A framework for simplifying educator tasks related to the integration of games in the learning flow

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Abstract

The integration of educational video games in educational settings in general, and e-learning systems in particular, can be challenging for educators. We propose a framework that aims to facilitate educators' participation in the creation and modification of courses that use educational games. Our approach addresses problems identified by previous experiences with games in educational settings, including assessment of learning outcomes and student tracking. Our framework has been implemented following an application model that takes advantage of pre-existing systems: the <e-Adventure> educational video game framework and the Learning Activity Management System (LAMS). This approach has been put into practice in a case study carried out in a primary school, covering from the design of the learning experience to the development of the educational games and the deployment and evaluation with students, involving the educators actively and gathering their perceptions. The first impressions expressed by the educators support the potential of the framework in terms of the students' assessment and the personalization of the lesson. Although educators pointed out the difficulty of creating games from scratch, they appreciated the easiness of introducing existing games in their courses and adapting them to their specific educational settings.

Introduction

In recent years, much research has been carried out in the area of digital game-based learning. Different authors have identified multiple features in digital computer and video games that can be used to address some of the challenges that educational systems face (Aldrich, 2005; Gee, 2003; Squire, 2003). Video games promote intrinsic and extrinsic motivation (Garris, Ahlers, & Driskell, 2002) and producing optimal flow experiences (Chen, 2007). Although their effectiveness to improve students' performance is still under discussion (Hays, 2005), recent studies show that games can increase: (i) student engagement during instruction (Annetta. Minogue, Holmes, & Cheng 2009); (ii) academic achievement in different domains (Blunt 2007); and (iii) skills, knowledge and attitudes, especially in the right environment and context (Pivec & Pivec 2008).

Therefore the discussion should also begin to consider educational and implementation issues related to the effective integration of games in the curricula, like the lack of alignment to educational standards or the availability of the appropriate equipment (e.g. up-to-date computers) (Rice 2007). In addition, the introduction of video games in the learning flow can be disruptive for educators. Games are a new medium, where educators face up to various challenges: aligning games with curricular objectives and pedagogical foundations (especially in formal education) (Van Eck, 2006), and evaluating the learning experiences with games (de Freitas & Oliver, 2006; Hays, 2005).

This paper focuses on how to facilitate the integration of video games into educational settings while at the same time minimizing disruption caused by the use of new technologies. The long-term goal is to support the integration of games in broader courses where they can coexist with other materials, minimizing the impact on the educators' workload. We present a framework that tries to address this goal by providing educators with three main tools: a) assessment of the learning outcomes and tracking student activity in the game; b) connecting assessment data with other learning activities to adapt the learning flow; and c) reuse of successful teacher-created courses that combine games and other educational materials throughout the community.

We also propose a specific implementation with an application model that takes advantage of two pre-existing e-learning tools: the Learning Activity Management System (LAMS) e-Learning platform (Dalziel, 2003) and the <e-Adventure> educational gaming platform (Torrente, Moreno-Ger, Martínez-Ortiz, & Fernández-Manjón 2009). A case study was set in a primary school setting in order to gather educators' first impressions about the potential of the framework.

This paper is structured as follows: First we set the motivation for this work by analyzing the main barriers posed by the application of educational gaming in educational settings. Secondly we introduce the framework and the application model in separate sections. Then we describe the case study and finally discuss our conclusions and describe future lines of work.

Applying video games in education

A common approach to using games inside the classroom is the use of COTS (*Commercial Off-The-Shelf*) computer games; that is, games that were produced for leisure but offer potential educational value. Squire (Squire, 2003) reported experiences where *Civilization III* was used in K-12 history courses. More recent examples include the use of games like the *Tycoon* sagas (Sandford, Ulicsak, Facer, & Rudd, 2006), action games (e.g., *Delta Force*) adapted for military training (Fong, 2006), or multiplayer role games as *World of Warcraft* (Dickey, 2011).

In these cases, the games are used as published, giving educators little control over the process or support to track students' interactions to effectively evaluate students' performance. Some researchers use post-game debates, debriefing sessions, or simply observe students' interaction with the game to establish the outcome from the video game (Squire, 2005). Although such activities can be beneficial, they can also be difficult to manage when the number of students is high (Egenfeldt-Nielsen, 2004) and require excessive dedication from the educator. Furthermore, authors like McFarlane et al. (2002), have pointed out the complexity of linking game objectives and contents with those presented in the curricula. This complexity arises partly from the difficulty in foreseeing learning outcomes in commercial video games (Gee, 2003). As a consequence, the skills and knowledge acquired by students may differ from educators' planned learning outcomes and goals (Sandford et al. 2006).

