Universidade de Aveiro Departamento de Comunicação e Arte
Ano 2010

Rosana Margarida Fernandez dos Santos Couceiro

DESIGN OF A COMPUTER GAME FOR AN INFORMATION TECHNOLOGY CLASS

DESIGN DE UM JOGO DE COMPUTADOR PARA A DISCIPLINA DE INFORMAÇÃO E TECNOLOGIA

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Dissertação apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Comunicação Multimédia, realizada sob a orientação científica da Doutora Ana Veloso, Professora do Departamento de Comunicação e Arte da Universidade de Aveiro, e da Doutora Marina Paparstergiou do Departamento de Educação Física e Ciências de Desporto da Universidade de Thessaly.

Dedicated to my grandmother Fernanda Leite dos Santos, who departed on her own journey before I could return from mine.

o júri

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agradecimentos

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palavras-chave

Digital game-based learning; ciências dos computadores; educação; game design; teorias de aprendizagem

resumo

Actualmente algumas fontes de investigação científica consideram que o ensino tradicional, ao longo das décadas, tem sido menos apelativo (Foreman, 2003). Os alunos encontram-se rodeados por outros estímulos causados pelas novas tecnologias, novas formas de entretenimento e redes sociais (Prensky, 2001a; Raines, 2002), estímulos que se tornam mais apelativos do que o ensino tradicional. Uma das soluções apontadas e proposta pelos peritos na matéria é a inserção de jogos, um dos principais estímulos do entretenimento actual, como ferramentas de aprendizagem em ambientes formal escolar, como a sala de aula (Eck, 2006; Paras & Bizzocchi, 2005).

O projecto que se apresenta foi desenvolvido no Departamento de Educação Física e Ciências do Desporto pertencente à Universidade de Thessaly e localizado em Trikala, Grécia, e apresenta um estudo sobre a aplicação do jogo como ferramenta de aprendizagem em contexto educacional.
Este projecto consiste na conceptualização, desenvolvimento e avaliação de um protótipo de um jogo criado com o objectivo de motivar os estudantes do Departamento de Educação Física e Ciências de Desporto da Universidade de Thessaly, Grécia, a aprender conceitos da unidade curricular de Tecnologias da Informação.

Considerado o propósito do jogo os conteúdos da unidade curricular foram adaptados para o jogo. Integrou-se a narrativa como elemento de motivação para os estudantes, foram conceptualizados cenários, personagens e *level design*, juntamente com a inserção de puzzles relacionados com os conteúdos da unidade curricular, mecânica do jogo e regras. O protótipo desenvolvido é constituído por um conjunto de puzzles com os quais se efectuou uma avaliação preliminar em dois grupos focais. A avaliação preliminar foi efectuada na Universidade de Thessaly, no pólo Trikala e na Universidade de Aveiro, com amostras de conveniência do público-alvo primário e secundário, respectivamente, para perceber se a estratégia do jogo e respectiva narrativa poderiam funcionar na unidade curricular em causa.

Os resultados apontam que o jogo pode ser uma ferramenta a incluir na unidade curricular, depois das amostras do público-alvo primário terem demonstrado uma recepção positiva ao jogo e os seus conteúdos, sobretudo a narrativa e gráficos, e esperam que as próximas versões tragam mais puzzles e desafios como os que estiveram presentes no protótipo.

keywords

Digital game-based learning; computer science; education; game design; learning theories

abstract

Recently, there has been some thought about the traditional education which may have lost its appeal through the decades, as some scientific investigation fonts claim (Foreman, 2003). The students find themselves surrounded by stimulus caused by the new technologies, entertainment and social networks (Prensky, 2001a; Raines, 2002), stimulus much more appellative than the traditional education. One of the solutions proposed by experts in the field is to use a game, one of the main stimuli in nowadays entertainment, as a learning tool in educational environments, such as the classroom (Eck, 2006; Paras & Bizzocchi, 2005).

The project was developed in the Department of Physical Education and Sport Science of the University of Thessaly, located in Trikala, Greece, and presents a study about the application of a game as a learning tool in an educational context.
This project consists in the conceptualization, development and evaluation of a game prototype created with the purpose of motivating the students of the Department of Physical Education and Sport Science of the University of Thessaly, Greece, to learn concepts from the course of Information Technology.

Considering the purpose of the game, besides adapting the contents of the course inside the game, a narrative was also introduced as an element to motivate the students, followed by the conceptualization of scenarios, characters and level design, along with the introduction of puzzles related with the course, gameplay and rules. The game prototype is composed by a group of puzzles which were evaluated and tested by a selected group in Trikala and Aveiro, the primary and secondary target audiences respectively, to best understand if the strategy of the game and its narrative could work in the aforementioned course.
The results show that the game can be used as a learning tool to be included in the course, after the participants from the primary target audience sample demonstrated a positive reaction to the game and its contents, especially the narrative and graphics, and are waiting for the next versions to bring more puzzles and challenges like those present in the prototype.

It's misleading to suppose there's any basic difference between education and entertainment. This distinction merely relieves people of the responsibility of looking into the matter. It's like setting up a distinction between didactic and lyric poetry on the ground that one teaches, the other pleases. However, it's always been true that whatever pleases teaches more effectively.

- Marshall McLuhan

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1. INTRODUCTION

First and foremost, it is important to establish the ground for this project. It cannot advance without a peculiar analysis over the problematic behind the need for this project, a selection of pertinent investigation questions and respective hypothesis, definition and justification of a methodology to use during the development, description of the objectives to be pursued, and organization of a calendar to follow. These elements work as guidelines during the execution of the project in order to achieve the desired results following academic and scientific methods for a better understanding over the subject, the problematic and possible solutions.

1.1. Problematic

There has been much instigation towards traditional teaching methods, accused of being inadequate for the most recent generations which have quick access to all kinds of information, and whose skills and attitudes have been shaped with the aid of the current technologies (D. G. Oblinger, 2004). It may be no exaggeration to say the current academic system from the K-12 to college needs to create strong, challenging, engaging, and fitting environments for the ones referred as "Digital Natives", since the current teacher methods, such as the lecture, do not get enough attention from the students who have difficulties in fitting what they learn in their daily life and instead memorize just enough for the tests and forget about it later (Foreman, 2003).

The students will grow unmotivated and uninterested in classes if they are not engaging enough. There are ways to revert this situation, from a charismatic lecturer who knows how to appeal his audience, to field trips, experiments and other social activities. The introduction of digital game based learning environments is but one of those ways, and while still viewed with some scepticism, investigators have proven so far that the right game for the right situation can affect learning (Eck, 2006).

Two main reasons can be considered as to why games are being implemented in our educational systems, not just in schools and colleges, but corporations, medical institutions, non-profit organizations and the military, with the use of simulations and computer games for their benefits since the 50s and 60s (Wolf, 2008). First of all, the Digital Natives are familiarized with games; they grew up with computers, cell phones, gaming consoles and MP3 players, and they spend more time playing or watching TV than reading (Prensky, 2001b). This recent generation, born between the 80s and 90s, prefers to learn in a team, with technology, experiments, and even entertainment (Raines, 2002).

