Computers in Human Behavior xxx (2008) xxx–xxx

Contents lists available at ScienceDirect

Computers in Human Behavior

journal homepage: www.elsevier.com/locate/comphumbeh

Educational game design for online education

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ARTICLE INFO

Article history:
Available online xxxx

Keywords:
Educational game design
Game-based learning
Online education
Pedagogical model
Instructional design
e-Adventure

ABSTRACT

The use of educational games in learning environments is an increasingly relevant trend. The motivational and immersive traits of game-based learning have been deeply studied in the literature, but the systematic design and implementation of educational games remain an elusive topic. In this study some relevant requirements for the design of educational games in online education are analyzed, and a general game design method that includes adaptation and assessment features is proposed. Finally, a particular implementation of that design is described in light of its applicability to other implementations and environments.

1. Introduction

While e-learning has been on the rise in industry and educational institutions for the past few years, it has also been attracting a lot of criticism due to a number of current limitations. Since learning is the result of rich and varied activities, many current e-learning environments propose passive educational models based on storing content that is distributed or consumed rather than learnt and where the current lore in the field of pedagogy gets scarce attention.

But the evolution in e-learning supporting technology and the environmental pressure created by commercially competing systems and institutions are changing this situation. Most modern e-learning systems have evolved and include more pedagogically sound features such as student tracking, online assessment, user feedback or community features. This is part of an effort that addresses several typical e-learning problems such as high dropout rates due to frustration and the lack of motivation to continue studying (Parker, 2003).

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doi:10.1016/j.chb.2008.03.012

Different approaches have been used to address the issues identified in e-learning (e.g. lack of motivation, no direct contact with a teacher, etc.). Multimedia environments (Schank, 1993) try to capture the attention of the students while yielding a deeper learning given the involvement of several senses in the learning process (Clinton, 2004). Hypermedia technologies facilitate constructivist approaches (Dillon & Gabbard, 1998; Jonassen, 1994; Merrill, 1991) that leverage human psychological traits such as curiosity or satisfaction with achievement. On a social level, the concepts of "Communities of Practice" (Alavi, 1994; Wenger, 1998) and "Learning Networks" (Hummel & Burgos, 2005; Johnson & Johnson, 1989) establish a social environment in which motivation is generated through peer collaboration, peer pressure, group meritocracy, and a very short feedback cycle.

Another approach to increase motivation and the quality of the learning experience is the use of computer and videogames as an educational medium (Betz, 1996; Jayakanthan, 2002; Jenkins & Klopfer, 2003; Prensky, 2001; Squire, 2003; Squire, 2005). This approach studies which elements make videogames attractive and engaging and try to take advantage of these elements for education (Anderson & Bushman, 2001; Cordova & Lepper, 1996; Gee, 2003; Lepper & Cordova, 1992; Leutner, 1993; Malone, 1981; Porter, 1995). It is interesting to note how the academic debate about whether videogames have educational potential is decreasing (Kirriemur & McFarlane, 2004; Van Eck, 2006). The debate is actually starting to focus more on issues such as the cost of development, the complexity of integrating the games into the curriculum or the need to assess the quality of the learning process (Michael & Chen, 2006; Squire, 2005). In order to address these issues, we propose to look for alternatives to ad-hoc and handcrafted approaches, whose scope is limited to the development of a single product and usually varies from product to product. A more industrial approach is required, in which specific game genres are identified, and suitable frameworks are set to facilitate the provision of educational games in such genres.

In this paper, we analyze this product-family approach. For this purpose, we start by presenting different approaches to educational game design by discussing their benefits and shortcomings. Then we identify some desirable pedagogic attributes in educational games for the e-learning domain such as adaptation and assessment mechanisms. Next, we introduce the product-family approach: by narrowing the problem and concentrating on a specific game genre we obtain a game design process that complies with the identified pedagogical requirements and can be effectively employed in online education. Finally, we describe an implementation that follows this model: the ⟨e-Adventure⟩ educational game engine.

2. Different approaches to the design of educational digital games

Almost by definition, any initiative that mixes videogames and education can be considered as game-based learning. Initiatives range from the introduction of AAA commercial games[1] in educational processes to the application of slightly interactive multimedia wrappers around traditional educational content. Thus, educational game design is a broad subject that groups very different approaches and methodologies.

Within that broadness, authors like Prensky (2001) state that an effective educational game design must achieve a balance between fun and educational value. Indeed, different designs found in the field seem to have an aim that is usually biased towards fun or educational content. In this section we present a number of initiatives that can be broadly categorized into three groups: (1) Multimedia approaches tightly linked to content presentation; (2) those that repurpose pre-existing games for education; (3) a middle category of specially designed games that seeks a balance between fun and educational content. The following subsections provide examples of some of these initiatives.

