Full Formative Assessment based on Educational Video Games

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Abstract

The attention on the use of computer games in education (educational gaming) is quickly growing. By investigating the impact of video games in school, researchers have shown a remarkable improvement in student engagement and motivation. Nevertheless, the effects of educational gaming have rarely been considered on a long running application and, most important, they have never been considered in the whole teaching process as a means for teachers to real-time monitor students' learning. In this paper, we investigate the use of video games associated with formative assessment to pursue the above objective. In particular, we have conceived and implemented a portal, named PlayLearn, aimed at administering online tests based on multiple-choice quizzes, by means of video games. By letting the students play, the portal helps students to learn, it evaluates them and, finally stores their learning parameters which can be used by the teachers to improve in real-time the learning process, all in a virtuous circle.

1 Introduction

Nowadays, the education community is facing a new generation of students: the "*Digital Natives*": born into a world of pervasive digital technologies, they behave differently from the "*Digital Immigrants*" who are teaching them. This difference has led to a very crucial debate on whether it is possible to create a more effective learning process by using these technologies.

Even though, as reported by Bennett et al. [2], claims made on the *digital natives* are often not supported by a scientific evidence, it cannot be denied that the actual generation of students has grown up in a closer contact with digital technologies such as computers, Internet, mobile phones and MP3s, etc., than the past generations. One of the activities in which the new generation is much more involved is playing with video games. As stated by Prensky [6], "today's average college graduate students have spent less than 5,000 hours of their lives reading, but over 10,000 hours playing video games". This aspect was also observed by the authors in a Project (*Innovambiente*) funded by the Italian Ministry of Innovation based on new technologies. In [5] it is shown that in the *Innovambiente Project*, implemented in a secondary first level Italian schools, interactive whiteboard and educational-based games can be used by teachers as useful tools in order to improve the students "emotional intelligence". Many educators think that this attitude to "play" with technologies could be fruitfully used for learning. Indeed, the attention on the use of computer games in education is growing [4, 7, 8, 9]. By investigating the impact of video games on high school students, researchers have shown a remarkable improvement in student engagement and motivation [1]. Nevertheless, the effects of *educational gaming* have rarely been considered on a long running application and, most important, they have never been considered in the whole teaching process as a means for teachers to real-time monitor students' learning.

In this paper, we investigate the use of video games associated with *formative assessment* to pursue the above objective: we have designed and implemented a portal, named *PlayLearn*, which allows the students to access formative online tests while playing an enthralling video game. *Formative* assessment distinguishes itself from *summative* assessment since it occurs during the learning process, gives information on the learning state of the class and allows the teacher to decide the most suitable learning path [3]. Following this principle, the teacher can access the report section of our portal and real time monitor the state of the class. Thus deciding the most appropriate action to improve his/her teaching.

PleayLearn is a web application equipped with a database. Each student has its own credentials to access the system. At any lesson *PleayLearn* works as follows. The teacher generates a test, by randomly selecting the questions from a common base for that lesson. Clearly, each question can be edited by the teacher. Then, the teacher validates the test and opens the game session. Now, the student can log

in *PlayLearn*, play a video game and answer the questions in order to obtain a high score on the game. Each given response will be stored in the database. After giving a response, the student will know the right answer and get a reward only if s/he is right. At any moment, the teacher can access the system and check the number of students who have already played the game, the overall knowledge level of each student on that unit, the most common errors of each student as well as those of the whole class, etc. All these data will help him/her to recover at the next meeting in class the arguments on which most of the students have failed, as well as to better set up the lesson for the future. Also, the system will allow the teacher to access several automatically generated learning indicators on each student as well as on the whole class. Last but not least, the students can access a wiki maintained by the teachers to recover the questions they failed, in order to have a sharper recover of the missing information.

The rest of the paper is organized as follows: the next section contains a brief literature survey on *educational gaming* in *formative assessment*; section 3 describes the online testing system's architecture and interface; lastly, some final remarks and a brief discussion on future work conclude the paper.