And the second reason: games can reunite characteristics which captivate students; whatever the player learns inside the game is directly related with the environment, and can be demonstrated and practiced, because it occurs inside the (game's) context, unlike formal instruction examples (Eck, 2006). It is possible to create simulations of real-life situations where the player can test his skills, and introduce a significant and appellative narrative, reinforcing the game's context. And by introducing elements like mystery or uncompleted problems which need to be solved, the player can be driven with curiosity, which motivates him to learn (Malone, 1980).

In the Department of Physical Education and Sport Sciences (DPESS), part of the University of Thessaly and located in Trikala, Greece, Information Technology is a compulsory course taught to all undergraduate students. Its theoretical components consist of: computer typology, basic computer functions, hardware and software types, computer networks, and Internet and data security. However, according to the previous experiences of teaching theoretical concepts from their instructor, Dr. Papastergiou, students "soon get bored and look forward to actually using computers and the Internet". In order to make students acquire more durable learning outcomes

and become more motivated with the course, the instructor is interested in "multimedia electronic environments designed according to basic principles of the constructivist learning theory", such as a game embedding the theoretical component from the course, which could be used as learning and motivation tool, thus exploring the benefit of Digital Game-Based learning in classrooms.

1.2. Investigation questions

For this project, two research questions were brought, and their respective hypotheses in how to answer them:

How can we design a computer game to teach basic computer science concepts to the Physical Education and Sport Science students?

According to the document describing the proposed project, the undergraduate students from the DPESS of the University of Thessaly, in Greece, who have to attend the compulsory course 'Computers', soon become bored with the lectures about theoretical concepts, and are eager to use the computers and Internet. If the students are not intrigued by the lectures, then it's possible they are not learning either.

In order to captivate the students, the game should be interesting enough for them to play it. For example, by including an engaging narrative, such as, for instance, plot of a ancient computer stolen during Olympic Games of 2204 which must be retrieved by the hero, the players may be more attracted to this fantasy/sci-fi setting instead of a typical real life situation, thus turning the educational game experience less of a chore and more of a fun activity (Rosario & Widmeyer, 2009).

But besides the inclusion of a theme and narrative compelling enough, it is also necessary to consider a way of introducing the contents of the course material inside the game, and make the students learn it, and one way to achieve this is by turning the course material into knowledge necessary to progress in the game, meaning the players will need to learn this content and put it in practice if they want to succeed.

In what way can a computer game help the Physical Education and Sport Science students regain motivation to learn basic computer science concepts?

Another problem with the classes was the students' overall motivation. In order for a game to motivate them again, there should be elements encouraging them to learn. Learning basic computer concepts does not need to be a dry and tedious process, and it could be possible to incentive students to be more active during class, by turning the contents of the course more appealing with the use of a game as the medium.

The students should also feel motivated in the first place to try out the game; and this is possible if the game is fun to play, and does not feel like a dull Shavian reversal where only the

bad features from crossing entertainment with education are present (Papert, 1998). The game should provide challenge, display a fantasy theme appealing enough, and leave the players curious and wishing for more as they progress in the game (Malone, 1980). Another form of encouraging players is the use of rewards and achievements, which is common practice in most games, and usually motivates the players to move forward.

1.3. Objectives

The initial objectives proposed for this project are as follows:

- Identify game design elements for a classroom educational game according with the constructivist learning theory;
- Create a game design document, with all elements defined, such as game genre, narrative, commands, challenges and goals;
- Implement a functional computer game prototype;
- Evaluate the game prototype.

The whole finality of this project is to create a playable game prototype “Level 1” that can be integrated as part of the Information Technology course, providing learning opportunities other than the lecture.

The continuation of the game development is a possibility; it may be resumed by the same individuals who started, or new developers, which is why there will be a complete design document to guide them. Most case studies about educational games are either games with a short duration or simple demos, so constructing a game with multiple levels, a coherent walkthrough, appealing graphics and game play, to be played during the entire semester by the students, would be a huge amount of work.

1.4. Methodologies of investigation

The methodology in use is the investigation-action coupled with bibliographic research as one of the data sources. More data was collected from both the game and the individuals who participate in the tests. By the end of this project, the game prototype was evaluated both in the department of Physical Education and Sports Science and the Department of Communication and Art from University of Aveiro.

Given the location where this project is occurring, it was important to get acquainted with the study participants. The participants were the first year undergraduate students from the Department of Physical Education and Sport Science and are part of the “Computers” compulsory course.

The students did not participate directly in the game design and development process, but it could have been helpful to know what they expect from a computer game created specifically for that course. In the beginning, it was known the participants were around 19 years old and have grown up playing video games, one fundamental characteristic from the Digital Natives, and it would be at least interesting to get to know their gaming habits (if they are hardcore or casual gamers), and find out why they become so "bored" with the class, what are their main difficulties (concentration, difficulty in learning, unfamiliar terms, among other difficulties).

During the preliminary tests, the participants were be required to play the game for a determinate period of time, and fill in a questionnaire after it, evaluating the game, which element was more appealing, if it was challenging or not, among other simple classification questions. Along with the students of the Sports Science and Physical education course, a group of volunteer students from the master degree in Communication and Multimedia from the University of Aveiro also tested the game. It will be known if the pedagogy applied to the game was successful, what other elements were noticed by the participants (such as narrative, graphics) and possible technical difficulties found in the game.

1.5. Personal Motivations

The investigator took interest in this project because it was related with fields of interest, such as game design, and this proposal became an opportunity for the investigator to deepen her knowledge about game creation, narratives, character design and construct content for her portfolio to be exposed to game companies.

But, more importantly, the investigator also wished to create something meaningful and of value for education, with the use of games as educational tools in school/college environments.

1.6. Dissertation Structure

Besides the introduction, bibliography and annex, this dissertation also contains four more sections: State of Art; Development of the empirical investigation; Presentation, Analyses and Discussion of Results; and Final Comments.

For the development of this dissertation it was important to research academic material, books and other sources of information, and compile a State of Art with relevant data including a summarized history of video and computer games and the definition of play and game. Research was also executed on the field of learning theories, especially about constructivism, and the digital natives as the current generation of students. Serious games and educational games were also researched, with the inclusion of some case studies.

In the Development of the empirical investigation section, the creation process of the game prototype is described, including the design of the narrative and characters, puzzles implemented,

description of the interface, gameplay and game rules, a walkthrough of the implemented acts and the development tools.

Next, the Presentation, Analyses and Discussion of Results from the tests executed in the Department of Physical Education and Sports Science from the University of Thessaly, and Department of Communication and Art from the University de Aveiro with the statistical data acquired through questionnaires along with comments and reactions from the test subjects.