In contrast to using COTS games, Van Eck (2006) considered the design of educational games where educators and game designers collaborate. The first games developed specifically for education dates back to the 70s. One example is *The Oregon Trail*, an adventure role-playing game developed to teach students about the 19th century colonization of the west of USA (Wesley 1974). A more recent title is *NanoMission*, a set of games for nanotechnology teaching covering different aspects from nanomedicine and nanoelectronics to quantum theory and quantum computing (Milburn 2010). However, the high cost of developing games from scratch makes this approach less feasible, costing around 20-100K dollars per learning simulation & game as reported by the eLearning Guild in 2008 (Wexler, Corti, Derryberry, Quinn, & Barneveld, 2008). Hence, there is a growing need of producing and sharing game-based educational content that is reusable.

Other experiences depict a more holistic approach, where the environment in a game is enhanced with tools that help educators to monitor and control the game experience. That is the case for 3D Multi User Virtual Environments (MUVEs) like *Quest Atlantis* (Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005) or *River City* (Ketelhut, Dede, Clarke, & Nelson, 2006), where the game interface also embeds tools to facilitate communication, review of the students' achievements and the assignment of goal-oriented tasks to the students. These systems are usually built upon the idea that it is not only the game what promotes learning, but also its environment (Pivec 2009). In this sense, issues such as the role of the educator, how the game is integrated in the curricula, or how the informal learning that occurs when students collaborate and discuss about the game enhance the educational value. This is related to the idea of games considered as an additional activity that is not isolated but linked to other activities and contents, and where the game's outputs can influence the development of the learning process. However, it is still an open research question how to design educational experiences that successfully include games, as the number of studies in this regard is still scarce.

A framework for video game integration

We propose a framework to help educators in integrating video games in education, assuming that games will be used as learning activities that are part of larger designs. The framework's is built on the following objectives:

- Defining the goals/learning objectives and measuring the learning outcomes for game-based learning activities.
- Adapting (on-the-fly) the learning experience for each individual student using the game's outcomes (data inferred from game/student interaction).
- Fostering the reuse of successful pedagogical approaches in learning designs that use games.

These objectives aim to reduce the impact on the educator by balancing the overhead and the educational benefits obtained from the integration of educational video games in learning designs.

Defining the goals and measuring the learning outcomes for game-based learning activities

To facilitate the alignment of the learning objectives with existing curricula, we propose to design games with well-defined learning objectives and short expected completion time (around 15-45 minutes on average). This facilitates the design of game mechanics that focus on addressing a single goal (or a small set of goals) proposed for the activity. Short games also facilitate development and maintenance, as well as an easier integration with existing curricula (Dickey, 2005), and align better with the ideas behind the Learning Objects Model. When the objectives are numerous, more games or complementary content can be developed, instead of making the game longer.

The extraction of user interaction information is necessary for exploiting the potential of games as assessable and adaptive content (Moreno-Ger, Burgos, Martínez-Ortiz, Sierra, & Fernández-Manjón 2008; Peirce, Conlan, & Wade, 2008). The games should be powered with interaction tracking capabilities to exploit the high amount of valuable information that can be gathered from the games for assessment purposes. However, not all the information that a game produces is useful from an educational perspective. We propose to make available an assessment mechanism to filter the tracking information according to educators' criteria, thus allowing them to decide the level of detail and the kind of information to extract from the game. Developing games with clearly identified learning objectives

powered with tracking information capabilities would alert educators about deviations from the desired goal.

However, this level of analysis may be, in some situations, too abstract or require a deep knowledge of the game's internal structure. We propose to focus in a set of predefined assessment criteria and data that could be used by educators with little experience with video games, improving their understanding of the game outputs. This basic dataset is only a baseline model, designed to be extended with the assessment mechanism when more detailed information is required. The values in this dataset are *global score*, *game completion* status, *total time* and *play time* (see Table 1) (Del Blanco, Torrente, Marchiori, Martínez-Ortiz, Moreno-Ger, & Fernández-Manjón 2010). Some interesting information can be expressed combining these values, for example if the main objectives of the game were achieved or not, the level of achievement and the time spent in this task.

Table 1. Predefined assessment dataset.

Data point	Description
Global score	Score obtained by the student for the global objective of the game. This value can be internally obtained by combining the values of each single objective.
Game completion	"Yes" if the student completed the whole game, "No" if he/she quit before completing the game. Notice that there could be more that one game completion states.
Total time	Time passed since the student enters the game until she/he completes the game or quits.
Play time	Actual play time. It is calculated by subtracting the time the game was paused from the total time.

Adapting the learning experience for each individual student using the game's outcomes

In the adaptive educational experiences, the outputs of some of the activities can be used as inputs in others. This approach results in learning flows that can be adapted during the execution of the learning experience (Hannafin, Hill, & Land, 1997). This way, considering games as a new learning activity type and using the tracking and assessment outputs gathering during in-game-play, games should modify the course flow accordingly. Setting up a scenario where game-based activities are part of larger designs that combine different activities requires the educator to consider assessment data collected throughout the whole learning process.

The combination of games with other contents and tools can provide educators with further control mechanisms over the learning flow by considering the information gathered from both the game and other activities in the lesson design. This approach can provide educators with a powerful tool for adapting the flow of the educational session at any point, either during the lesson development or while the course is being executed. For example, educators could define conditions over the outputs of the activities and drive the learning flow through different paths, depending on each individual's achievements. If the learner underperforms in the game, additional contents and examples are provided as reinforcement.