2.1. Edutainment

In one of the extremes of the relation between educational focus and entertainment we find a number of initiatives usually labelled as edutainment. In spite of its etymology (merging the words

[1] AAA is the usual term used in the videogame industry when referring to a high-profile game with a high budget, substantial marketing support and widely expected sales.

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education and entertainment), this term is often used to label those initiatives that correspond to the "educational content" extreme of the spectrum. These initiatives, backed by either commercial or public entities, focus on translating the official educational content (usually in primary education, sometimes in high school) into a game-like environment. From a game design perspective, those titles are designed from their content and the playability is added on top of that content later. Some authors such as Kirriemur and McFarlane (2004), MacFarlane and Read (2004), and Sim and MacFarlane (2006) consider these approaches a dead end, which gives the term edutainment a negative load. When the entertainment aspects fail to shine in the design, most of the advantages of game-based learning in terms of motivation and engagement are lost and the learning experience suffers (Koster, 2004).

2.2. Repurposing existing games for education

On the other side of the spectrum we find a number of initiatives based on products that were originally designed as commercial games. Even though the development of these games did not contemplate a potential educational use, sometimes their contents and models are so rich and detailed that they can have an educational value if handled properly, as several (although isolated) initiatives show. Two well-known examples are the SimCity and the Civilization sagas:

- In SimCity, the different titles in the saga put the player in the role of a mayor governing the city. The work presented in Kolson (1996) describes experiences with different titles in the saga, focusing on how they provide reflection on topics regarding social dynamics and evolution. After the impact of the SimCity games, the studio published a number of games under the name "Sim", which focus on the economical and practical management of different environments. Thus, we find games such as SimFarm or SimHealth, which have also been used as educational tools as described in (Starr, 1994).
- Games in the Civilization series are simulation games where the player must manage and balance the construction of infrastructures, military progress, exploration and scientific advances, starting on a tribal scale and ending in a world-wide scenario of different civilizations in confrontation (Bittanti, 2005). The work in (Squire & Barab, 2004) reports some experiences with students that were enrolled in a History class that combined game sessions with reflection and discussion sessions.

These examples suggest that existing games can be successfully introduced into educational processes. The main advantage of this approach is its cost-effectiveness: creating brand new educational games that rival commercial games has a prohibitive cost in most cases, which makes these repurposing approaches very interesting (Burgos & Tattersall, 2007). However there are handicaps that may affect their educational potential. One of the main shortcomings to this approach is that these games were designed as entertainment products, without taking into account pedagogical and educational considerations. Even if realism and historical accuracy may contribute to the success of the game, any decision that gauges them against overall fun will obviously fall for the fun side. Some of the concepts in these games are oversimplified and this may eventually lead to wrong conclusions as hinted by other work cited in this section. For this reason, these approaches should always be complemented with the supervision of an instructor and frequent reflection and discussion.

2.3. Experiences with specifically designed games

The conclusion derived from the previous two subsections is that none of the extremes of the spectrum is optimal. The key to success is to reach a balance between fun and learning in a gameplay design model (Prensky, 2001). Unfortunately, this is not easy because game design is not a precise science, which is mostly due to the subtle nature of fun (Koster, 2004). However, there have been many success stories of game designs that managed to teach almost pervasively while engaging external players to the point of playing the game even if they were not interested in the educational content. These initiatives range from fast-paced action shooters to reflective games that just happen to be entertaining as well. Some interesting examples follow:

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- *The monkey wrench conspiracy*™ is a first-person shooter oriented at learning how to use a computer-aided design tool. In this game, the player must construct his/her own weapons in an in-game console which works like the software tool that is being taught. The work in (Prensky, 2001) reports some additional reflections about this game and the amazing results obtained by the publisher in terms of both staff training and marketing.
- *Virtual leader*™ (Aldrich, 2004), focuses on teaching a subject as complex as leadership. The game is structured as a number of scenarios, representing different meetings at different levels and with different agendas. The player can observe the different participants in the meeting (gauging their mood, body-language, etc) as different ideas are proposed and discussed. The player must be able to get his ideas (and those of others) accepted without harming the morale of those whose ideas do not make it through.
- Imitating the model behind the "Sim" saga presented in Section 2.2, Virtual U™ (http://www.virtual-u.org/) puts the player in the role of the university president, having to balance the budget among campus management, employees, teaching quality, research facilities and throughput, etc.