And finally, the last section where this dissertation is concluded and reviews of the process and results are made.

2. STATE OF ART

Before getting started with the game design document, it was necessary to research what has been done so far in the educational gaming field and what results it had brought so far. It was also fundamental to be acquainted with the different learning theories such as constructivism. And to complement the research, review the gaming history and understand how computer games and video games grew to be one of the most important forms of digital entertainment available in the present.

2.1. Games

When someone says the word “game”, what will the other person relate the term with? Maybe a football game, if the person is interested in sports, maybe cards or board games, or maybe a childish activity. Or a video game or a computer game, if you happen to be one of those Digital Natives. At least one fact is hold in truth; games have always been part of the human nature. (Crawford, 1997).

2.1.1. History of Gaming – An Introduction

> *In 1966, thoughts about playing games using an ordinary TV set began to percolate in my mind. When I designed and built a TV set at Loral in 1955, I had proposed doing just that: Build in a game to differentiate our TV set from the competition. Management said No and that was that.*
>
> - Ralph Baer, (1998)

As Baer described, when he published his book Videogames: In the beginning (2005), he had no idea at the time when he first began scribbling down his idea of being able to play games in a television, that his concept would revolutionize the technology and entertainment world during the following decades. And the culmination of his efforts, the Magnavox Odyssey TV game system, launched in 1972, was the start point for the current videogame industry. But Baer was not the only one exploring the idea of introducing games into well-known electronic appliances, like the television.

In 1958, Willy Higinbotham developed Tennis for Two, a two player game played on a oscilloscope, where they could control the direction and motion of the object moving on the screen (Wolf, 2008), which was a ball, and they could do it with two rackets on each side of the screen. The game was displayed at Brookhaven National Laboratories, and it was later known Higinbotham created it with one curious purpose: to keep visitors from being bored.

Regarding the history of computer games, the introduction of the concept was brought by Alan Turing, said to be the father of modern computer science, in 1950, when he proposed an imitation game in the article Computing Machinery and Intelligence, published in the Mind magazine (Wolf, 2008). In 1961, Steve Russel, at the time a MIT student, created *Spacewars!*, considered to be the first computer game in history (Suciu & Gerardi, 2005) but there were other games developed during the 50 decade, from chess and blackjack games, to the first military simulation games, programmed by researchers in the Rand Air Defence Lab in Santa Monica (Wolf, 2008). The reason why the game *Spacewars!* was often quoted as the first computer game in history might have to do with the popularity it gained over the previous experiments. Proof of such popularity could be found in 1971 in a coffee shop at the Stanford University campus, where Bill Pitts and Hugh Tuck installed the arcade game *Galaxy Game*, a popular hit among students, and considered to be the first commercial game machine in history. But at that time, it was one of a kind, with its production costs around 20,000$[1], and someone else had thought of the same concept: In 1965, during his summer job at a Salt Lake City amusement park, Nolan Bushnell thought about the possibility of transiting the system used to play Spacewars! from the university mainframes into something more compact and usable for commercial purposes[2], and after

[1] Information retrieved 22nd January, 2010, from http://infolab.stanford.edu/pub/voy/museum/galaxy.htm

[2] Early Video Game History, retrieved 22nd January, 2010, from http://www.thedoteaters.com/stage1.php

investing in his idea, two months later after the introduction of *Galaxy Game*, Nutting Associates manufactures Computer Space, with Bushnell overseeing the project, producing 1,500 cabinet units with a futuristic appearance and a 13 inch black and white screen (Herman, Horwitz, Kent, & Miller, 2002). Bushnell would later leave Nutting, and together with Ted Dabney, they start with their own company Atari[3], for the creation of video games.

And the history extends. Most video games dedicated companies created around this period up to the 80s, still survive with tremendous success, like Sony, Sega and Namco. Nintendo gained its name by 1951, but it was first known as Marafuku, a playing cards manufacture company founded in 1889 (Herman et al., 2002). Gamers from the 80s decade can tell about the most popular hits such as *PONG*, *Asteroids*, *Pac-man* and *Tetris*. Today, those games are icons of gaming nostalgia, symbols of an industry which began with the realization of new concepts, and today is strong enough to compete with the music and movies industries.

2.1.2. The Actual Impact of Digital Games

To understand how influential the digital gaming industry is in today's society, it is necessary to look at numbers and realize its growth. As it was mentioned before, it's an industry which nowadays competes directly against music, movies and cinema. One study was released by the ESA in 2007, conducted by Economists Incorporated, comparing financial and sales data from 2002 to 2006 for the entertainment software industry in the USA, which had the real annual growth rate of 17%, compared with the remaining US economy which was below 4% (E.Siwek, 2007, p. 5), the number of establishments with 5 or more employees grew from 432 to 514, between 2002-06 (p. 19); Computer and video game unit sales exceeded 250 million in 2006, a considerable difference compared with 1996, where 74,1 million units were sold (p. 33).

Concerning the gamers' population in the US, a brief recap of essential points from the "Essential Facts" sheets released in 2008 and 2009:

- In 2008, 65% of the American households played computer or video games, increasing to 68% in 2009;
- The average gamer age is 35; 25% of the total game player population is under 18 years old, 49% were between 19-49 years old, and 26% was more than 50 years old;
- 60% of the game players are male, 40% are female, and woman aged 18 or older represent a greater portion of the gamer population than boys aged 17 or younger (34% versus 18%). In online games, 57% players are male, 43% are female;

[3] Company's website: http://www.atari.com/

- The average number of years adult gamers have been playing is 12 (13 according to 2008 studies)
- In 2009, 62% of the gamers played with other gamers in person, compared with 2008 (59%) and 2007 (56%);
- 62% of the parents believe games are a positive part of the children's lives, and when asked about the top reasons for playing video games with their children, the "It's Fun For the Entire Family" was the highest rated one (72% in 2008, 82% in 2009) (ESA, 2008, 2009)

The Interactive Software Federation of Europe (ISFE) did too realize studies around UK, Spain and Finland, not too different from ESA's studies. For instance, 37% of the UK population aged between 16 and 49, describe themselves as active gamers, compared with 28% from Spain and Finland, and the average age ranges between 33 (UK) and 26 years old (Spain) (Nielsen, 2008, p. 5); gamers aged between 16-24 have the heaviest game play activity during a typical week, while gamers aged 30 or more say they play between 6 to 10 hours a week (p. 7). When asked about the reasons for playing video games, 80% claimed it was fun, while 55% identified gaming as a relax/de-stressing activity, 41% play when they are bored, and 36% enjoy game challenges (p. 8). The proportion of gamers versus non gamers in UK, Spain and Finland is relatively 80% versus 20%(p. 19).

