Teaching sciences in K-12 using 2D educational massive online games

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Abstract. Digital game based learning is some kind of boom in education and for many good reasons. There is however an 'Achilles heel' in this approach for being appropriately implemented in many schools: the lack of familiarity with digital games for teachers, as well as the lack of authoring tools to transform course curricula into games. What is presented in this paper is precisely a solution for that, an authoring tool for one kind in particular, 2D massive online games, along with a brief description of its uses in K12.

Resumo. A aprendizagem baseada em jogos digitais encontra-se é uma espécie de boom na educação e por muitas boas razões. Embora, existe um 'calcanhar de Aquiles' nesta abordagem para ser adequadamente implementada em muitas escolas: a falta de familiaridade com os jogos digitais dos professores, assim como a falta de ferramentas de autor para transformar os currículos dos cursos em jogos. O que é apresentado neste trabalho é precisamente uma solução para isso, uma ferramenta de criação de uma espécie em particular de jogos, jogos 2D massivos online, juntamente com uma breve descrição das suas utilizações em K12.

1. Introduction

Digital game based learning (DGBL) is one of those promising technologies that look for revolutionize education in the next few years. In fact, according to the Horizon Report, one of the most important outlooks in education worldwide, its adoption in the short term for both K-12 and higher education, is imminent. The key element behind this approach is that educational gameplay has proven to foster engagement in several desired aptitudes in students like critical thinking, creative problem-solving, and teamwork (Johnson et al., 2014a, 2014b, 2015)

There are a lot of studies that demonstrate the advantages of digital games (console, computer, or mobile -based) in learning, not only for transversal skills like communication, collaboration, fine motor skill, etc., but also for specific skills in particular knowledge domains. In (Carmichael, 2014) for example, a proposal is presented for studying physics using warriors, mages, and healers in a digital role-playing game called Classcraft, whereas in (Squire & Barab; 2004) a computer simulation games are used for learning world history. In (Moreno & Montaño, 2009) a

video game about a boxing robot is presented for studying some basics about computer programming, whereas in (Coller & Scott, 2009) another one is used but for learning some issues in mechanical engineering. Other studies about DGBL in other domains may be found in (Delwiche, 2006; Baker et al., 2005; Erhel & Jamet, 2013; Zin et al., 2009, Hwang et al., 2015; Cornillie et al., 2012).

Spite the potential of DGBL, there are still several limitations for its regular use in classrooms. For one hand, in a conceptual point of view, is not easy for teachers to connect the content of their courses with game mechanics. For the other hand, and now from a technological point of view, even if those connections are found, there are few tools that teachers can use to easily create and manage educational games. In fact, with few exceptions, most of the projects found in literature, incorporates commercial digital game engines or make their own implementations from the scratch. In any case, time and cost for the creation process is a matter to consider.

Considering this panorama, in this paper we present an authoring tool called Erudito that allows for the creation, monitoring and management of 2D educational massive online games. Such a tool may be considered generic because it may be used in knowledge domains of different kinds.

The rest of this paper is organized as follows. A description of Erudito is presented in the next section, whereas a brief analysis of its use in schools is presented in section 3. Finally, in section 4 some concluding remarks are discussed.

2. Authoring tool

As mentioned previously, the creation of an educational game-based environment is not an easy task, especially if teachers do not have programming, design and animation skills. In most cases, teachers are used to prepare their courses in a fece-to-face fashion and, in some cases, they translate such course design to some LMS either because they would use it completely on-line, or because they would use it as complement for their regular classes.

What Erudito demands of teachers is not more than that: to design their course curriculum but in a way that it becomes easy translated into a game. In order to do so, we propose a metaphor between course and game. Our starting point is the course itself that represents a "world" in the Erudito's context. A course is composed by topics (another term for what teachers could refer as modules or units) which may or may not have a pre-requisite structure between them. In Erudito such organization becomes in the several regions that make up the world. Those regions are geographically separated and the sequence to travel through them would depend on the pre-requisites defined by teacher.

A topic group several concepts, which might be seen as the atomic parts of the knowledge domain according to the teacher's course curriculum. In a geometry course for example, a concept might be "the Pythagoras' theorem". Those concepts have related educational resources and assessment items. In the case of course resources, teachers can upload five different kinds of files: PDF's, videos, audios, images, or animations. In the case of assessment items, 10 options are available: True/False; Multiple choice, unique answer; Multiple choice, multiple answer; Comparisons,

Ordering; Matching; Assisted text answer, Assisted numeric answer; Free text answer; and Free numeric answer.

Once a course has been created, how do students perceive it? Well first off, like in many games they have to create their own avatar, a graphical, personalized, representation of themselves in the virtual world. Figure 1 presents some examples of such avatars.



Figure 1. Examples of avatars in Erudito.

