INTEGRATING GAMEPLAY AND LEARNING IN VIDEOGAMES

Kostas Anagnostou
Department of Informatics
Ionian University
Greece

Anastasia Pappa
IT in Science Education
Greece

Abstract

Videogames are increasingly becoming the preferred entertainment activity for young people. Researchers claim that videogames have the ability to enrich and encourage learning by augmenting traditional learning methods. Here we are investigating how videogames can support physics education by stimulating students and creating an environment for them to experiment through a series of game activities. We have developed a pilot platform game for students attending Year 2 of secondary school in Greece (13 years old) to cover the course "Forces and their Effects." The aim of this work is to explore whether integrating the learning process to the game play can enrich learning and investigate if videogames can offer an alternative tool to the teaching of concepts that students have difficulty in understanding.

Introduction

Students raised in the new digital age are gradually losing interest in the traditional forms of teaching and learning. One of the subjects that particularly suffers is science. According to a report by UK's NESTA[1] pupils in the UK are losing interest in science because too often the subject is being taught as just facts on a blackboard. The current, narrative, teaching methods do not allow practical experimentation whereas the fundamental scientific principle of 'trial and error' is not encouraged.

The new generation of students has been developed and shaped in the new digital world. Digital technology is fully integrated into their everyday life and they use it for searching for homework, maintaining relationships and playing games (Green & Hannon, 2007). The nature of digital technology has influenced and shaped the way they receive and process information. As a result, traditional teaching fails to keep them stimulated and challenged.

In particular, videogames appear to be one of the favourite pastimes of young people. A study in the USA showed that virtually all American teens play computer, console, or mobile phone games (Lenhart et al., 2008). Similarly in the UK, 82 per cent of children play games after class at least once in a fortnight (Sanford et al., 2006)

In response to that, over the last decade there is a huge amount of research concerning the use of videogames in learning in general, and in science in particular. Videogames can develop and enhance a lot of the skills that science requires. They enhance inductive discovery by allowing players to make observations, and figure out the rules governing the behaviour of a dynamic representation (Prensky, 2006) and they create a safe simulated environment where kids can experiment, develop critical thinking and problem solving qualities through playing.

These qualities can potential create a fun and stimulating educational environment. Although there is a lot of theoretical work tackling this issue, the number of games that integrate learning in their gameplay is limited. This reflects the difficulties and challenges that such an effort involves (Klopfer et al., 2009).

In this work we investigate whether an action game can enhance teaching of physics in secondary school students and examine how integrating learning in the playgame can produce an educational but fun and involving game. We also explore what the impact of using a videogame is on students learning physics.

Contrary to the published edutainment products of the past decade, our aim is to create a simple videogame with clear educational value which will equally entertain and educate the students without introducing them into a formal educational environment.

In this paper we review the potential of videogames as learning tools for teaching focusing on physics education. We present the initial phase of our pilot study which attempts to investigate how videogames can enhance physics learning. Towards this, we have designed a 2D platform game which integrates physics concepts (forces and their effects) into the gameplay mechanics.

Learning through Videogames

The origins of learning through videogames can be traced as far back as the first successful videogames console, the Atari 2600. Those primitive games took advantage of the unprecedented graphic and interaction capabilities of the early consoles to introduce some basic educational applications to children such as Fun with Numbers. In the early eighties the personal computer, in the form of Apple II

and Commodore 64, found its way to many households and along came educational software as a major hook for parents to justify the purchase of those expensive machines. In the nineties, the personal computer acquired high resolution colour displays, CD-ROMs, music playback and large processing power. A whole new market segment evolved with the sole purpose of producing educational games for children (eduntainment) targeted at parents. By the end of the nineties, the rise of the Internet as an educational tool and the failing quality of educational games shrunk the eduntainment market segment. The new millennium saw the renaissance of videogames as an educational tool to enhance the learning process in the classroom (Chen, 2005).

At a first glance it may seem contradictory to combine learning with fun, as learning is thought of as a serious process that requires great concentration and effort. There is a large body of, mostly theoretical, work that advocates the suitability of games as a learning tool.

Why are Videogames Suitable for Learning?

Playing games is not a privilege restricted to the human species, but a universal process across the animal kingdom. Most animals use game-playing as a means to learn crucial survival skills, such as hunting alone or in groups, fighting off enemies, escaping danger. Humans use games in a similar way in the context of a more civilized, social, environment. For instance, board games that evolved over the years for entertainment and socialization purposes have also been used for centuries to enhance decision-making skills by the Army.