2.1.3. What is a game?

There are different perceptions of what is a game. First off, the purpose in this section is not to describe any particular game subtype (videogame, board game, and other types of games) but to search for a concrete definition of game, if there is one. There are various discussions of what can be considered as a game, following proposed models and schemes, like the Magic Circle and the classical game model. And before moving on with the various definitions of game it is equally important to define what play is first, since it is a verb constantly present whenever the subject is related with games.

2.1.4. Definition of play

> *We all play occasionally, and we all know what playing feels like. But when it comes to making theoretical statements about what play is, we fall into silliness.*

- Brian Sutton-Smith, (2001)

Like game, there is no definition of play set in stone. When two lion cubs fight with each other without growling or hurting, it is called “playing”; when a child is building a tower made of LEGO, the child is playing; when two girls pretend their dolls are alive and having a tea party while chatting with each other, the girls are playing; a father and his son throw a ball at each other, they are playing; in a LAN party, two teams dispute for victory inside a first-person shooter game, they are playing.

What do these activities have in common? For starters, they are enjoyable, albeit some activities may be more enjoyable than others, like the LAN party tournaments, where competition is usually fierce among rival teams, but then again the main objective of those parties is, besides winning, to have fun with players alike. And in the case of the lion cubs “fighting”, while it might be questionable if the animals are having fun (which would force us to go for an animal and human comparison, slightly off the context of this chapter), it is certainly known they are mimicking what adult lions do, just like a child will sit at his miniature desk and pretend to write papers, just like his mother.

Catherine Garvey (1990) proposed the following characteristics of play in her publications from the Harvard University Press:

- Play is an enjoyable activity. Even if there is no noticeable presence of joy, it can still be viewed as a positive activity for the player;
- Play has no extrinsic goals; its motivations are intrinsic and serve no objectives. It could be considered as unproductive since it is not an activity aimed for a particular goal.
- Play is spontaneous and voluntary; the player should not be forced to participate
- Play involves some active engagement on the part of the player.

These are acceptable characteristics of play, but there could be possible exceptions. Theoretically speaking, if a player is forced to join an activity, is it still play, or is there another definition? A possible conclusion is that a forced player will not enjoy the activity as much as the remaining players who joined by free will.

2.1.5. Definition of game

Kevin Maroney has presented the simplest definition of game so far: “a game is a form of play with goals and structure” (2001). Indeed, a game needs to have a set of objectives, and an organized structure with rules and guidelines which the players need to follow. The definition of play has been observed as well.

Jesper Juul (2005)collected several descriptions of game from other authors and investigators:

- a free activity standing quite consciously outside "ordinary" life as being "not serious", but at the same time absorbing the player intensely and utterly. It is an activity connected with no material interest, and no profit can be gained by it. It proceeds within its own proper boundaries of time and space according to fixed rules and in orderly manner. *(Huizinga, 1950)*
- At its most elementary level then game can be defined as an exercise of voluntary control systems in which there is an opposition between forces, confined by a procedure and rules in order to produce a disequilibrated outcome. *(Avedon & Sutton-Smith, 1971)*
- (…) is a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome. *(Salen & Zimmerman, 2004)*

A society needs rules in order to maintain harmony and stability, and so does a game, which without rules, will collapse, either because it is too easy, or there is little challenge. When a kid is about to break a *piñata* with a baseball bat, there is one condition he must obey: wear a blindfold. If he did not need to use the blindfold, he would break the *piñata* too soon with little difficulty. Game rules should be seen as part of the challenge, and interaction, whatever is with a person or an object, should be seen as part of the progress to overcome the challenge.

2.1.6. Taxonomy

Constructing a game classification scheme is one complex task, and due to the vast variety of games, ranging from sport games to electronic ones, it may be necessary to break the grand scheme into subcategories. Not only it is necessary to consider game genres, number of players, objectives, set of rules and mediums used for the construction of a detailed game taxonomy, it also needs to be updated frequently.

One of the earliest game classifications was proposed by E. Solomon, dividing games in three categories, based on their function and form:

- *Simulations:* The way the game reflects reality is the main focus of interest;
- *Abstract games:* The point of interest is the game itself;
- *Sports:* Dependent on physical skills. (Solomon, 1984)

Solomon still added other factors should be considered, like the quantity of players involved in the game, and debates the inclusion of the “zero-player games”, where there are no players, only observers, mentioning Conway’s game of Life as one of those “games”. (1984)

New classification schemes have emerged as consequences from the introduction of video games, computer games, new game play elements, demanding for a redefinition of the previous characterizations. This is why Craig Lindley (2003) suggested orthogonal taxonomies to organize game types, so it would be possible to keep design concerns apart, focus on the game genre, game play and narrative, regardless of the medium used, and keep taxonomy where not everything has to fall into a hierarchical system of categories and subcategories, as seen in the Figure 1.

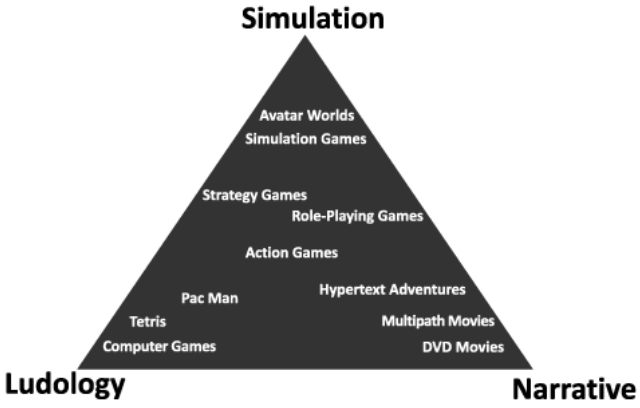


Figure 1: 2-dimensional classification plan, where a particular game or genre is ludic, narrative or simulation-based. (Lindley, 2003)

An initial proposed classification divides the realm between:

- *Ludology:* (the word ludus meaning game in Greek) A discipline that studies games and video games (Frasca, 2003);
- *Simulation:* Representation of the function, operation or features of one process or system by using another (Lindley, 2003);
- *Narrative:* Anything that tells or presents a story, using text, picture, performance, or a combination (Jahn, 2005).

Objects with a strong story element, and little or lack of interactivity would be located as close to the narrative extreme if appropriated. A hypertext adventure would not be as close to such extreme like a DVD movie, because it shares some elements of game play and/or simulation. Computer games like *Tetris*, where there is no story to be unfold, belong to the game play extreme, while objects such as the early avatar worlds belong to the simulation extreme. Other objects mixing either two or three elements would be found close to the borders or in the middle of the scheme.