However, it should be noted that, in spite of these success stories, many other initiatives fail or are even rejected at an early stage. Most of the time, this is due to the high development costs associated with these projects and the risks involved when trying to make a product that will capture the attention of the public fun and interesting (this is a problem faced by all entertainment industries, such as music or films).

A possible alternative to find a balance between the two extremes is the modification of existing commercial games to improve their educational value as in (Purushotma, 2005). Although this approach can dramatically reduce the development cost, the objective is still to find an appropriate game design to suit the needs of the project. If the original games or engines are very specific, the characteristics of the games that can be produced are closely bound to the basic traits of the originals, usually devoid of educational value. On the other hand, when the engines are very generic (handling essentially low-level operations) the technical requirements in terms of game programming background are usually very high.

As long as reducing costs and lowering the technological requirements of the educational games are also a desired objective, we advocate the use of specifically designed educational game engines with built-in features that increase their pedagogical value and which can be freely used by instructors or organizations to develop educational games. These engines will be able to execute games in specific genres, which will be described using domain-specific languages tailored for such genres. Being domain-specific, these languages will be easy to use, which will let educators use them directly to produce and maintain the videogames. Therefore, we promote the use of well-known approaches in software engineering regarding the development of program families in order to support the production and maintenance of educational games. The first step in this process is the definition of the specific pedagogical characteristics required for the educational game engine, as described in the next section.

3. Identifying pedagogical requirements

Based on previous research (de Freitas & Oliver, 2006; Ju & Wagner, 1997; Moreno-Ger & Martinez-Ortiz, 2005), we derived the pedagogical requirements of our educational games and then decided on a specific educational game design that would incorporate those requirements. The next subsections describe the main requirements identified.

3.1. Integration with online education

It is common to find situations where games are included in a traditional classroom environment, and an instructor monitors the activity of the students inside the game. In these scenarios, the instructor fills the gap between the game and the rest of the course by promoting reflection and discussion. In online education, the educational value of these educational videogames could be greatly increased by integrating them with the emerging e-learning standards and platforms in on-line education. This integration adds a number of requirements to be addressed. To begin with, looking at current trends in online education, these educational games should be able to coexist in environments that follow the learning objects model (Polsani, 2003), which calls for small and focused games covering very specific topics. Additionally, the potentially heterogeneous audience of online education environments should be taken into account when designing the games, with special consideration given to concepts and cultural sensibilities such as violence in games or sensitive topics.

3.2. Adaptation

Adaptation can play a very important role in the quality of the educational experience, allowing the learning environments to cater to students with different learning styles, different levels of initial knowledge and different expectations and objectives. Videogames are inherently interactive and reactive to the actions of the user and they are complex pieces of software being executed in the student's computer, which facilitates the inclusion of adaptation mechanisms in the games. An additional consideration is that the games will be delivered from a learning management system that is in charge of tracking and guiding the learning experience. Thus, the engine should be able to communicate with the LMS in such a way that the LMS can guide the process and command the games to activate their adaptation mechanisms to fit certain requirements every time they are run.

3.3. Assessment

A very important part of any learning process is the assessment of the progress of the learning experience. Games are a very rich interactive medium, and this interactive behaviour can be exploited for assessment purposes. When a LMS delivers a PDF file to the student for study, there is little that the LMS or the instructor can know about how the student used that PDF file (Did he/she read it? Did he/she just skim through it?). In contrast, as already mentioned, games are active pieces of software running on the student's computer. We can leverage this and define an assessment model in which the game monitors the student's activity, logs all the relevant events and generates useful information which can be used to grade the student's activity. This process can be either automated (the game sets the grade) or require the participation of an instructor to assess what the student's activity tells of the learning experience (e.g. Did the student visit all the areas in the game? Did he/she wander around aimlessly? How much time was required to solve a specific problem?)

4. General design

In this section we discuss a set of design guidelines that allows the integration of adaptive and assessable games in online education environments, taking into account the requirements identified in the previous section.

4.1. Choosing an appropriate genre

The first design decision is to choose a suitable genre for the games to develop. By doing so, it is possible to devise a suitable language for describing the games, and thus to support the language with an appropriate engine. Since the language is domain-specific, it will be possible to make the computational model behind the engine explicit. This will be very relevant in order to satisfy the different pedagogical requirements identified. In particular, declarative computational models for games can usually be characterized as state transition systems (Winskel, 1993) in which the actions of the player trigger state transitions and the sequences of actions eventually lead to one or many end states. In addition, for many interesting cases, the number of states will be finite, and therefore the progress through the game behaves as a finite state machine (FSM).

