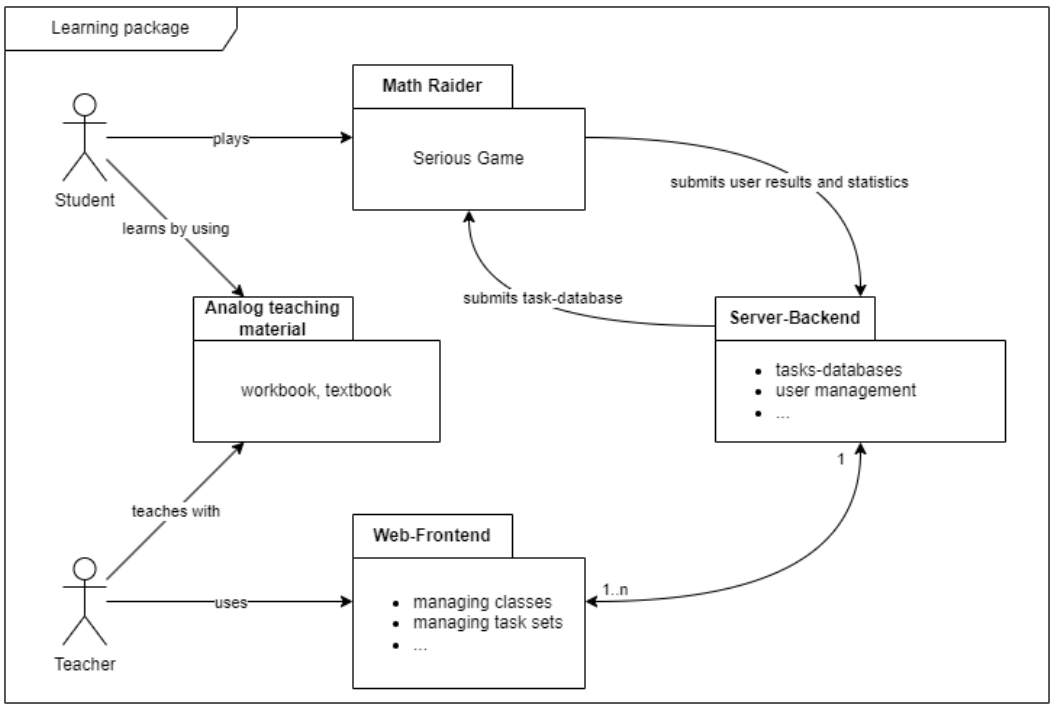

Figure 1. Component overview of the learning package

2 THE SERIOUS GAME – MATH RAIDER

2.1 Overview

Math Raider is a serious 3D action-adventure game that combines Lara Croft and Indiana Jones with maths to create an exciting learning experience.

The players can choose between a female or male character and search for gold and other treasures in ancient temples and tombs. This involves overcoming different obstacles and frequently requires solving mathematical problems. However, the builders have not left the ancient walls unguarded, so the treasure hunters should expect a fight or two. The gold collected can then be used to buy better equipment for the character in the game. There are also points awarded for completing each level; the faster and more error-free, the more you score. Math Raider is a single-player game that creates an exciting environment in which students enjoy learning and practice maths. Math Raider is initially being developed for the PC but may be ported to mobile devices in the future.

2.2 Integration of math into the game

When combining learning and games, [4] lists three possible approaches:

1 Adapting the game world to the learning situation

2 Integrating the educational content into the game world

3 Enriching the real-life learning situation with game elements

Math Raider uses the second of those approaches. Math Raider is first and foremost a game, with different gameplay elements, including fighting enemies and collecting gold and other valuable things. One of those game mechanics integrates the solving of mathematical tasks. As already mentioned in the overview, the player must overcome obstacles to progress in the game. In addition to the enemies mentioned, these obstacles include traps, such as spears that emerge from the ground or arrow-shooting walls, and locked doors. While traps could potentially be ignored by players who are willing to just accept the damage they take by walking through them, doors are hard-locking them from progressing, and with the previously mentioned enemies wandering around the level, players are discouraged from just walking through traps and instead are encouraged to disarm them. To do so, as well as to unlock the doors, ‘puzzles’ or riddles in the form of maths problems are placed on the levels. These are represented as glowing runes on the walls, which are ‘translated’ by the adventurer and then solved by the player. How such a riddle looks in

the game can be seen in Fig. 2. If the player solves these correctly, they can move on, as the corresponding trap is then deactivated, or the door is now open.

The difficulty of the tasks the player must solve is dynamically adapted to the player's performance. For this purpose, Adaptive Task Selection (AdapTS) had been developed. At the end of each level played, when the player reaches the treasure and finishes the level, as shown in Fig. 3, AdapTS analyses how many tasks in the level were solved correctly at the first attempt and raises or lowers the difficulty accordingly. If the difficulty remains the same because only a few tasks were solved incorrectly on the first attempt, those tasks are marked by AdapTS and will be asked again the next time the player plays a level with the same subject area. If all tasks are solved correctly on the first attempt, the difficulty level for that subject area will be. On the other hand, it is reduced if many tasks are solved incorrectly at the first attempt. In addition to the subject area-related tasks, there are also time-limited mental arithmetic tasks that are assessed separately by AdapTS.

Figure 2 Game screenshot: a riddle inside the level.

Figure 3 Game screenshot: Treasure at the end of the level.

3 THE WORKBOOK

The workbook is a classic workbook, as used in schools on a daily basis, supplemented by illustrations of the game characters, which guide the students through the exercises and give hints on arithmetic rules and the like. In addition, the topics are explained in explanatory texts and then cemented through increasingly challenging exercises. Teachers can use the workbook directly in the classroom or it can be used for self-study – or a combination of both – and thus also enable students who lack the technical equipment to play Math Raider to still use the learning package partially.

4 THE WEBPLATFORM

The web platform fulfils two purposes. On the one hand, it hosts the assignment database files for all class levels of the respective educational institution. When a student logs into the game, the game will then load the corresponding task database file from the back-end and save it locally to make it possible to play the game without an internet connection.

On the other hand, the Web platform also receives statistics from the game and processes them, so that teachers can see how often students use the game, how well they perform in it, and which students may need further support in certain subject areas.

Each institution hosts its own backend.

5 OUTLOOK

With the conceptual design and most of the necessary technical details already planned, the next steps include the actual development of the web platform, as well as the serious game itself. The aim is then to evaluate the package under real conditions by using it in the maths primer course at Aalen University. The results of that test will be used to further improve the concept.

REFERENCES

[1] P. Sweetser and W. Peta, "GameFlow: a model for evaluating player enjoyment in games", Computers in Entertainment (CIE), Vol. 3, no. 3, pp. 3-3, 2005

[2] F. F. Varela, E.V. Couago, and E. Martínez-Piñeiro, "The impact of serious games in mathematics fluency: A study in primary education", Commuicar vol. 29, nr. 69, pp. 115-125, 2021

[3] O.Dele-Ajayi, J. Sanderson, R. Strachan, and J. Pickard, "Learning mathematics through serious games: An engagement framework", IEEE Proceedings of the 2016 Frontiers in Education (FIE), 2016, pp. 1-15, 2016

[4] B. Spies, „Entwicklung von Serious Games aus lerntheoretischer, mediendidaktischer und medienpsychologischer Perspektive", Digitale Lernwelten – Serious Games and Gamification, W. Becker and M. Metz, Springer VS, pp. 27-41, 2022 [in German]