Fostering the reuse of successful pedagogical approaches in learning designs that use games

We identify as a key aspect for the advancement of the field the existence of mechanisms that facilitate sharing good practices in pedagogical approaches with games among the educators' community. There should be a repository in the learning community where not only the learning designs with games but also games themselves can be shared including some relevant educational information (e.g. learning objectives, target students). Besides, the game internal elements (i.e. design, tracking model) should be accessible allowing future educators to understand and modify the in-game objectives and assessment. In the same

way, there should be a mechanism that allows identifying and changing the learning designs defined using the game outcomes.

Our framework highlights the importance of providing mechanisms that facilitate as much as possible the repurposing or reutilization of learning designs that combine games with other activities. On one hand, the simplified dataset allows a better understanding of how assessment works within an existing game and the game's role inside the educational lesson.

In summary, games offer new opportunities for education but, at the same time, they can be disruptive and require additional work. To simplify the use of video games in educational environments, it is necessary to reduce the technical barriers related to several problems such as game delivery, assessment of game learning outcomes, and its connection with other course activities

Game integration workflow

The objectives presented above can be combined in a workflow for video game integration (Figure 1) in which educators design their own courses leveraging existing content, and deploy adaptive learning experiences that can be tracked and modified during their execution.

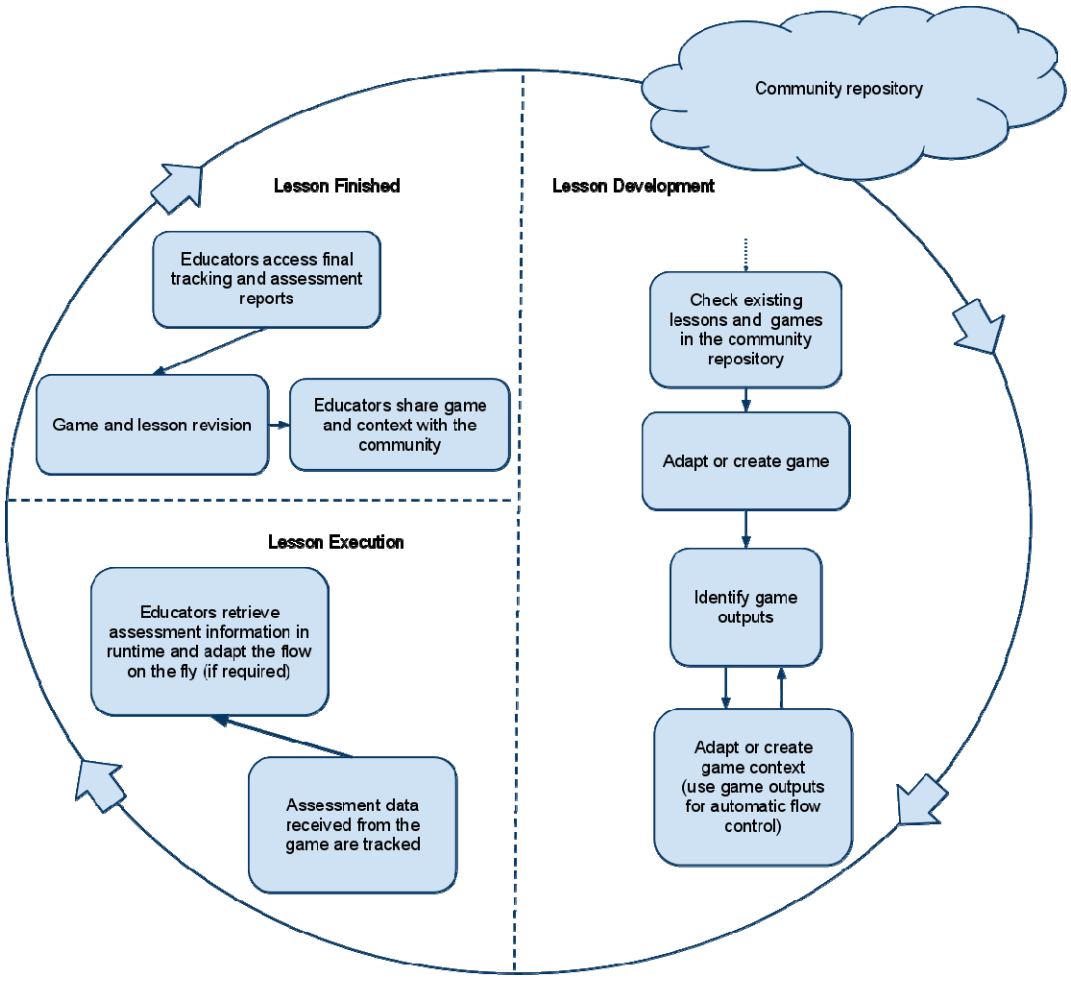

Figure 1. Workflow for video game integration in the learning flow. The diagram shows the three different phases during in video game integration: lesson development, lesson execution and post-lesson execution.