Videogames are, in essence, interactive virtual simulations of physical spaces and processes, populated by characters and objects. The player is represented by a character (or more generally an avatar) and can navigate and interact with this virtual world. In the past decade the virtual world of videogames has been almost exclusively presented in three dimensions, with high quality graphics and sound.

The videogames exhibit an abundance of characteristics that can prove useful when used in education (Chen 2005; Gee, 2007; Prensky, 2007):

- Representation. The virtual world represents a physical environment, at various degrees of abstraction, and any component or process in it. The virtual world is rendered visually and aurally and frequently augmented by tactile input/output.

- Simulation. Processing power is cheap nowadays and this allows accurate simulation of many processes in a virtual world, including physical interaction, motion and intelligent behaviour.

- Rules. A virtual world is bound by rules and is deterministic. For every action we can define an outcome. Furthermore we can design the rules in such a way as to teach.

- Interaction. A player can interact with the virtual world in real time and navigate through it.

- Feedback. A player receives instant feedback on her actions. If she performs well, she will be rewarded. If not, she can learn what she did wrong.

- Motivation. Through interaction, feedback and reward the player is motivated to keep on playing the game, for much longer that she would spend reading the textbook or paying attention to the teacher.

- Collaboration. Many players can take part in a videogame through a local network or the Internet and learn collaboratively.

- Logging. User actions and consequences can be logged in a videogame and later studied and evaluated.

- Low cost. A virtual simulation is cheaper as well as safer than a real one.

In a videogame the player can interact with various components, she feels "present" in a virtual world where she has perform actions to progress. Learning through doing is compatible with a relatively new popular learning theory called constructivism (Fosnot, 1996; Gijbels et al., 2008). According to this theory the student is not a passive consumer of knowledge but has to actively participate in knowledge-producing by experimenting and applying processes herself.

Each videogame is an abstract version of a real system, bound by rules and processes. The player is motivated to learn those rules and processes in order to play the game successfully. Through this, learning knowledge is acquired. The expectation and belief is that this knowledge can then be transferred from the virtual to the real world. This (and how it takes place) is the main research goal of this work, as well as the work of other researchers' that study the use of videogames in education.

Different Modes of Learning

Videogames can support two different modes of learning. The first is through narration which is not directly related to the gameplay. The student plays the game and receives information about a topic at intervals. For instance, information could

include the history of a building or place that appears in the game. Alternatively, the player receives the information at the end of the level (often through a video cutscene). The second mode involves learning through gameplay (i.e. through doing).

In the first mode gameplay is just a hook to keep the learner involved and motivated to keep playing. In the second mode an attempt is made for the player to gain knowledge through actively following processes and performing actions.

Learning through narration in a videogame can be efficiently used in some cases, for example in teaching history or culture. Furthermore it is the easiest mode to implement in an educational game since gameplay mechanics are not really affected by it. Learning by doing on the other hand requires special game design, in order for the gameplay to assist in knowledge construction.

We believe that actively integrating learning and gameplay is better suited to science education and especially physics education. The player takes part in a simulated world, and learns through a "physical" interaction with it. We have based our game design on this assumption.

Physics Education and Videogames

Physics is probably one of the most challenging subjects to teach using videogames. Physics runs through any videogame, everything from racing cars and flying airplanes to water flow and character animation is simulated using the fundamental principles of physics.

Physics simulation is a fundamental ingredient of videogames, enabling the implementation of realistic interaction with the virtual world, which leads to increased immersion in the game. When playing a game, players come across a range of physics concepts all well built-in into the game activities that become unnoticed. So how can a game designer integrate physics learning, without spoiling the player's experience?

There are a few empirical studies investigating the impact of videogames in teaching. The potential of teaching physics has only recently been tackled.

Can videogames provide a visual and experimental space for students to understand complex and abstract physics concepts? Research using the 3D simulation game Supercharged! (Squire et al., 2004) showed that games can be effective tools in physics education, but they suggested that students did not infer some of the more complex concepts and were unable to interpret game events in terms of physics concepts, while some misconceptions about the interaction among charged particles persisted.

Methodology

We have designed an action platform videogame to allow students to develop an intuitive understanding of concepts relating to the unit "Forces and their effects" taught within the Greek curriculum to the Year 2 students of Secondary school. Specifically the game deals with the following concepts: representation of forces using vectors, forces and interactions, measuring forces, balance, friction, inertia, types of forces. Players learn about the related physics concepts by helping the main character overcome a series of obstacles in order to complete the game successfully.