2 Related Work

Even though *educational gaming* has been frequently associated to assessment activities, we have not found any work in literature which uses the feedback obtained from the games to improve teaching quality. Rich data collection during game activities is performed in the system presented by Wideman et al. [9]. To elaborate, it can remotely and unobtrusively record screen activity during game play together with synchronized audio of player discussion. The system has been used to gain useful insights concerning the students' behavior during the playing activities, in order to better comprehend their level of engagement and their capacity of cooperating.

By surveying the current literature, we found examples of software games or experiments aimed at evaluating learners or making them learn through online tests. Wang [8] has compared the impact of *formative assessment* through a quiz-like game and through the classical web-based online testing interfaces, obtaining as a result that the game enhances the participation of the students to the learning activities.

Ramani et al. [7] describe a system to administer online tests *clothed* as computer games. Following the principle that users engage not only in playing, but also in the design of games (in fact video game companies encourage *modders*, those users who modify the games), they also allow students to create questions. In this case, their performance is measured through *Item Analysis* and best score is assigned to the authors of the best discriminating items).

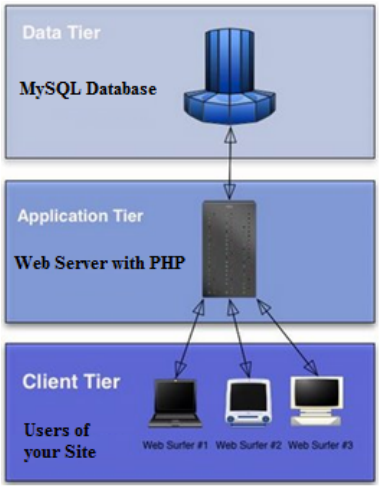

Figure 1. The *PlayLearn*'s system three-tier architecture.

Educational gaming is also spreading in the field of mobile learning. An example of educational video game using test activities accessible through mobile devices is described in [4].

3 The System

PlayLearn is a portal containing a game-based testing system which can be used for training students by creating (the tutor) and taking (the student) online *formative assessment* tests based on multiple choice question items. The system adopts the classical three-tier architecture of the most common PHP-based web applications.

3.1 Architecture

As shown in Figure 1, *PlayLearn* has a tiered architecture. In particular, it is composed of the following three tiers:

- **Client Tier**: this tier is composed of the front-end pages of the teacher's and the student's interfaces. These interfaces are described in detail in the next subsections;
- **Application Tier**: this tier is composed of the PHP modules implementing the business logic of the application. Most of these modules are responsible for processing the user input from the lower tier and for loading and storing data in the upper tier;
- **Data Tier**: this tier is based on a relational database, deployed on a *MySql* database server. *Test* and *Question* entities have a *many-to-many* relationship, meaning that a test is obviously composed of more questions and a question can be presented in more tests.

Macrotags and *Microtags* identify the generic subject of a *Test* and the specific subject of a *Question*, respectively.

The application is fully accessible with a Web Browser. Navigation is facilitated across the simple interfaces based on menus and navigation bars. No browser plug-in installations are needed, except for the Java runtime to run applets. It is worth noting that the system has been tested on recent versions of the most common browsers (i.e., *Internet Explorer*, *Mozilla Firefox* and *Google Chrome*).

3.2 The Student's Front-End

The student's interface has the purpose of administering the formative tests to the student through a simple and captivating video game. After a login interface, the student can directly access the game.

The video game interface requires the student to personify a character, whose objective is to reach a destination located at the end of the game stage. In order to do this, the character has to run and jump through the game stages. Several diamonds are placed on the path to the destination. A diamond can be caught by the student only by answering a question. Once the destination has been reached, the final score obtained by the student is given by the number of the diamonds gathered on the path.

In order to be formative, the questions administered to the student during the progress of the game adopt the following strategies:

- *Options pruning*: if a student gives a wrong response to a question, a second chance to correctly answer the question is given. The previously selected *distractor* cannot be selected anymore. Half the score for the correct response is given in case of right response given at the second chance.
- *Revising*: at the end of the game, a summary of the performance is given. Besides the score and the time needed to complete the game, all of the questions with the given response and the indication of the right option are shown. In the case of a wrong response, a link to the section of the learning material related to the question is shown too.