This workflow is conceived as cyclical process where the mechanisms on which the framework is built on, are used to:

- Modify the lessons/games existing in the repository or create games.
- Adapt the lessons both automatically and on the fly using the game outputs.
- Gather the assessment reports and, if the educator finds some weak points in the lesson, modify the lesson accordingly.
- Share the lesson with the community.

It is difficult for educators to develop their own interactive contents due to time and workload constraints. The educators' role in video game integration is in most cases restricted to understanding how to better employ games in their learning designs. Content and lesson providers are responsible for feeding the repositories with new games/lessons and educators can contribute with their modifications over the created ones.

Application model

The objectives proposed in the framework so far require a solid environment to develop and execute lessons that supports the described mechanisms for tracking and adaptation features, and a game platform with assessment data reporting and in-game objectives identification. Besides, the application model should deal with delivery problems that arise in the on-line distribution of video games and be able to establish communication links to exchange information (Burgos, Tattersall, & Koper 2007).

The application model is built using two e-Learning platforms that meet both pedagogical and technical requirements: the Learning Activity Management System (LAMS) as a back-end, and the <e-Adventure> gaming platform, which includes reusable communication and assessment facilities and game objectives definition.

LAMS is an e-Learning solution that facilitates the creation and execution of designs for the course. LAMS is inspired by the IMS Learning Design specification (http://www.imsproject.org/learningdesign/index.html) and its ancestor, the Educational Modelling Language (Koper & Manderveld, 2004) where the concept of *activity* appears as the minimal meaningful unit in the sequence of contents. LAMS provides a mechanism to control and track the student's performance in some of the included activities (e.g., Multiple Choice activity). Using the data gathered, LAMS allows defining a complex control over the sequence's flow either at lesson authoring or during the lesson execution. The educators can follow the lesson execution in a specific view where they can monitor the students' progress. Also, LAMS fosters the reutilization and repurposing of learning designs by a mechanism to export/import the learning sequences to external repositories.

<e-Adventure> is an authoring platform created with the aim of facilitating the development of 2D educational video games and simulations, enhancing their educational value and simplifying the participation of educators in the development process. The most relevant educational features in <e-Adventure> in regard to this work are the possibility to easily deploy games in a wide range of popular Learning Management Systems using common specifications and standards from the e-Learning field (Del

Blanco, Torrente, Moreno-Ger, & Fernández-Manjón 2010) and the mechanism that allows for the extraction of an assessment report on the students' progress (Moreno-Ger et al. 2008).

In their last official releases LAMS (v.2.3.5) and <e-Adventure> (v1.3) have been extended with a new type of activity to integrate <e-Adventure> games into LAMS sequences (Del Blanco, Torrente, Marchiori, et al. 2010). In relation with the main objectives of this paper, the combination of <e-Adventure> games and LAMS allows educators a deeper control over the game experience inside an educational course.

Using <e-Adventure>, game authors can identify the objectives as the game states and filter the information that will be appended to a human-readable report and/or sent back to LAMS as attribute-value pairs. This way, an educator can define and link in-game objectives with game outputs. <e-Adventure> implements the predefined assessment dataset previously described that can be easily extended creating new variables and values to be exchanged. With the <e-Adventure> activity in LAMS it is possible to enable an active communication between the games (in the students computer) and LAMS (in a central server) to gather the assessment information.

Moreover, educators can use an <e-Adventure> activity like any other LAMS activity for monitoring and flow control tasks. On one hand, educators can define conditions taking into account the values returned by the game for automatic flow control. On the other hand, during the execution of the activity sequence, educators can access the assessment reports produced by games and, if necessary, modify the sequence flow.

Finally, the combination of the two platforms provides new ways to exchange and reuse designs of educational courses that include games using the exportation/importation features of LAMS. LAMS provides a learning repository (http://lamscommunity.org/lamscentral/) to share learning designs and <e-Adventure> has a repository (http://e-adventure.e-ucm.es/repository) to share educational games. Taking the underlying design of the educational session as a basis, educators can adapt not only the sequences (sequence flow, available activities, etc.), but also the games themselves (e.g. modify the learning objectives, adapt the language of the game to the local requirements, add/remove game elements or personalize the assessment system).

Case study

We conducted a case study with primary education students in the Ramiro de Maeztu School, a K-12 institution in Madrid (Spain). The aim of the case study was to gather insight about the applicability of the framework proposed using a particular technical solution. Therefore, the main objective of this experience was to establish the feasibility of the creation and execution of an adaptive lesson using games by educators without experience in games and to examine their perceptions about the usefulness of the approach. In close collaboration with educators from the institution, we developed an educational session in LAMS covering the mathematical concept of parity, including two different versions of an <e-Adventure> game created for this experience. The target audience was a group of 6 year old students. Educators provided the educational session design and all the pedagogical support for the development of the educational game.