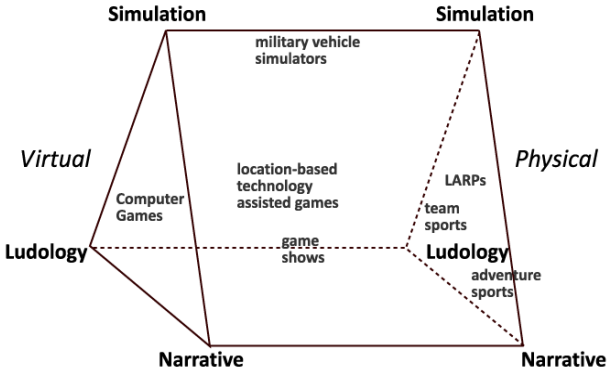


Figure 2: Game classification prism differentiating the virtual from the physical realm. (Lindley, 2003)

While Lindley proposed other variations of this classification model, by adding new extremes (like the gambling element, in order to include games of chance), the final classification - as seen in the Figure 2 - is quite relevant, because it divides the realm between "virtual" and "physical", so it is possible to introduce digital games in the classification. Games dependent on physical skills and presence, like sports, can be found in the right plane, along with LARPs (Live Action Role-Play) and adventure sports, while games which can only be played with computers and consoles are found in the virtual plane. There are game examples which can be found between the two planes, relying on physical presence, mobile devices, augmented reality and GPS. It is safe to affirm most educational and serious games, which rely on technology, locate themselves in the virtual realm.

Another way to place games in categories, especially the digital games, is by sorting them by genre (Table 1). Games from the same genre share similar characteristics, game play style, and even interface schemes. Of course, there are exceptions, where a game can fit inside two genres (the game *Borderlands* is considered to be a mixture of First Player Shooter and Role-Play Game), or be part of a subcategory (J-RPG are Role-play games with game play elements and theme most exclusively Japanese).

Table 1: Known Game Genres and respective descriptions.

Game Genres	Brief Description	Examples
Adventure Games	Games which usually allow the player to assume the role of the protagonist, and explore the environment, advancing in both game and story plot.	*Prince of Persia, Mirror's Edge*
First Person Shooter	The player experiences the game as seeing through the eyes of the protagonist. Usually these games involve weapons and competition. There may or not exist a story plot to follow.	*Counter-Strike, Modern Warfare 2*

Role-Play Games	It is a genre heavily centred in a narrative. The player is the hero, and may have a party with him, controlling all characters.	*Final Fantasy, Dragon Age, Bioshock*
Racing Games	The central theme is racing, whatever is by using cars or another vehicular.	*Trackmania, Need for Speed*
Strategy Games	Games which require planning and managements of resources. Skilful thinking and use of tactics is fundamental to succeed.	*Civilization IV, Dawn of War*
Sport Games	Usually these games portrait real-life sports where the player can take control of his favourite sports team. They are mostly realistic.	*FIFA Games, Maiden*
Simulation Games	These games are about simulation and management of events, activities, places or people.	*The Sims, Age of Empires, Sim City*

2.2. Learning Theories

2.2.1. Behaviourism

> *Loosely speaking, behaviourism is an attitude. Strictly speaking, behaviourism is a doctrine.*
>
> - George Graham (2000)

Behaviourism is a worldview that assumes a learner is essentially passive, responding to environmental stimuli [4] and whose behaviour will be shaped by either reinforcement or punishment, both positive and negative.

Learning is achieved when the change of behaviour occurs, affected by certain conditions. There are two known types of conditioning: Classical conditioning, which is a reflexive or automatic type of learning in which a stimulus acquires the capacity to evoke a response that was originally evoked by another stimulus [5], where an example of this would be the experiments done with Pavlov's dogs; and operant conditioning, a form of learning in which voluntary acts become either more or less probable, depending on the consequences they produce (Shaffer, 2000), easily explained with the experiment where the like hood of a mouse using a push lever is increased if it is rewarded with food, or decreased if it receives an electric shock.

[4] Retrieved 6th January, 2010, from http://www.learning-theories.com/behaviorism.html#more-21

[5] Retrieved 6th January, 2010, from http://www.learning-theories.com/classical-conditioning-pavlov.html

There were different figures present in the development and explanation of behaviourism, starting with John B. Watson, considered to be the father of behaviourism, and known for his studies with children. He described the child as a tabula rasa, with no inborn tendencies, whose turn out depends on their rearing environments and the ways in which their parents and other significant people in their lives treat them (Shaffer, 2000).

2.2.2. Cognitivism

Figures like Boyd H. Bode were concerned with the principles set by behaviourism, the learning process based on behaviour change. The focus of behaviourism was on stimulus and response, on habit formation, rather than on development and exercise of intelligence (Toews, 1996), and Bode, with his publication Conflicting Psychologies of Learning, criticized the behaviourists' antipathy towards mind, soul and consciousness (1985). Thus, the cognitive psychology emerged during the late 1950s due to lack of explanations from behaviourists for the human cognition (Vosniadou, 1996)

Ditching the animal and human behaviour comparison apart studied by the behaviorists, the human learning process is investigated apart (especially by Gestalt psychologists), and later on, Albert Bandura classifies humans as cognitive beings who are capable of thinking about the relationships between their behaviour and its consequences (Shaffer, 2000). Bandura and Richard H.Walters wrote *"Social Learning and Personality Development"* in 1963, in order to expand the social learning theory already devised by Miller and Dollard in 1941, a theory which rejected behaviourism, but was considered incomplete and failed to understand "the creation of novel responses or the processes of delayed and non-reinforced imitations"(Pajares, 2002).

According to Bandura, the one psychologist who specialized in the social cognitive theory and self-efficacy, cognitive processes *"are emergent brain activities that exert determinative influence"* (2001, p. 4). Furthermore, there are three important aspects within the social cognitive theory, being the development of competencies through mastery modelling, reinforcement of people's trust in their own capacities in order to improve themselves, and self-motivation (Bandura, 1988).

Vosniadou (1996, p. 97) claims the cognitive revolution took place thanks to the invention of the computer, which provided the basis for the analogy of the human mind as a computer program, in other words, *"the mind is an active and constructive manipulator of symbols that interprets stimulus information"*.

2.2.3. Constructivism

Jean Piaget, recognized figure in psychology for his research on knowledge formation and children's logic and modes of thinking[6], is quoted for being the pioneer behind the constructivist learning theory. For Piaget, knowledge is not information that is simply delivered to be encoded and memorized, it is experience acquired by interacting with the world, people and things (Ackermann, 2001). This is the basis of constructivism, where learning is an active process of constructing knowledge, and instruction is a process of supporting that construction rather than communicate knowledge (Cunningham & Duffy, 1996).