The difficulty level of the game has been set in order to allow every student to reach the destination without shouldering his/her cognitive and articulatory skills too much. Several game stages have been designed in order to avoid boring repetitive tasks across subsequent game sessions. A screenshot of the interface of the video game is shown in Figure 2. The screenshot shows the game interface while a question is being answered by the student.

At the end of the game, a list of the best five performances is shown, in order to stimulate the learners to improve their outcomes. The limited number of results is due

Figure 2. A Screenshot of the *PlayLearn*'s video game interface.

to the will of not discouraging the less trained students from playing again. Furthermore, a complete history the student's performances, reporting all of the given responses, on his/her previous tests is available, in order to allow the student to revise anytime his/her gaps.

3.3 The Teacher's Front-End

Among other functionalities, the teacher's interface enables the operations of creating questions and tests and of visualizing the reports.

The teacher can manage the lecture material, which is organized in a wiki-based portal. The contents are developed by teachers expert in a given subject, who collaborate to the editing of the articles, basing the content on the textbook. The benefit of using a wiki is twofold: on one hand, the notions to convey to the students are kept down to the strictly necessary to achieve the target for which they have been conceived; On the other hand, it is easy to refer to specific sections of the subjects on which the questions are based, thus correctly advising the students in case of a wrong response.

The report section is rich with information and fit out of charts (see Figure 3) and tables. The teacher can have a complete and deep control over the performance of the class and the learners even on a single subject, and over the effectiveness of the authored resources. To elaborate, the following data are available:

- performance and progress over time of the whole class;
- performance and progress over time of a single student;
- performance and progress over time of the whole class and of a single student on a given subject;

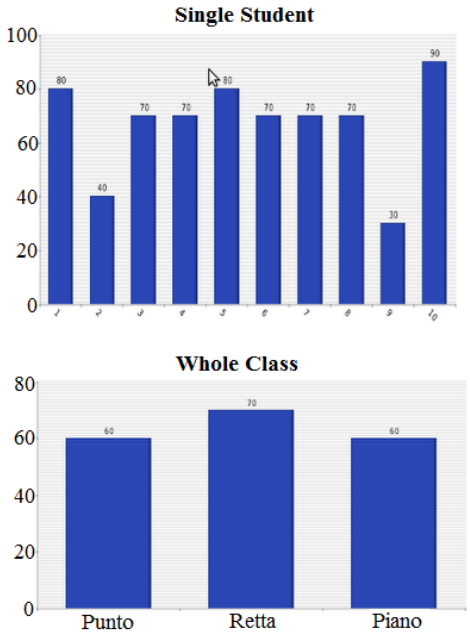

Figure 3. *PlayLearn*'**s Test Report: performance and progress over time of a single student (up) and of the whole class over given subjects (down).**

In *formative* assessment, the main steps of the teaching process are the following:

1. The teacher delivers a lesson on a given topic and schedules a test;

2. the students practice with the formative test;

3. the teacher checks the results and decides the most suitable learning path.

The above methodology requires a relatively long time in monitoring the effectiveness of the teaching due to the large amount of time spent on test preparation, and the correction of its outcomes. *PlayLearn* enables the bringing of the above steps in a real-time continuous process. The benefits are in the following points:

- the tests can be prepared in a relatively short time, since the questions to select for a test are already available in the database;

- test outcomes are immediately available;

- the tests are continuously and regularly taken by the students, since they are motivated by the pleasure of the game.

4 Conclusion

In this paper we have presented *PlayLearn*, a portal intended to exploit *educational gaming* on the long-run as a means for teachers to real-time monitor students' learning, in order to improve the learning process. The usefulness of the system is intrinsic in the necessity of the tutors of checking the effectiveness of their teaching. Unfortunately, this is not possible in the traditional teaching, since the teacher has to wait for the results of a test to have an insight on the level of learning of single students and of the whole class. By exploiting the high level of engagement of the students in *educational gaming* activities, *PlayLearn* allows the tutor to have this kind of feedback in real-time, thus immediately deciding the most appropriate action to improve learning process, all in a virtuous circle.

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