Two aspects were mainly under evaluation:

- The applicability of the framework in a real educational context and educators' perceived usefulness.

- The value of the assessment features of the proposed framework in terms of potential (i.e. ability to extract a reliable measurement of the students' achievements) and cost (i.e. ease to define and gather the assessment information required).

The experiment was performed with a group of 26 students. During the lesson execution two researchers and one educator were present during the session to assist the students with the usage of the system. No help in solving the challenges proposed in the course was provided. An analysis of the assessment data gathered during the experience was performed through the monitoring capabilities of the LAMS environment. Educators could track the progress of each student within the sequence, both during the lesson execution and when the lesson finished, including the activities that each student had already executed, the time spent on each activity, and the assessment report about their interaction with the video game.

Lesson development

The design of the educational session targets two main objectives: (1) to acquire the concepts of odd and even; and (2) to recognize odd and even numbers and associated elements in both groups. The lesson was implemented as a sequence of activities in LAMS. The general structure of the sequence includes several activities that all students must complete as well as different execution paths that depend on the student's performance (Figure 2).

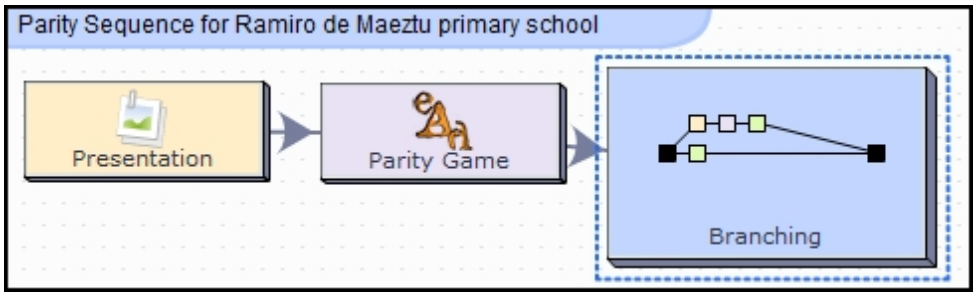

Figure 2. LAMS educational sequence of contents, including an introduction of the main concepts, an interactive game to reinforce the concepts and assess student understanding and a final branching activity.

The game's main characters are a couple of turtles called *Odd* and *Even*. After a brief introduction, the students must solve different puzzles involving the identification of odd and even items (Figure 3). The level of difficulty of each puzzle increases as the students advance in the game. Interaction is through *drag & drop* actions. The game has five levels and the expected completion time of the game is 15 minutes.

The educational game includes in-game assessment of student interactions. When a student fails in solving a puzzle (e.g. she/he drops an odd number in the *Even* chest – Figure 3) a number of points are subtracted from the total score, depending on the difficulty of the puzzle. This information is appended to an assessment report, including a timestamp, the puzzle level and whether it related to odd or even groups, but is not shown to the students. At the end of the game the final score and the assessment report are automatically sent back from the game to LAMS, where the educator can access them (Figure 4).

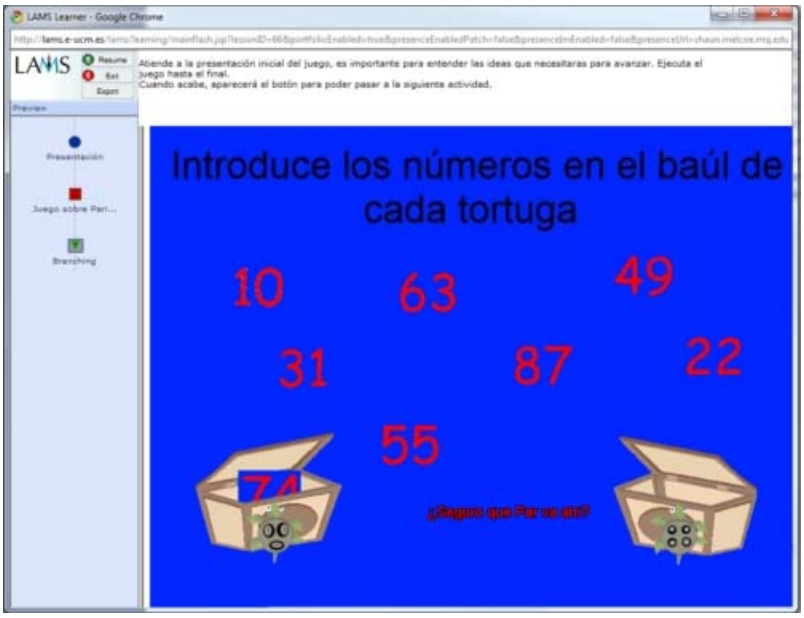

Figure 3. Screenshot of the "Odd and Even" <e-Adventure> game included in the LAMS learning sequence. In this level of the game, students have to drag and drop the numbers where the corresponding turtle is.