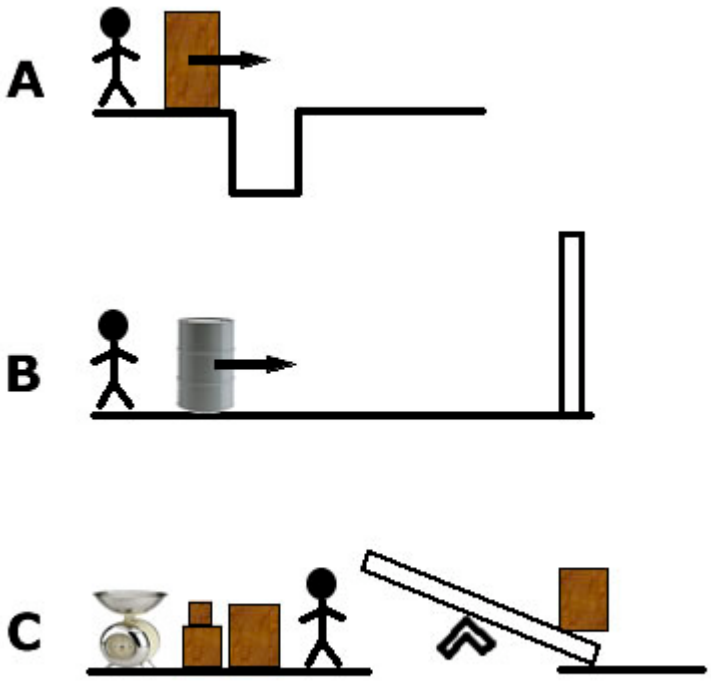
Designing a Videogame for Physics Education

The game is a two-dimensional platform game, in the same vein as the early Mario games. Platform games are a very popular genre among children and their mechanics are well understood. Furthermore we decided the game to be in two dimensions so as to remove the requirement of three-dimensional navigation which some players, especially the inexperienced, are not comfortable with. The fewer degrees of freedom supported by a two dimensional game is expected be less of a distraction and to allow the player to concentrate at the tasks at hand. Finally, two dimensional games, in general, require less computing power and display capabilities and run equally well on older personal computers. This is very important when designing a game to be used at school computer laboratories which often are not state of the art.

The aim of the game is for the player to reach the end of each level, negotiating the various obstacles and collecting treasures in the process. Various enemy characters are present on the game platforms which pose a threat to the player's character. To enhance competition between children we reward players when they successful pass obstacles with extra points.

In Figure 1 we show samples of concept art developed for the pre-production phase. Through the gameplay mechanisms, players visualise that the length of the vector representing the force depends on its magnitude (A), try to overcome an obstacle by using the concept of inertia by adjusting the mass of the content of a barrel so that it reaches and breaks the obstacle (B), use the forcemeter and comprehend balance (C).

