What evidence is there that digital games can be better than traditional methods to motivate and teach students?

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1. Introduction

This paper explains why and how video games may be considered as an alternative to traditional teaching methods. The first section describes the background and rationale for the paper. It analyses the limitations of traditional methods for teaching, and identifies how Game-Based Learning (GBL) can be a more practical and effective approach. In the second part of the paper, empirical evidence of the advantages of GBL over traditional methods is presented, with reference to recent scientific studies conducted essentially between 2005 and 2011. The evidence collected shows that, while games in isolation may not always be as effective as traditional methods, environments that include Game-Based Learning approaches can be more motivating and educationally effective than traditional settings. Empirical evidence demonstrates that video games provide a meaningful context and an interactive visual representation that makes learning material accessible, useful and relevant. It also shows that we can learn a lot from video games, and that schools, universities and other instructional settings, should account for gaming literacy and incorporate it in traditional teaching methods.

2. Why consider GBL compared to other traditional methods

2.1. When is it best to use GBL

Although video games cannot replace teachers, researchers have found that games can be employed, in specific circumstances, to increase learning outcomes compared to other media or teaching methods, such as text books or web-based learning. As suggested by Hays (2005), who conducted a comprehensive literature review of the advantages and limitations of GBL, the benefits brought by video games may be applicable only in specific situations, and games are not the preferred mode of instruction in all cases. Hays (2005) found that video games are more effective when they are incorporated within instructional programs that include debriefing and feedback, and that instructional support during play may increase the effectiveness of GBL. Games should be used as adjuncts, not as standalone applications, and combined with relevant pedagogies (Hays, 2005; Shaffer, 2006). As indicated by Wainess (2007) and Dickey (2003), games on their own may not always promote motivation or learning; instead, they need to be considered within GBL practices, and attention should be payed to the environment, rather that the game itself. Support and guidance from the teacher are also crucial for the integration and successful use of video games (Mayer & Bekebreda, 2006).

2.2. Important features in GBL systems and settings

According to Becker (2006), games are educational and can maintain players' attention for extended periods of time. Video Games inherently employ relevant and well-known educational principles (Gee, 2007), they support all five learning capabilities defined by Gagne and Briggs (1972): motor skills, attitude, verbal information, cognitive strategy and intellectual skills or Gagne's nine events of instructions (1981). Video games have proven to be ideal in order to support teaching methods, increase motivation, and provide a

medium that taps into constructivist theories. In terms of motivation, games often seem to be more motivating than traditional teaching methods. In terms of learning outcomes, they are effective to develop a wide range of cognitive skills, including procedural knowledge, declarative knowledge, and higher thinking skills. Video games may take the form of practice drills or quests in which users are required to conduct scientific enquiries. While the evaluation of the former is relatively easy, the latter often raises issues, as it is difficult to evaluate students' higher thinking skills or domain knowledge. This being said , some scientist have successfully employed evaluation tools such as concepts maps to measure students' degree of expertise. This would apply, for example, to video games featuring open-ended environments where users can experiment, learn from their mistakes, and update their internal *knowledge map* accordingly. Such environments are especially conductive of higher thinking skills required in third-level education; however, because of their open-ended nature, these games, unless they have already been developed commercially, could involve high development costs and therefore dissuade educators and developers to develop or use them. Video games are especially efficient to engage students, promote an interest in and a positive behavior toward the topic, and consequently increase their knowledge. In particular cases, video games may be more efficient than pen-and-paper methods, because the electronic format enables students to repeat tasks indefinitely and consequently learn from their mistake through a process of trial-and-error. Some video games such as MMORPGs, (Massively Multiplayer Online Role Playing Games) are based on collaboration between players, and may therefore be more appropriate and effective for collaboration-based activities. Video games are often developed with flexibility and portability in mind; they can be employed and deployed ubiquitously, inside or outside the classroom, and may therefore offer more opportunities for learning. An additional advantage of video games is that they feature most of the Web 2.0 technologies already employed in school and universities, including Instant Messaging (IM), video, or web content. Some forms of games, such as ARGs (Alternate Reality Games), that combine the technologies already employed in most educational settings, may offer a cost-efficient solution for GBL development. As it will be described in the next sections, video games promote digital literacies, especially for students who are required to combine different information sources such as text, audio, or graphics, to create an educational game.