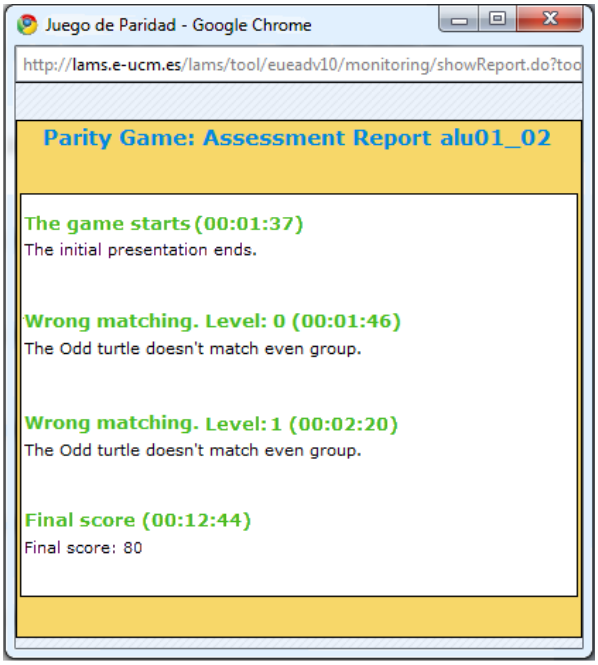

Figure 4. Example of an assessment report with information about errors, timestamp and type of error, and the final score that educators can monitor in LAMS. (Original report was in Spanish).

After playing the game, the next step in the LAMS sequence depends on the individual performance of each student. Depending on the game final score, students may carry on with the final activities planned for the lesson or complete an additional reinforcement module. A LAMS *Branching Activity* controls the flow of the sequence automatically (Figure 5) by providing discriminating branches either for finishing the

sequence when the score is higher than 60 points ("Pass" condition in Figure 6) or for visiting the reinforcement section when the score is 60 points or less ("Fail" condition in Figure 6).

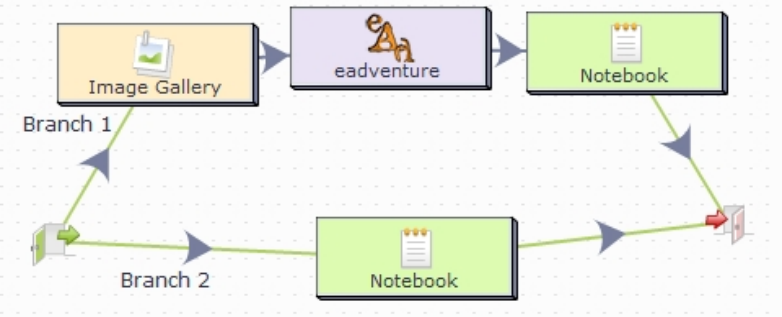

Figure 5. A screenshot of the branching activity that appears on Figure 2 with the detail of the two possible lesson paths (i.e. branches) depending on the student performance in the game.

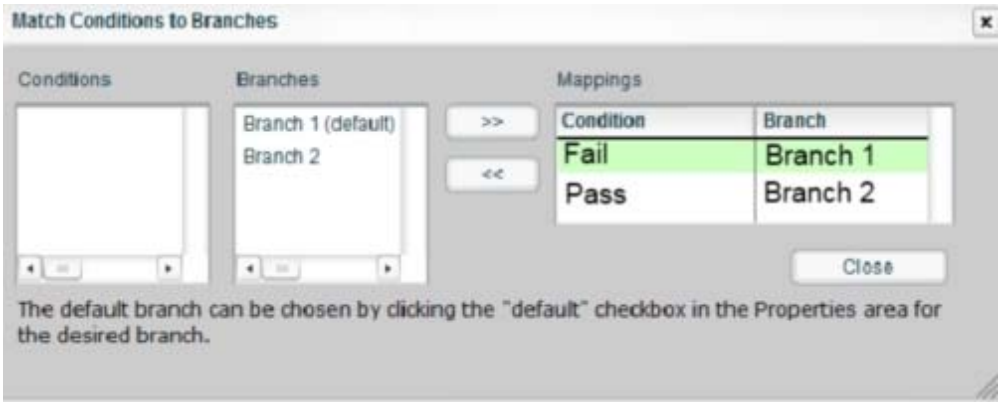

Figure 6. Detail of LAMS dialog box to match conditions and branches of the two paths in Figure 5.

Results of the case study

Figure 7 shows some of the data extracted. As Figure 7.a depicts, 16 out of 26 students (61.5%) completed the first execution of the game with a "pass" score and finished the activity without using the reinforcement material or the second execution of the game. Figure 7.b and 7.c focus on the remaining 10 students. In this group, three students achieved a "pass" score on the second game and one failed this activity again. All these four students who finished the second game achieved better results than in the first game's execution, even though one of them did not achieve the minimum pass score. The six remaining students were stuck when the session ended and did not complete the activity. One of them remained stuck on the first game, another in the reinforcement presentation and four in the second execution of the game.