Martin Dougiamas, starter of the open source course management system *Moodle*, wrote an extensive essay over constructivism as a result of his studies about the matter, due to its importance on his *"day-to-day practices and research in communication, teaching and learning"* (1998), and introduced several "faces of constructivism":

- *Trivial Constructivism*: It is the root of all other variants of constructivism, also known as personal constructivism (Glasersfeld, 1990), the principle installed by Piaget of knowledge being a constructive process;
- *Radical Constructivism*: Knowledge is seen as a dynamic process, and the individual can construct his own "reality" and different interpretations;
- *Social Constructivism*: Individuals learn by interacting with others, participating in social activities and discussions;
- *Cultural Constructivism*: The knowledge process can be influenced by cultural elements, such as customs, religion and language;
- *Critical Constructivism*: can be seen as *"a framework using the critical theory of Jurgen Habermas to help make potentially disempowering cultural myths more visible"*, supported by conversation, questioning, and critical self-reflections;
- *Constructionism*: it *"asserts constructivism occurs especially well when the learner is engaged in constructing something (…)"* (Dougiamas, 1998). This particular subject is best explored by Seymour Papert, who also compares it with Instructionism (1980).

Seems cognitive constructivism (individual) and social constructivism are the two schools of theory which are more explored among the remaining ones mentioned by Dougiamas. Still, as a whole, constructivism is a philosophy of learning which has a growing impact on the way education is being conducted (Greening, 2000).

[6] Retrieved 21st October, 2009, from http://www.piaget.org/aboutPiaget.html

2.2.4. Constructivism in Education and Games

It is known the metaphors used in cognitivism would not be possible without the presence of computers (Bandura, 2001), and constructivism has a strong presence within computer science education, necessary for more effective educational changes inside classrooms (Greening, 2000). If the premise of a constructivist pedagogy for the student, is to engage in activities and contact with the environment in order to construct his own views over the world, rather than just listen and memorize *"the correct view of reality"* (Jonassen, Davidson, Collins, Campbell, & Haag, 1995), then this learning theory could be easily implemented inside a game, since (most) games show characteristics of being constructive experiences: the play interacts with the world and learns with his experience in game. Even if it is a type of game the player is not familiar with, by playing several times, and repeating the same experience (for example, beating the time score in a car race), the player's performance improves. In a multiplayer game, chances are the player will find other comrades with more experience with who he can exchange knowledge.

In order to create a game which truly reflects the constructivist concept, it may have to follow some guidelines during its design process. In his argument over learning conditions of video games versus school environments and reviews of what he considers to be good game examples for the expansion of cognitive development theories, Gee (2003) introduced a set of guidelines to be considered when using games in educational environments. From the same set, Bonk and Dennen (2005) selected about ten guidelines during their review over methodologies used in Massive Multiplayer Online Gaming (MMOG). Later, those same guidelines were retrieved by Rosario and Widmeyer (2009), who revised them to better fit the conception of a constructivist learning environment, and used them as a basis for their research in MMOGs and if they supported all the established principles:

Probing Principle: The Learner should be encouraged to fund his own hypothesis, put them in action and test what works and what does not work. This is common in role-play games where, for example, a wizard character has access to different spells and elements, such as fire, water and earth, but can only invest a limited amount of points in those skills, and monsters in the dungeons have different properties and weaknesses. If his selection of spells does not help in survive in a certain dungeon, he has to reset the skills, choose new ones, and try again;

Distributed Principle: Learners should be able to interact and share knowledge with others. And the experience gained by interacting and exploring inside one game, can be reutilized in other games. Rosario and Widmeyer provide the best example of a player who learns how to identify sources of nutrition in a game, and how his experience will carry on to other games. Usually an individual, who has played a first player shooter for a long time, will have little to no difficulty in emerging in a new FPS, unlike a newbie player who never played one;

Multiple Routes Principle: Learners should be given access to different progression routes, and be faced with choices. Clearly, this is one characteristic predominant in most MMOGs, and it may or not be present in other game genres. When it is used the expression of a game "*on rails*", it

means the game contains a linear path, and lacks alternative routes or choices. While this principle keeps games more interesting since players are granted more freedom in what they want to do, it may not be the easiest to implement, especially for the smaller games;

Practice Principle: Learners should be able to practice as much as they want. Fighting games, for example, introduce a practice mode, where the player can customize everything, and practice complex attacks towards an immobile opponent, without consequences. Depending on the player's preferences for training, he can also adjust the opponents' settings to dodge only or fight back;

Psychosocial Moratorium Principle: Unlike real life, learners should be able to take risks in artificial environments. This is why simulations are so valuable in the military;

Regime of Competence Principle: It should be invested in challenge; learners should be motivated to go beyond their comfort zone;

Self-Knowledge Principle: Learners should learn about themselves and be conscious of what they are capable to do. This involves having to take decisions and make choices depending on not only his experience, but external factors;

Collective Knowledge Principle: Learners should be able to share knowledge with other learners. If not in game, then by recording their findings and solutions in forums or knowledge base. With the crescent popularity of the wikis, almost every game has one dedicated to it;

Engaging Principle: The game should be attractive enough for the learners to engage in it, with elements such as the theme and plot story (if there is one). Rosario and Widmeyer consider this element important for educational games, so it does not seem too much like a chore for students;

User Interface Ease of Use Principle: The interface should be intuitive, consistent and easy to navigate. Furthermore, the interface between games of the same genre tend to follow an homogenized pattern with only slight modifications (In FPSs, there is always an health bar, or numbers indicating current HP);

On Demand and Just-in-time tutorial Principle: The very first mission of a player ingame is usually a tutorial, where he learns the basics. There should also be tutorials for the remaining aspects of the game, like chatting, or setting up a store, and those tutorials should provide feedback for the player's actions;

Achievement Principle: Learners should be rewarded for the progress in the game, as a form of encouragement. The achievement could be anything, like unlocking abilities upon advancing to a new level, or receive a reward upon completing a mission. In the digital distribution and gaming platform Steam, certain games have a list of achievements for the player to attain, and display on their profiles, and in Valve's game *Team Fortress 2*, the player can gain new weapons once he achieves a milestone of achievements.

While these principles are meant to be applied in large scale gaming environments shared by various players at the same time, some of them can also be applied in the creation of simpler, one-player games. Then again, this is what constructivism in games is about: a combination of concepts from different realms inside one game, dependent on imagination, inspiration, vision and other creative acts (Tschang & Szcypula, 2006).

Another different approach from the constructivist ones has also been studied: there those who approached games with instructional concepts, and basically let the computers do the instruction, and teach the students (Papert, 1980), but the concept does not play well if the objective is turning difficult ideas in something easy and fun for students (Kafai, 2006). Certainly there would be need to have a source of instruction inside a game, but the experience is more rewarding and the learning process is more efficient if the learner acquires the "instruction" by exploring and trying.

2.3. The Digital Natives/ Net Generation / Millennials

Many observe this generation with great interest, for reasons which will be clarified soon. Different names have been given to them: Claire Raines calls them the "Millennials", born between 1980 and 2000, claiming they are charged with potential (2002); Marc Prensky preferred the term "Digital Natives", native speakers of the digital language of computers, video games and Internet (2001b) and he claims to be the one who claimed such term in 2001, according to his article "Listen to the Natives"(2005) .