3. Empirical evidence

3.1. Introduction

Researchers have conducted controlled studies to explore the motivational and learning advantages of using video games in comparison to traditional settings. Evidence of the advantage of GBL over traditional settings presented in this paper, is based on both qualitative and quantitative data, and has been collected using a wide range of methods and techniques including pre- and post tests, interviews with students and teachers, recordings of students during game play, or focus groups. In the light of the literature, it appears that settings incorporating video games are often more engaging and educationally effective than settings that don't. GBL can be better than traditional teaching methods to improve learning and motivation for a wide range of topics including mathematics (Sorensen & Meyer, 2007; Miller & Robertson, 2010)), physics (Squire et al., 2004), software engineering (Navarro & Hoek, 2007), languages (Yip & Kwan, 2006; Miller & Hegelheimer, 2006; Neville et al., 2009), history (Abrams, 2009; Watson et al., 2011), literature (Stevens, 2000), rehabilitation (Adavovich et al, 2003), fire fighting (Tsung-Yen & -Fan Chen, 2009), digital skills (Beavis & O'Mara, 2010; Owston et al., 2009)), mechanical engineering (Coller & Scott, 2009), healthy eating (Serrano, 2004), algebra (Kebritchi et al., 2010), geography (Virvou et al., 2005), or reading comprehension (Bransford & Schwartz, 1999).

3.2. General Benefits compared to traditional teaching

The studies mentioned above have demonstrated that video game, compared to traditional teaching methods, strengthen students' knowledge, skills and attitudes towards the topic taught (Serrano, 2004), that a game-based learning approach is more motivating and educationally effective (Barab et al., 2009), especially for students with poor pre-test scores. GBL is often more effective than conventional educational software such as web-based or CAI (Virvou et al., 2005; Papastergiou, 2009; Tsung-Yen & Chen 2009). In some cases, the educational effectiveness of the game, can be improved by customized mechanisms such as

pedagogical agents and Intelligent Tutoring Systems (Conati & Zhao, 2004).
Students are significantly more engaged by GBL compared to traditional teaching. They usually find the medium much more enjoyable (Toprac, 2011; Vogel et al., 2006) and can be in some cases, more focused and disciplined than in web-based instruction settings (Papastergiou, 2009). GBL improves students' self efficacy (Toprac, 2009) and can be more efficient than traditional methods for rehabilitation. This was illustrated by (Adavovich et al., 2003) who explain that attention, reward, progression, complexity, and skill acquisition are critical to produce improvements in neural structures and functions. They found that virtual reality and video games, because they include all these features, are a suitable tool, especially for the new "MTV generation", who would be well suited to video game-based therapy.

Students following a game-based approach are able to test their knowledge and refine their understanding of the concepts they have learnt previously. Teachers often notice a change in the behaviours of these students. Amongst other noted benefits, games may be better than paper-based because students can complete exercises repeatedly, with increasing difficulty and challenges. They develop a sense of collaboration or competition between players (Lee et al., 2004; Miller & Robertson, 2010). Games often help students to become more perseverant, and it was suggested that they could be used as an additional resource to palliate teachers' lack of contact hours (Yip & Kwan, 2006).

Abrams (2009) conducted a particularly interesting study with three students who underperformed academically and found it difficult to be engaged in traditional settings. The study showed that when students are exposed to video games related to the history lesson, they manage to understand concepts by playing the video game. Their gaming experience enriched their understanding of the Second World War by providing them with more vivid details of the battles. The results of the study showed how video games can provide a meaningful context and an interactive visual representation that make the learning material 'accessible, useful and relevant', especially for students who usually find it difficult to be engaged in traditional settings. The video game helped them to memorize concepts more vividly because they were contextualized within the game.

3.3. Learning by creating a game

Students who create an educational game need to collect and consolidate information from different sources, and review thoroughly the learning material before they integrated it into the game. They are also often committed to provide correct and typo-free information to their class mates. This process tends to improve their memory retention, engagement, editing skills, and knowledge of the concepts. The process of creating educational games engages students in authentic activities, where knowledge is contextualized and employed for a purpose other than just 'regurgitating information'. For example, Beavis & O'Mara (2010) showed that requiring students to create an educational game, improved their literacy skills, digital skills, writing skills and knowledge of the topic.