Still focusing on the 10 students that required the reinforcement, Figure 7.b depicts the number of errors per student in each game level. Even though the levels were designed with incremental difficulty, students present the highest rate of errors in "Level 3" followed by "Level 2" and "Level 4". Finally, Figure 7.c provides descriptions of the time that each of those students spent in each activity.

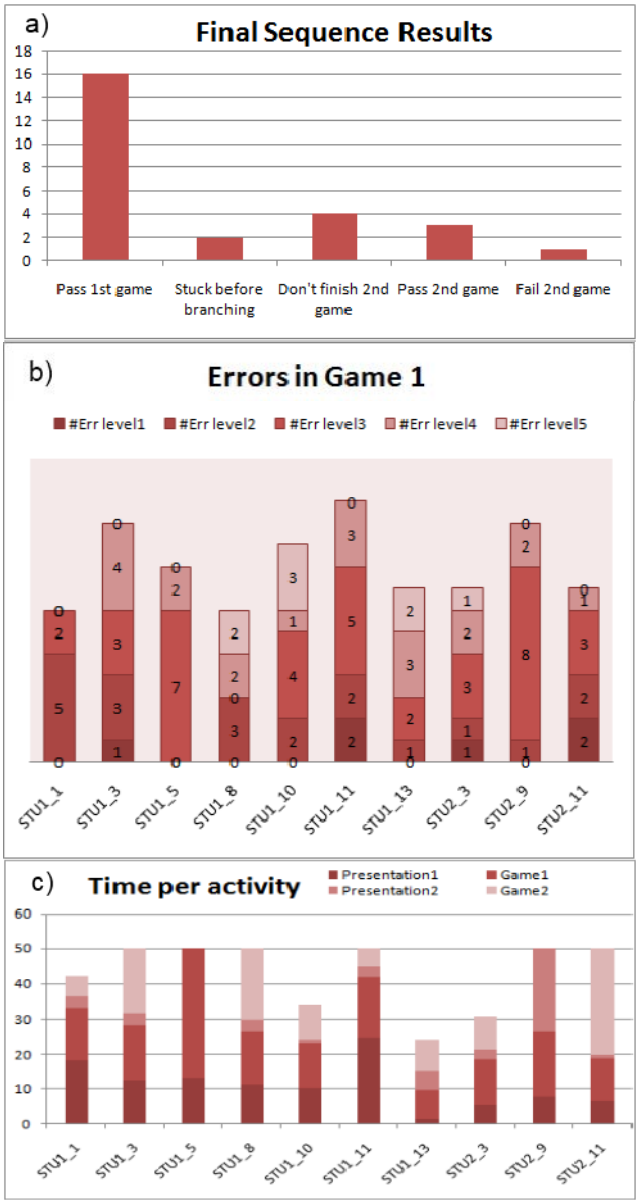

Figure 7. Charts extracted for the analysis of the data gathered from the LAMS. STUx_y is a student identifier to maintain their anonymity, where x is the turn and y the number assigned to the student in each turn.

Educators involved in the case study were the teacher of the class (T) and the Director of Studies (DS). Two weeks after the session we conducted a one-hour unstructured interview with both educators, following the ideas of Bernsen & Dybkjaer (2009). The interview was recorded and transcribed (the original interview was conducted in Spanish but the excerpts shown in the article have been translated). The aim of this interview was to capture educators' perceptions about the gaming and integration framework proposed, especially the assessment and adaptation features. A qualitative approach was followed because of the small sample size (only two educators).

In relation to the educators' opinion on the use of video games in education, the DS pointed out the importance of attractiveness in interactive software as educational tools. She highlighted how previous

experiences with ICT had resulted less attractive to students, providing low interactivity and poor engagement through written text. They also pointed out the value of using an interactive and narrative approach to the assessment process, as opposed to a more traditional type of evaluation.

> *DS: We see how the students react negatively to such programs because those contents are unattractive.*
>
> *T: The writing test with a pencil, on paper, without color… this is unattractive to the students, and after two minutes they are exhausted.*

Comparing this approach to their usual approach, they showed interest in further using games as evaluation instruments for their subject areas.

We asked the educators about the efforts necessary for the development of sessions of this kind. The educators considered that the task of creating games from scratch was complicated *"not only because of the use of technology but also because it is difficult to have an idea for an engaging game that is also attractive"*. They identified the possibility of *"modifying and adapting a game previously created*" as very interesting, but they also highlighted that they *"would need prior training to use these tools"*.

We asked the educators about the assessment possibilities of <e-Adventure> games and the reports we had gathered using LAMS. They were very interested in this kind of assessment (*"This evaluation method is easier for us"*), and they highlighted the possibility of extracting more information than in conventional tests.