As an example of choosing a genre we can highlight classic point and click adventure games. In these games the player is the main character in a story and drives it forward by speaking to other characters, finding objects, combining them in creative ways and solving riddles and puzzles. The game progresses through a storyline in which performing some actions unlocks some other potential interactions. The presence of elements such as a slow pace, reflection, study of the environment, and problem-solving make point and click adventure games relevant from a pedagogical perspective (Van Eck, 2007). This decision is also supported by studies like (Amory, 2001; Amory & Naicker, 1999; Ju & Wagner, 1997), which describe the main traits of the genre and identify a clear bias for content instead of just plain action.

4.2. Adding assessment and adaptation to the design

Choosing a suitable genre is only one aspect in the design process. The requirements outlined in Section 3 demand the facilitation of both assessment tools and support for adaptive learning scenarios without breaking the game model.

From the description of the games as state transition systems (e.g. using FSMs) we can design assessment and adaptation mechanisms based on checking and modifying specific states of these systems. In particular, the assessment of the activity of the student inside the game can be performed as an analysis of the states that the game went through during the game session. The game engine should keep track of the transitions, log relevant events and generate reports describing them. However, a game will contain thousands of states and transitions, and it is not reasonable to have the instructor review every single action performed inside the game. In our approach, the instructor should be able to create assessment rules that identify those states and transitions that are relevant for the course and have the engine generate its reports according to those rules. In Fig. 1 some typical situations that can be addressed using assessment rules are depicted.

On the other hand, adapting the behaviour of an adventure game can consist in adding/removing puzzles, changing which objects are in each room, adding/removing characters, skipping parts of the game, etc. However, since the game is just a succession of states and branches, all of these changes can

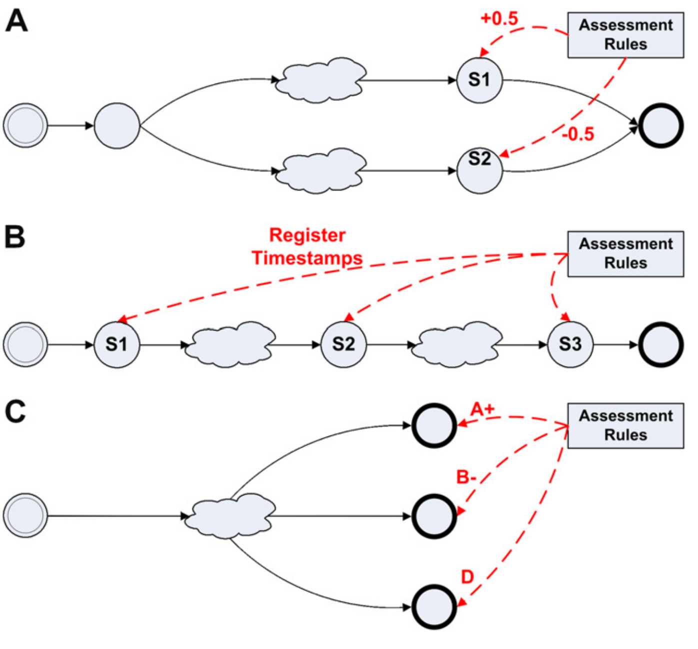

Fig. 1. An external configuration file created by the instructor defines which events should be traced and reported. (A) Rules indicating that solving a certain problem in a certain way should increase/decrease the final grade. (B) Rules indicating that the activation should simply be reported along with a timestamp for an instructor to evaluate it (the grade is not affected directly). (C) Rules assigning final grades to the different end-states of the game.