Figure 1: Sample Gameplay Design



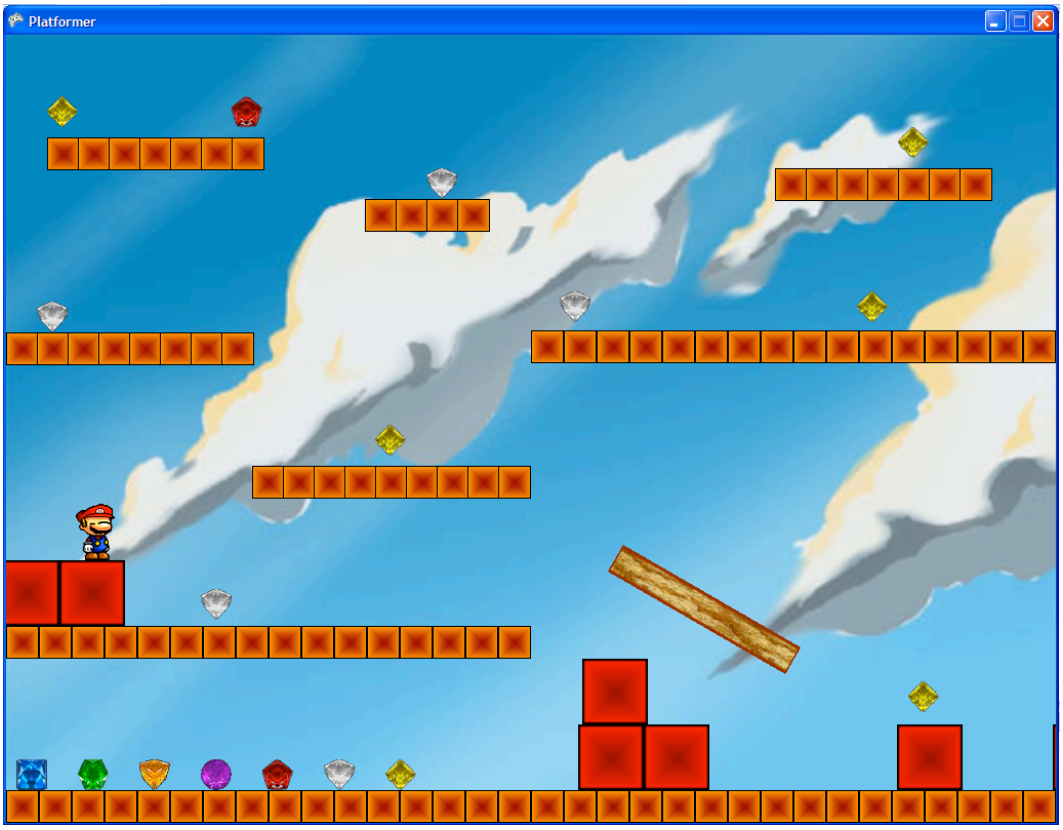
Implementing the Videogame

The game was implemented using the XNA Game Studio 3.0 platform[2] which is available for free over the Internet. Games developed with XNA Game Studio support both Windows and the Xbox360 console. In our case the game will be tested on Windows XP platform only and the keyboard is used as the input device.

Data Recording and Evaluation Plan

This game is a pilot study to evaluate the impact of videogames in the learning of physics. The game is designed for Year 2 secondary School students (age 13) and attempts to support the unit "Forces and their effects." On that year students come across abstract physics concepts for the first time, so the sample is well suited as a testing ground to evaluate whether complementing the learning process with a videogame actually enhances their understanding of conceptual science.

Figure 2: Sample Game Instance



The pilot study will take place at a secondary school on Corfu, Greece and will involve 32 students, all taught by the same teacher. All students will be taught the content of the "Forces and their effects" unit using the traditional method of teaching that the teacher employs. In addition, a subgroup of these students will play the videogame.

We will use post-game tests and interviews to assess the impact of the game in the learning process.

Conclusion and Further Work

Employing videogames as a user-friendly and powerful interactive simulation is expected to enhance the learning of science topics, especially physics which is the subject of our work. In this paper we have presented our initial work on a pilot study we are conducting on the use of videogames to assist in physics learning. The next step of our study is to evaluate the videogame following the evaluation plan described above (qualitative and quantitative), with a group of secondary school students. The results will give us an indication on how much and how the

videogame has improved the understanding of key physics concepts relating to "Forces and their effects."

Notes

1. A Mission for Innovation — Fostering science enquiry learning across the UK, http://www.nesta.org.uk/a-mission-for-innovation-fostering-science-enquiry-learning-across-the-uk/
2. XNA Game Studio, available at http://creators.xna.com

References

Chen, S., & Michael, D. (2005). *Serious games: Games that educate, train, and inform.* Course Technology Inc.

Fosnot, C. T. (1996). *Constructivism. Theory, perspectives, and practice.* New York: Teachers College Press.

Gee, J. P. (2007). *What video games have to teach us about learning and literacy* (2nd ed.). Palgrave Macmillan.

Gijbels, D., Segers, M., & Struyf, E. (2008). Constructivist learning environments and the (im)possibility to change students' perceptions of assessment demands and approaches to learning. *Instructional Science: An International Journal of the Learning Sciences, 36*(5), 431–443.

Green, H., & Hannon, C. (2007). *Their space: Education for a digital generation.* Demos.

Klopfer, E., Osterweil S., & Salen, K. (2009). *Moving learning games forward: Obstacles, opportunities & openness. The Education Arcade.* MIT.

Lenhart, A., Kahne, J., Middaugh, E., Macgill, A., Evans, C., & Vitak, J. (2008). *Teens, video games and civics. Pew Internet & American Life Project.* http://ww.pewinternet.org/Reports/2008/Teens-Video-Games-and-Civics.aspx

Prensky, M. (2006). *Don't bother me mom — I'm learning!* Paragon House Publishers.

Prensky, M. (2007). *Digital game-based learning.* Paragon House.

Sandford, R., Ulicsak, M., Facer, K., & Rudd, T. (2006). *Teaching with games: Using commercial off-the-shelf computer games in formal education.* NESTA FutureLab.

Squire, K., Barnett, M., Grant, J. M., & Higginbotham, T. (2004). Electromagnetism supercharged!: Learning physics with digital simulation games. In *Proceedings of the 6th International Conference on Learning Sciences* (pp. 513–520). International Conference on Learning Sciences.