There are important factors distinguishing the Digital Natives from the previous generations. While for previous generations, technology artefacts such as the computer and the cell phone are viewed with different interpretations, depending on their functionality, for the Digital Natives, Internet, computers, cell phones and other multimedia devices have been part of their lives (Figure 3). Or, to quote from the introduction from the studies of the Kaiser Family Foundation "Generation M2": *"… media are among the most powerful forces in young people's lives today."* (Rideout et al., 2010, p. 1)

Among all 8- to 18-year-olds, average amount of time spent with each medium in a typical day:			
	2009	**2004**	**1999**
TV content	4:29[a]	3:51[b]	3:47[b]
Music/audio	2:31[a]	1:44[b]	1:48[b]
Computer	1:29[a]	1:02[b]	:27[c]
Video games	1:13[a]	:49[b]	:26[c]
Print	:38[a]	:43[ab]	:43[b]
Movies	:25[a]	:25[ab]	:18[b]
TOTAL MEDIA EXPOSURE	10:45[a]	8:33[b]	7:29[c]
Multitasking proportion	29%[a]	26%[a]	16%[b]
TOTAL MEDIA USE	7:38[a]	6:21[b]	6:19[b]

Figure 3: Average amount of time spent with each medium, from 1999 to 2009 (Rideout, Foehr, & Roberts, 2010)

The "Generation M2" study exposes just how deep this connection between teens and technology goes: the average amount of time spend consuming media has increased from 7h29m in 1999, to 10h45m in 2009, due to the expansion of mobile technology and online media (p. 2). The ownership of media devices increased drastically from 2004 to 2009; if in 2004, 18% of the teens owned a MP3 player, 33% had a cell phone, and 12% had their own laptop, today (2009/10), 76% have a MP3 player, 66% have a cell phone, and 29% own a laptop (p. 3), and Internet access at their homes increased from 47% in 1999 to 84% in 2009 (p. 4). A similar study brought by Fuse Youth Marketing Agency gathered media preferences and usages from teens, where 45% classify themselves as heavy users of Internet, 32% of TV, and 29% of video games[7]. At this point, it could be questionable what kind of impact technology has over today's youth, as this is not just about consuming, but also about shaping new mentalities, habits, behaviours and learning methods.

Raines (2002) described the Millennials as "*sociable, optimistic, talented, well-educated, collaborative, open-minded, influential, and achievement-oriented*", positive characteristics for a generation constantly "plugged in". Prensky (2001b, p. 5) claims Digital Natives are "*accustomed to the twitch-speed, multitasking, random-access, graphics-first, active, connected, fun, fantasy, quick-payoff world of their video games, MTV and Internet*", and judging by the amount each native spends consuming media, it seems right. And Prensky uses these characteristics to support his claims that the overall educational system is no longer fitting for today's students (2001b, p. 1), and it is easy to see why: someone who is used to "twitch-speed" environments is subject to difficulties when trying to attend a ninety minute lecture.

Thanks to the Digital Natives the educators are now willing to test new alternative methods. But the youngest millennial generations are not the only ones to blame: there are members from the previous Gen-X and Baby Boomer generations who despite having different expectations, may also be part of that college class which usually consisted of 18-19 year old students, and there are

[7] Retrieved 20th January, 2010, from http://www.fusemarketing.com/Youth_Research

more students over the age of 25 (D. Oblinger, 2003). This means there are more students, who have a family to take care of, and have a job at the same time, yet they are willing to advance their academic education, and the system needs to open alternatives for them. And if they are willing to accept the new technologies in a similar of the Digital Natives, they may be called of Digital Immigrants.

It was important to study the digital natives for this project's context in order to best understand what the current generation is used to and why it became necessary to introduce new teaching techniques in the classrooms. It would be wrong to identify the real target audience, the physical education and sport science students, as digital natives when there are many factors that difference them from the generalized aspects of a millennial: The Greek educational system, habits, culture, their passion for sports. And as the research progresses the definition of digital native is always updated, and like any other generation, this one has its positive aspects and negative aspects.

Even Prensky (2009), nine years after his initial article, reviewed his own definition of digital natives, and suggest the distinction between them and the digital immigrants is becoming less relevant and new distinctions are necessary.

2.4. Games in education

> *Games serve many functions such as tutoring, amusing, helping to explore new skills, promoting self-esteem, practicing existing skills, drilling existing skills, automatizing, or seeking to change an attitude.*

- John V. Dempsey (1994)

The use of games as not just entertainment objects, but as educational tools, is not something new, and the concept is being explored. Teachers who are willing to try alternative teaching methods have the introduction of games inside a classroom as a viable option. Such is the case of a teacher in Minneapolis who brought TVs and video games to his eighth grade class to manage to get their attention, and make them study the stories inside the games, even making them pause the game to take notes (DeRusha, 2006). The case gained media coverage in 2006 for exposing a different type of a familiar environment: the classroom with children sitting orderly in their desks, listening to the teacher.

Games can be great teachers as the studies have proven. For example, Douglas and Ronald Gentile (2008) conducted a research about violent video games and the principles used to teach players how to master a selection of skills. But can any game be turned into a possible teacher? No, it has to meet requirement first, and be somehow affiliated with the course being taught. It should also be questioned the reason behind the introduction of games in classrooms (and other learning environments as well).

2.4.1. Informal or Formal learning/education/environment

> *Learning is what enables people to participate successfully in life and work. It is a knowledge-age survival skill.*
>
> - Jay Cross (2006)

Learning is a process permanently active inside our brains, whatever the individual is aware of it or not. From childhood to elderly, the human beings learns something new every day, whatever is at school, or at work, with his family friends, neighbours, intentionally or by accident. And not all learning is the same, meaning the learning process in a workplace will be different from the break room.

The distinctions between formal and informal learning were first developed in the 1950s, according to Marcia Conner, who also identified four types of learning: formal and informal, intentional and accidental. (1997) Intentional learning occurs when the individual is determinate in learning something, and goes search or ask about it, while accidental learning happens when the individual learns something that was not intended. The differences between formal and informal learning, however, are strong enough to start debates about learning processes.

Formal learning includes the hierarchically structured school system (Conner, 1997), from schools to colleges, to training programs invested by corporations. Characteristics include a learning framework; organized learning event or package; the presence of a teacher or trainer; awards of a qualification or credit; and the external specification of outcomes (Eraut, 2000). In school and college environments, each class has a unique list of contents to be taught to the students within a limited period of time, using accepted and available methods, and the students' knowledge is tested with exams and project assignments, to determinate if he/she has learnt all or enough of the proposed contents. The student must achieve an acceptable qualification or quantity of credits in order to advance to the next level in school. In corporations, it may be required for employees to join training programs in order to acquire required skills essential for their jobs. These programs differ slightly from school or college classes, as they may be mandatory or optional, and the individuals may or not be evaluated by the end. With the new technologies, it is possible to have lessons taught with e-learning tools, with its advantages and disadvantages.