3.4. How is engagement characterized in GBL environments

Increased engagement in GBL environments is often characterized by students' interaction and discussions outside the classroom. This can be explained by the fact that while teachers are trying to engage students in typical classes (e.g., humor, questions, analogies, etc.), this approach does not always work, probably because teachers are at the centre of the activity and that the traditional setup of the classroom (e.g., desk lined up in rows and teacher at the head of the class) is not student-centered. In contrast to common traditional classes, settings using GBL, where students play or create video games, can be more conducive to user-centered and collaborative learning. For example, while some team members may play the game, the other members can discuss strategy and provide suggestions. As suggested by Watson et al. (2011), this type of settings promotes interaction within and between teams, and because the teacher is not the centre of instruction, this can result in a more engaging experience. Theses settings, usually referred as 'wall-less classrooms ' are effective because they emulate authentic computer supported collaborative working environments, where students collaborate, develop their knowledge-finding skills, and engage with communities in order to find solution to some of the problems they may encounter (Beavis & O'Mara, 2010).

3.5. Conditions for successful integration

Researchers often indicate that while playing games is increasingly a part of what it means to be literate in the 21st century', it is not always acknowledged in traditional settings. As a result, teaching practices need to be modified in order to account for the digital literacies developed outside the schools.

Most studies referred to in this review suggest that educational benefits are increased when the students have had a prior exposure to the topic and that the game allowed to put learned knowledge into practice (Navarro & Hoek, 2007). It also appears crucial that, in the case of bespoke educational video games, students be included in the development process, and introduced to new or unfamiliar game mechanics through a training module. Neville et al. (2009) advise that in-game training (e.g., demo levels or feedback) be complemented with class training sessions, and that attention be paid to contemporary games for affordance with which students would be familiar and would expect in a game (e.g., same quality than commercial games). Providing well-known control schemes may facilitate the learning curve and consequently improve the overall experience. Finally, Owston et al. (2009) advise that students should not be involved in collaborative activities (e.g., playing or designing a game) for more than 45 consecutive minutes, otherwise their' productivity may decrease significantly.

4. Summary

This literature review has managed to explain why and how video games may be more effective to both teach and motivate. A theoretical analysis of video games shows that video games are inline with well-received learning theories, and what's more, theories that have been widely accepted in education, but not always implemented (i.e., constructivism and 'learning by doing'). Video games seem to include and combine all necessary factors and conditions for learning to occur. Compared to traditional education, not only do they offer a more motivating environment, but they also make it possible for students to learn by doing, and to promote skills that could be more difficult to practice in traditional school settings, especially for science (e.g., laboratory experiments) where scientific inquiry and higher-order skills are required. Video games may be more effective in this case as they include authentic problems presented through narratives that offer a suitable format for scientific enquiry. Video games employ multi-sensory cues that are better adapted to address individuals' differences (e.g., learning styles). They combine the benefits of eLearning media, as students can learn at their own pace, perform tasks repeatedly if necessary, and avail of tailored feedback and interaction. One of the features that makes them especially more efficient, both in terms of motivation and education, is their ability to immerse users, improve their focus, and promote collaboration. In some particular cases, when experiments are required or when the topic taught is highly theoretical and may require additional visual representations, games are more practical and efficient. This is the case for history, where players can appreciate the settings from different perspectives, chemistry where experiments with hazardous chemicals may not be possible in real settings, or physics where the observation and manipulation of real life phenomenon can be conducted precisely and realistically with game technology. This being said, games may not be the best tool to motivate or teach in all situations and practitioners should therefore be aware of their advantages and limitations.

5. Method for answering the question

Searches were conducted using a combination of academic search engines, academic journals, and books. Publication containing evidence were peer-reviewed, published between 2005 and 2010. Whilst the ebsco database was initially employed for the search, it did not seem to include recent scientific work pivotal in the understanding of motivation and learning in digital games. As a result the research was extended to other academic resources.

While an effort was made to include only recent references (e.g., between 2005 and 2011), it was sometimes necessary to include earlier references, due to their theoretical relevance.

Search in the ebsco database was performed for publication between 2005 and 2011, using the following query:
“(study or experiment) and ((video or digital) and game) and (learn or teach or motivation or achievement)

and traditional (all text) “

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