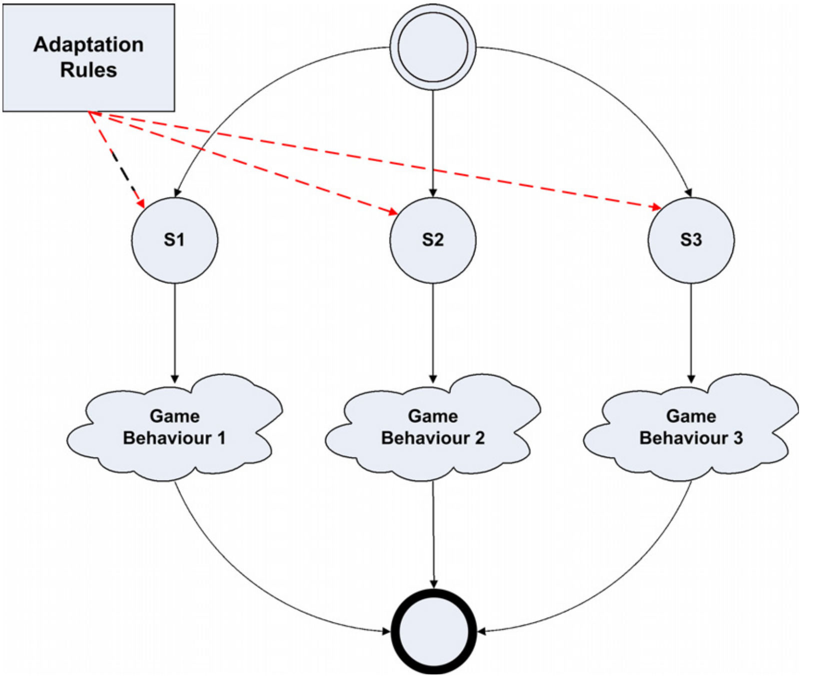

Fig. 2. The structure of the game can be defined in such a way that entering a specific state can modify the game experience completely. The adaptation rules can trigger a transition towards one of these states.

be made by just forcing the game to enter a specific state. Provided that the game is written accordingly, this simple change can modify the behaviour of the game completely as depicted in Fig. 2.

4.3. Integration with an online environment

Integration of games with standards-compliant learning management systems implies packaging them as learning objects and the inclusion of standard metadata to facilitate their discovery, integration and deployment. More important, it is necessary to face the notion of communication between the games and the LMS. The external rules that drive the adaptation and assessment mechanisms described above should actually reside in the LMS. The typical LMS includes mechanisms for user profiling that should be part of the input of the adaptation mechanism. Similarly, the LMS will usually include assessment and grading facilities that should be connected to the assessment mechanisms of the games.

The game-based learning objects are interactive pieces of content that, after being sent from the LMS to the student's computer, establish a communication link with the server. Through this communication link, the server initializes the learning object (in this case, our educational game) using the profile of the user to configure the adaptation mechanism. Then, during the execution of the game, the game engine retrieves the set of assessment rules from the server and monitors the progress of the player. When one of those rules is activated, the event is reported to the LMS along with the relevant data.

5. Implementation

We have implemented the previous design using the ⟨e-Adventure⟩ educational game engine[2] (Moreno-Ger & Martinez-Ortiz, 2005). The technical details of the implementation of the engine and

[2] ⟨e-Adventure⟩ was formerly mentioned in the literature as "The ⟨e-Game⟩ Project".

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the language used to describe the games can be found in (Moreno-Ger & Sierra, 2007). The following subsections describe how this engine fits this design and what the requirements for the LMS that will support this model are.

5.1. Integration of ⟨e-Adventure⟩ games in online education

The ⟨e-Adventure⟩ engine, which runs the games described using the ⟨e-Adventure⟩ language, can be used as a stand-alone tool, thus allowing instructors or learners to execute educational games on their computer.

However, the educational value of the engine is enhanced when it is executed as part of an online learning experience as initially described in (Martinez-Ortiz & Moreno-Ger, 2006). The engine with a copy of a specific game is distributed as a single executable file embedded as part of a package in a LMS as long as this system supports the IMS content packaging specification (IMS Global Consortium, 2004) or the IMS learning design specification (IMS Global Consortium, 2003).

When the engine is executed in the student's browser, it initializes a Javascript API that allows the communication between the engine and the server. This API was inspired by the structure of the SCORM specification (ADL, 2006) and employs a subset of the same standards included in SCORM: the IEEE data model for content to learning management system communication (Richards, 2003) and IEEE ECMAScript API for content to runtime services communication (Richards, 2004). If the LMS supports this API, the communication link is established and the LMS will use it to drive the adaptation and assessment mechanisms.

This approach has already been implemented and tested in the ⟨e-Aula⟩ system (Sierra & Moreno-Ger, 2006) and in a modified version of the official service-oriented implementation of the CopperCore engine (Vogten et al., 2006) developed at the Open University of the Netherlands to support the IMS learning design specification (IMS Global Consortium, 2003). The communication mechanism and its implications from an authoring perspective are further described in (Burgos & Moreno-Ger, 2007).