> *DS: Not only does it reflect the overall result but you can also extract additional information such as time spent in different parts, the difficulty for each student in particular and other aspects that you cannot know through paper and pencil.*
>
> *T: Besides, in a traditional exam you cannot keep an eye on each student and with this approach you can extract more personalized information.*

When we asked them about the possibility of changing the sequence flow after taking the information extracted from previous activities into account, the director of studies agreed and asserted:

> *DS: This is a key concept. It is very interesting if we can detect not only what students are doing during the sessions but also what the students' problems are. Then we can modify the methodology trying to get all students to acquire the important concepts.*

The teacher offered to relate some experiences from her class. She pointed out that some students complete all the activities without problems. In this sense the educator found the possibility of adding extra content or more advanced goals interesting, even if that content or goal belonged to another course, so that *"this system allows for managing the different learning paces"*.

Discussion

The main objective of the case study was to gather educators' perceptions about the benefits, flaws and feasibility of use of the framework. Given the small number of students and teachers involved, it was not intended to evaluate the learning effectiveness of the game-based approach nor the potential of the assessment and flow adaptation capabilities to improve education. For this reason, the case study presents simple assessment and adaptive features to facilitate the understanding of the framework by educators.

The overall results of this experience are positive. Educators found the game to be useful and gave a positive appreciation of the balance between the effort of preparing and executing the sequence of activities (not just the game) and the amount of useful information gathered, how the experience was adapted at runtime, and the level of control they had during the process. Educators highlighted the advantages of the adaptation of the learning experience to different learning paces, promoting individualized learning, and the great amount of information that can be extracted.

In addition, educators perceived that the extraction of the game's assessment data and its linking with LAMS were easy enough for them, but they also pointed out that they felt that independent game development was out of their reach, even using the tools provided. They did, however, point out that they thought they would be able to adapt existing games to their needs and even use the games as a new assessment tool, as long as they had the resources and adequate training.

Conclusions and future work

In this paper we have proposed a framework trying to facilitate the use of games in learning designs by educators. The framework is built on the ideas of powering educators with assessment and flow-adaptation capabilities, and fosters the reuse of learning designs with games. We also present an application model based on two pre-existing e-Learning platforms that implements the frameworks and deals with implementation issues (e.g. game delivery). Finally, we put the application model into practice in a case study with six-year-old students.

Some of the ideas proposed in our framework are present in other approaches or educational tools. For example, the notion of establishing relations among the activities in a course so that they can result in an adaptive learning flow has been around for years. Numerous approaches for conditional branching have come from the field of Adaptive Hypermedia, resulting in a number of educational tools (De Bra, et al. 2003; Weber & Brusilovsky 2001, Brusilovsky, 2004). However, these approaches usually rely excessively on automatic adaptation, limiting educators' participation during the educational experience. In contrast, our approach focuses on giving educators capabilities to control the flow at all times to increase the educational value.

In the e-Learning field there are also several works supporting adaptive learning. On the one hand, there are e-Learning standards such as SCORM, which includes basic adaptive sequencing features; and IMS Learning Design (IMS-LD), which can support complex adaptive learning flows due its flexibility that allows educators to define virtual courses following any pedagogical approach (Van Es & Koper, 2006). However, the sequencing in SCORM turns out to be insufficient for highly interactive contents (Shute & Spector, 2008), there are few systems that fully implement IMS-LD, and the effective use of the supporting IMS-LD editors still requires significant knowledge about the specification. These aspects limit the possibility of reusing content and learning designs.

The application model proposed in this work, based on extensions of the previously existing LAMS and <e-Adventure> platforms provides a more accessible solution, highlighting the role of the educator and providing support for the desirable characteristics proposed within the framework. Our case study has been useful in determining whether educators without extensive ICT training can find the implementation of this technology beneficial, although its small size does not allow us to fully validate our approach. This will require carrying out additional studies with lessons that present more complex assessment and adaptation features and larger sample sizes, as well as an in-depth examination of how our approach compares with other approaches for game integration.

The evaluation of reusing pedagogically sound designs including games is planned for a later stage. To validate this aspect, a community of users needs to be established first, and a wide range of learning designs with games should be available. Both goals cannot be reached in the short-term. We have already initiated some initiatives for this purpose: the LAMS official release that includes support for <e-Adventure> activities (v2.3.5) has been recently made available for public use. We are also promoting different repositories. As proposed by the workflow, the LAMS sequence and the parity game along with more sequences and games have been included both in LAMS community and <e-Adventure> repositories. The perceived acceptance of these materials within LAMS and <e-Adventure> users may allow us to estimate whether there is a real interest in reusing this kind of content, and therefore the practical applicability of the approach.

There are also other open issues which need further research. One is related to testing the applicability of the framework implementing the course following e-Learning standards as IMS LD or SCORM, comparing the benefits and pitfalls against this specific application model. In addition, our current work focuses on gathering adaptation data from a technical perspective, rather than indicating what to do with it. Finding effective ways to use the data extracted from the game for adaptation purposes is still an open research question. However, we expect the notion of promoting the reuse of contents and lesson patterns supported by the application mode to facilitate this process. We are currently working on improving the customisation possibilities introduced by this model, including providing both extra materials for advanced students and remedial contents for those whose do not achieve the learning objectives. We are also working on the proposal and development of different sample courses and lessons to include them in publicly available repositories.

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