Then the adventure begins. Also like in many games there is an initial region, not related to the course, where students receive basic instructions about the game mechanics and artifacts. Once they are ready, the tour through the regions can start. A region is composed by a set of contiguous cells that forms a non-homogeneous grid. Such cells are called sectors and have two main purposes. From the technical point of view they provide a modular organization which allows for the optimization in the graphical objects load. From the curricular point of view they provide a sequencing mechanism through the concepts that make up a topic. Generally, in the first - geographically speaking- sectors of a concept students may find course materials, whereas the assessment is usually find in the last ones.



Figure 2. Presentation of a video file.

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In the case of the course materials, as mentioned previously, teachers may upload files in five different formats. However, how students access them differs a lot of simply open them in their regular viewers: Acrobat Reader in the case of PDFs for example. As in many games, students must collect such materials –items in terms of the game-dialoging with characters in the sectors. Such characters are known as NPC (Non Player Characters) who in Erudito are personified by friendly wise men and women. Once collected, those items can be stored in the player backpack and used as many times as wanted. As shown in Figures 2 and 3, such items suffer a "transformation" from the original files uploaded by teachers in the sense that they are presented to students embed into the game, and in a fashion that follows its aesthetics and narrative. Figure 3 presents for example a video linked from YouTube turned into a videotape, whereas figure 4 presents a PDF turned into a book.



Figure 3. Presentation of a PDF file

Now, in the case of the assessment items, they are not presented in a regular way either. Here 'regular' means in the way that LMS usually do so, i.e., like a HTML form. Instead, each of the 10 kind of questions is transformed in one of the 20 types of minigames that Erudito has. A mini-game, in the games context, is usually a short game with simple mechanics.

Figure 4 presents an example of a mini-game for a matching question. In this case the player must move the chicken so the eggs fall in the appropriate nest. These mini-games have two goals. First, they must be fun, obviously, so player feels attracted to solve it. Second, and more important, they have an evaluative purpose. In the case presented in figure 4 for example, the student must match the corresponding type of fraction.

Another example of a mini-game is presented in figure 5, this case for a multiple choice question. In all of the 10 options for questions that Erudito provides there is a possibility for the student to guess, of course with higher probability in some kinds than

in others. As in any regular face-to-face or online course is the teacher who must provide an appropriate questions design to avoid, as much as possible, such an issue.



Figure 4. Presentation of a matching question



Figure 5. Presentation of a multiple choice question

3. Educational uses

Erudito emerged as the outcome of a research project but, since its release in 2012, it had such a reception in the teachers community that now there are over 11.000 users and 300 courses. A big part of this success is that, as described in this paper, it was designed with one target: being attractive for students but being easy to use and friendly with teachers.

As presented in table 1, most courses created are in K12, i.e. primary and secondary education, and almost a half of them in mathematics. Most of those courses are created for teachers in the state of Antioquia, Colombia, where the research group is

located. However, there are courses from teachers in at least 10 other states. There are even courses from teachers abroad. As far as we know, there are courses from Brazil, Argentina, and México.

Subject	Courses	Percentage
Math	116	47,9%
Physics	19	7,9%
Chemistry	17	7,0%
Biology	26	10,7%
Social sciences	23	9,5%
Others	41	16,9%

Table 1. Implemented courses in K-12 by subject

Regarding to researches about those courses in real educational environments we are aware of the ones performed in the research group. However, we suspect that there have been others at least in Colombia.

One of those researches we are proud of, is presented in detail in (Moreno & Valderrama, 2015). It refers to the use of the course "Palacio de la diosa Safnkit Estocástica" or Palace of the goddess Safnkit Stochastic, in a fourth grade with 17 children diagnosed for Attention deficit hyperactivity disorder (ADHD). What we found was that such a population performed slightly better than students without ADHD when both used Erudito.

Other research that has not been published yet was a joint experience between three primary schools, two in Colombia and one in Brazil. In this case we took advantage of the 'soccer fever' around world cup in both countries to create a game for five graders about operations with fractions. This time we found that in two of the three cases, the students in the experimental group, i.e. those who used Erudito, performed better than those in control, who did not use it. In the third case there was no statistical evidence in favor of any group.

4. Concluding remarks

According to numerous reports and researches, DGBL has proved to be effective in several educational formation levels and knowledge domains. There are however several barriers for its adoption in schools worldwide. One of such barriers is the lack of methodologies and tools that allow teachers for embracing in an appropriate manner this approach. As an alternative for this situation, Erudito emerges as an authoring tool for the creation and management of 2D educational multi-player online games. From the teachers point of view, its main strength is that proposes a metaphor between course and game which is easy to interpret and provides integration with the course curriculums in a direct and simple way.

As some studies have proved, Erudito is also appealing for students because it brings the language and culture of digital games to classrooms, which are part of their daily life. As a result of this, the general students' performance has been affected positively, as well as their perception about course curricula. There is however a lot to work to do in the future. Although it is true that a lot of courses have been made using Erudito, a systematic analysis of their use need to be made. What are the elements that influence performance improvement?; Is it only the motivation factor?; What happens when few or no improvement is achieved?; How do the effects of DGBL change through time?; among other issues.

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