5.2. Assessment and adaptation in ⟨e-Adventure⟩

As described in (Moreno-Ger & Sierra, 2007), the state of the game in ⟨e-Adventure⟩ is based on a number of variables which are defined when the game documents are created. The state of the game at any given point can be described as a combination of these variables. Additionally, as described in Section 4, the combinations of all the actions that can be performed in an adventure game implicitly describe a FSM. In ⟨e-Adventure⟩, thanks to the association of relevant events with flags, we have a mechanism to characterize the state of the game when needed for either adaptation or assessment.

In ⟨e-Adventure⟩ assessment rules are defined in XML form, and they contain an expression that uses game flags and a payload or effect. When the expression evaluates to true (i.e. the game has entered the state described by the expression) the rule is activated and its payload executed. The payload includes two types of effects. On the one hand, the engine saves the human-readable portions of the payload and generates an HTML report that is sent back to the LMS when the game session ends. On the other hand, when the payload contains an instruction to change a property in the LMS (like a grade or a piece of information in the student's profile), the command is sent immediately to the LMS.

On the other hand, putting an ⟨e-Adventure⟩ game into a specific state of the game only requires setting the internal flags of the game to certain values. This adaptation is therefore configured using adaptation rules, which are also described using an XML form.

6. Discussion and future work

The design of educational games is not a simple task and there are no all-purpose solutions. As discussed in Section 2, the designs need to balance pedagogical requirements with an elusive fun-factor, with the second aspect being an issue even in the high-profile entertainment industry.

The design described in this work takes a well-established game design and modifies it to support a number of pedagogical features. The result is a generic gameplay design that could support several pedagogical approaches, including features such as real-time adaptation to fit learner needs, in-game assessment and grading, and the integration with online education environments following the learning objects model. Also note that, although other more specific aspects (e.g. the social part of learning/gaming) are not directly addressed in the paper, it is a natural addition to this generic design. The integration of these games in e-learning systems in a standards-compliant way and allowing a two-way communication (system–game, game–system) opens new ways for the educational use of games. It is possible to create instructional designs in which the activity of each user within the different games has an impact on the overall learning experience. Indeed, games can be included as learning objects in units of learning based on community-oriented/collaborative learning strategies, and they can interact with the overall execution environment of those units of learning during runtime.

The ⟨e-Adventure⟩ framework provides the tools required to implement such design approaches, supporting the additional pedagogical requirements and facilitating the integration between the games and standards-compliant learning management systems. In particular, the engine can be used in conjunction with educational modeling languages, such as IMS Learning Design (IMS LD) (Burgos & Moreno-Ger, 2007). It is interesting to note that works such as (Burgos & Tattersall, 2006) argue that the games, as well as the adaptation and assessment rules, might be modeled directly using the IMS LD specification. An important drawback to this approach is that it forces game designers to write their games using a language conceived for a different purpose: to model instructional designs. Similarly modeling the pedagogical impact of the assessment rules using ⟨e-Adventure⟩ brings up the same issues: the platform was not created to model instructional designs. The solution is to combine both technologies to support instructional designs that include educational videogames in adaptive and collaborative learning environments. Even though this work is focused on the design of individual games, its applications to adaptive learning environments supporting IMS LD is described in (Moreno-Ger & Sancho Thomas, 2007).

However, this is not a perfect solution. Choosing the genre of point and click adventure games is pedagogically sound, but the burden of creating a compelling story that will provide the fun-factor still lies in the writers of the game. It is perfectly possible to use this game design and still create a boring and non-motivational story. It should be noted that the ⟨e-Adventure⟩ implementation of this design focuses on providing a development model that facilitates the transition from a previously written storyboard to a fully functional game without losing value, but that concept assumes that the process begins with a good script. Writing compelling stories is a creative task and its study is beyond the scope of this work.

On the other hand, the design and its implementation using ⟨e-Adventure⟩ has already been tested successfully in the development of several educational games in different fields, including safety regulations in construction and clinical procedures (Moreno-Ger & Blesius, 2007).

Finally, it should be noted that the general design, including adaptation, assessment and integration with online learning environments is specified in a generic fashion. Since all these mechanisms rely on viewing the games as state transition systems (e.g. using FSMs), and these are standard computational models (Winskel, 1993), the pattern can be applied to different genres (other than adventure games) and different implementations (other than ⟨e-Adventure⟩).

Acknowledgements

The Spanish Committee of Science and Technology (Projects TIN2004-08367-C02-02, TIN2005-08788-C04-01, FIT-350100-2007-163 and TIN2007-68125-C02-01) has partially supported this work, as well as the Regional Government of Madrid (Grant 4155/2005) and the Complutense University of Madrid (research group 910494). Special thanks to James Flath for his collaboration during the proof-reading process.

References

ADL. (2006). Advanced distributed learning sharable content object reference model (ADL-SCORM). <http://www.adlnet.org/> Retrieved 26.12.07.

Alavi, M. (1994). Computer-mediated collaborative learning: An empirical evaluation. *Management Information Systems Quarterly, 18*(2), 150–174.
Aldrich, C. (2004). *Simulations and the future of learning: An innovative (and perhaps revolutionary) approach to e-learning*. San Francisco, CA: Pfeiffer.
Amory, A. (2001). Building an educational adventure game: Theory, design and lessons. *Journal of Interactive Learning Research, 12*(2/3), 249–263.
Amory, A., Naicker, K., et al. (1999). The use of computer games as an educational tool: Identification of appropriate game types and game elements. *British Journal of Educational Technology, 30*(4), 311–321.
Anderson, C. A., & Bushman, B. J. (2001). Effects of violent videogames on aggressive behaviour, aggressive cognition, aggressive affect, physiological arousal and proposal behaviour: A meta-analytic review of scientific literature. *Psychological Science, 12*(5), 353–359.
Betz, J. A. (1996). Computer games: Increase learning in an interactive multidisciplinary environment. *Journal of Educational Technology Systems, 24*(2), 195–205.
Bittanti, M. (Ed.). (2005). *Civilization: Virtual history, real fantasies*. Milan, Italy: Ludilogica Press.
Burgos, D., Moreno-Ger, P., et al. (2007). Authoring game-based adaptive units of learning with IMS learning design and ⟨e-Adventure⟩. *International Journal of Learning Technologies, 3*(3), 252–268.
Burgos, D., Tattersall, C., et al. (2006). Can IMS learning design be used to model computer-based educational games? *Binaria, 5*.
Burgos, D., Tattersall, C., et al. (2007). Re-purposing existing generic games and simulations for e-learning. *Computers in Human Behaviour, 23*(6), 2656–2667.
Clinton, K. A. (2004). Embodiment in digital worlds: What being a videogame player has to teach us about learning. In *2004 Annual meeting of the American educational research association, San Diego, United States*.
Cordova, D. I., & Lepper, M. R. (1996). Intrinsic motivation and the process of learning: Beneficial effects of contextualization, personalization, and choice. *Journal of Educational Psychology, 88*(4), 715–730.
de Freitas, S., & Oliver, M. (2006). How can exploratory learning with games and simulations within the curriculum be most effectively evaluated? *Computers and Education, 46*(3), 249–264.
Dillon, A., & Gabbard, R. (1998). Hypermedia as an educational technology: A review of the quantitative research literature on learner comprehension, control, and style. *Review of Educational Research, 68*(3), 322–349.
Gee, J. P. (2003). *What video games have to teach us about learning and literacy*. New York: Basingstoke, Palgrave Macmillan.
Hummel, H., Burgos, D., et al. (2005). Encouraging contributions in learning networks using incentive mechanisms. *Journal of Computer Assisted Learning, 21*, 355–365.
IMS Global Consortium. (2003). *IMS learning design specification, Version 1.0 final specification*. <http://www.imsproject.org/learningdesign/index.html> Accessed 26.12.2007.
IMS Global Consortium. (2004). *IMS content packaging specification, Version 1.1.4 final specification*. <http://www.imsglobal.org/content/packaging/index.html> Accessed 26.12.2007.
Jayakanthan, R. (2002). Application of computer games in the field of education. *The Electronic Library, 20*(2), 98–102.
Jenkins, H., Klopfer, E., et al. (2003). Entering the education arcade. *ACM Computers in Entertainment, 1*(1).
Johnson, D. W., & Johnson, R. T. (1989). *Cooperation and competition: Theory and research*. Edina, MN: Interaction Book Co.
Jonassen, D. H. (1994). Thinking technology: Toward a constructivist design model. *Educational Technology, 34*(4), 34–47.
Ju, E., & Wagner, C. (1997). Personal computer adventure games: Their structure, principles and applicability for training. *The Database for Advances in Information Systems, 28*(2), 78–92.
Kirriemur, J., & McFarlane, A. (2004). Literature review in games and learning. *NESTA Futurelab series*. Bristol: NESTA Futurelab.
Kolson, K. (1996). The politics of SimCity. *Political Science and Politics, 29*(1), 43–46.
Koster, R. (2004). *Theory of fun for game design*. Paraglyph.
Lepper, M. R., & Cordova, D. I. (1992). A desire to be taught: Instructional consequences of intrinsic motivation. *Motivation and Emotion, 16*, 187–208.
Leutner, D. (1993). Guided discovery learning with computer-based simulation games: Effects of adaptive and non-adaptive instructional support. *Learning and Instruction, 3*, 113–132.
MacFarlane, S., & Read, J., et al. (2004). *Evaluating interactive products for and with children. Computers on human factors in computer systems (CHI 2004). Vienna, Austria.*
Malone, T. (1981). What makes computer games fun? *Byte, 6*(12), 258–276.
Martinez-Ortiz, I., Moreno-Ger, P., et al. (2006). *Production and deployment of educational videogames as assessable learning objects. First European conference on technology enhanced learning (ECTEL 2006), Crete, Greece, Lecture notes in computer science*. Springer.
Merrill, D. (1991). Constructivism and instructional design. *Journal of Educational Technology, 31*, 45–53.
Michael, D., & Chen, S. (2006). *Serious games: Games that educate, train, and inform*. Boston, MA: Thomson.
Moreno-Ger, P., & Blesius, C. R., et al. (2007). Rapid development of game-like interactive simulations for learning clinical procedures. In *Game design and technology workshop and conference, Liverpool, UK*.
Moreno-Ger, P., & Martinez-Ortiz, I., et al. (2005). *The ⟨e-Game⟩ project: Facilitating the development of educational adventure games. Cognition and exploratory learning in the digital age (CELDA 2005)*. Porto, Portugal: IADIS.
Moreno-Ger, P., Sancho Thomas, P., et al. (2007). Adaptive units of learning and educational videogames. *Journal of Interactive Media in Education, 2007*(05).
Moreno-Ger, P., Sierra, J. L., et al. (2007). A documental approach to adventure game development. *Science of Computer Programming, 67*, 3–31.
Parker, A. (2003). Identifying predictors of academic persistence in distance education. *Journal of the United States Distance Learning Association, 17*(1), 55–62.
Polsani, P. (2003). Use and abuse of reusable learning objects. *Journal of Digital Information, 3*(4).
Porter, D. B. (1995). Computer games: Paradigms of opportunity. *Behaviour Research Methods, Instruments and Computers, 27*(2), 229–234.
Prensky, M. (2001). *Digital game based learning*. New York: McGraw-Hill.
Purushotma, R. (2005). Commentary: You're not studying, you're just.... *Language Learning & Technology, 9*(1), 80–96.

Richards, T. (2003). *IEEE standard for learning technology – data model for content to learning management system communication*.
Richards, T. (2004). *IEEE standard for learning technology – ECMAScript API for content to runtime services communication*.
Schank, R. C. (1993). Learning via multimedia computers. *Communications of the ACM, 36*(5), 54–56.
Sierra, J. L., Moreno-Ger, P., et al. (2006). A highly modular and extensible architecture for an integrated IMS based authoring system: The ⟨e-Aula⟩ experience. *Software-Practice & Experience, 37*(4), 441–461.
Sim, G., MacFarlane, S., et al. (2006). All work and no play: Measuring fun, usability, and learning in software for children. *Computers and Education, 46*(3), 235–248.
Squire, K. (2003). Video games in education. *International Journal of Intelligent Simulations and Gaming, 2*(1), 49–62.
Squire, K. (2005). Game-based learning: An X-learn perspective paper. *MASIE center: e-Learning consortium*. Available at: <http://www.masieweb.com/research-and-articles/research/game-based-learning.html>.
Squire, K., & Barab, S. (2004). Replaying history: Engaging urban underserved students in learning world history through computer simulation games. *Sixth international conference of the learning sciences*. Santa Monica, United States: Lawrence Erlbaum Associates.
Starr, P. (1994). Seductions of Sim. *The American Prospect, 2*(17).
Van Eck, R. (2006). Digital game-based learning: It's not just the digital natives who are restless. *EDUCAUSE Review, 41*(2), 16–30.
Van Eck, R. (2007). Building artificially intelligent learning games. In D. Gibson, C. Aldrich, & M. Prensky (Eds.), *Games and simulations in online learning: Research and development frameworks*. Information Science Publishing.
Vogten, H. M. H. et al (2006). CopperCore service integration integrating IMS learning design and IMS question and test interoperability. In *6th IEEE international conference on advanced learning technologies, Kerkrade*. The Netherlands: IEEE Computer Society Press.
Wenger, E. (1998). *Communities of practice: Learning, and identity*. New York: Cambridge University Press.
Winskel, G. (1993). *The formal semantics of programming languages: An introduction*. Cambridge, Massachusetts: The MIT Press.