Informal learning, as expected, is much unlike formal learning. Basically, it is all the learning that occurs outside of classes and training programs; it is knowledge coming from other sources than teachers and instructors; a lifelong process from which individuals acquire attitudes, values, skills and knowledge from daily experience and the educational influences and resources in his or her environment (Conner, 1997); it is the unofficial, unscheduled, impromptu way most people learn to do their jobs (Cross, 2006). Where formal learning would take the classroom as its prime environment for granted, informal learning is present in the halls, break rooms, and even in pubs,

taking Frank Coffield's testimony as an example, *"It is only a slight exaggeration to say that during my years at Glasgow University I learned more in beer bars than I did in lecture halls..."*(2000, p. 2)

How is informal and informal learning related with games? While the classroom is considered to be a formal environment, games are considered to be informal environments. And given the outcomes from informal learning are argued to be superior to those from formal learning (Conner, 1997; Cross, 2006), this constitutes a reason to explore the introduction of games in educational environments, even inside postgraduate medical education, where informal learning strategies have been considered in order to help medical apprentices develop inside his community (Swanwick, 2005)

2.4.2. Digital Game Based Learning

It may be possible that the introduction of such thing as a game inside a stereotypical formal and serious environment like a classroom where lectures are the predominant teaching method would not even be considered if it was not for this generation who spend its time playing games, and will find such lectures "boring".

Digital game-based learning (shortened to DGBL) is an approach, according to which, where educational content and principles are introduced intro video games or computer games, and its purpose is to engage learners, and can be used in almost all subjects and skills levels (Coffey, 2009). It combines the need of educating the individuals at the same time it keeps them motivated enough. However, it would be unwise to say that any game can be used as an educational and/or motivation tool, as it would also be wrong to say that only edutainment products should to be considered for this approach. To quote Van Eck (2006, p. 18), *"Games are effective not because of what they are, but because of what they embody and what learners are doing as they play a game."* He also introduces us to three different approaches of implementing DGBL adopted by educators:

Have the students build their own games, an approach similar to the method used by programmers during the 50s-60s decades, who created computer games as a way of teaching themselves programming language (Wolf, 2008), and it is still widely popular among online game development communities;

Have the educators and/or developers build educational games from scratch to teach students, it has the advantage of creating a game specifically for a particular course, and requires an investigation in order to identify problems, and how can a game help in their solution; it may be a complicated process if educators do not have the minimum requirements to create a game (programming language knowledge), but there is a wide variety of game creation and open source tools for them to use, and online communities ready to help;

Reuse COTS games in classrooms for educational purposes. It may be a difficult experiment with video games, but various game studies release modification tools for computer games, allowing users to create their own levels and edit game content.

2.4.3. Serious Games

Long before video games and other gaming electronic gadgets became part of the mainstream entertainment and our daily lives, Clark Abt published a book, *"Serious Games"*, where he discussed about a certain type of games with specific purposes besides entertainment; to start with, he defined a game as "*an activity among two or more independent decision-makers seeking to achieve their objectives in some limiting context*" (p.6), among other characterizations, and defined serious games as activities with "*an explicitly and carefully thought-out educational purpose and are not intended to be played primarily for amusement*." (1987, p. 9)

In the publication From Visual Simulation to Virtual Reality to Games, Michael Zyda (Abt, 1987; 2005) made a new approach to serious games, formally defining them as "a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives" . This approach is not too different from Abt's, but it adds the computer element to the definition, and provides other purposes besides education. Zyda also distinguished serious games for the introduction of pedagogy in the combination of "story, art and software" that make up a video game, in order to *"infuse instruction into the game play experience"*. One example presented is of the game *America's Army*, considered to be one of the best communication tools every produced by the U.S. Army[8], since it is used for recruiting and training.

Because serious games can be used for multiple purposes in education, military, health institutions, and even for production and advertising, and due to common misconceptions of what a serious game is, Ben Sawyer and Peter Smith (2008) presented a complex serious games' taxonomy (Table 2) in order to provide a snapshot for the current state of this particular industry, and eliminate myths about it.

[8] Retrieved 8th January, 2010, from http://www.americasarmy.com/aa/about/makingof.php

Table 2: Serious Games Taxonomy (Sawyer & Smith, 2008)

	Games for Health	Advergames	Games for Training	Games for Education	Games for Science and Research	Production	Games as Work
Government & NGO	Public Health Education & Mass Casualty Response	Political Games	Employee Training	Inform Public	Data Collection/Planning	Strategic & Policy Planning	Public Diplomacy, Opinion Research
Defence	Re-habilitation & Wellness	Recruitment & Propaganda	Soldier/Support Training	School House Education	Wargames/ planning	War planning & Weapon Research	Command & Control
Healthcare	Cyber-therapy/ Exergaming	Public Health Policy & Social Awareness Campaigns	Training Games for Health Professionals	Games for Patient Education and Disease Management	Visualization & Epidemiology	Biotech manufacturing & design	Public Health Response Planning & Logistics
Marketing & Communic.	Advertising Treatment	Advertising, marketing with games, product placement	Product Use	Product Information	Opinion Research	Machinima	Opinion Research
Education	Inform about diseases/ risks	Social Issue Games	Train teachers/ train workforce skills	Learning	Computer Science & Recruitment	P2P Learning	Teaching Distance Learning
Corporate	Employee Health Information & Wellness	Customer Education & Awareness	Employee Training	Continuing Education & Certification	Advertising/ Visualization	Strategic Planning	Command & Control
Industry	Occupational Safety	Sales & Recruitment	Employee Training	Workforce Education	Process Optimization Simulation	Nano/Bio-tech Design	Command & Control

2.4.4. Educational Games

Following the taxonomy studied before, games for education can find a place within the serious games classification table. The concept is the same; the purpose is to teach or test skills, and educational gaming is often associated with schools and colleges.

Earliest examples of educational games inside classrooms (with no digital supports) involved simulation of near real life experiences, role-play performances where students assume social roles, activities where cooperation, bargain and compromise are strong features, and the teacher assumes the role of a coordinator or consultant (Pasricha, 1963, p. 284). And during the 70s decade, digital educational games were already being distributed commercially: In 1971, Don Rawitsch, Bill Heinemann and Paul Dillenberger created *The Oregon Trail*, which was produced by MECC in 1974[9]. In this game, the player conducts a family and its wagon across the old migration routes towards the Oregon territories, during the 1840s. Not only it was a simulation and management game, where the player had to deal with the available resources, and obstacles such as famine, diseases, weather, and fording rivers, he was also able to visit historical sites and contact with different cultures. The game started as a non-profit project, but it was such a popular hit among students and schools, that in 1984, MECC began selling the game to fund their educational efforts in Minnesota (Coventry, 1997). The game is not immune to criticism and accusations of being *"culturally insensitive"* (Bigelow, 1997), but even gamers who studied during the 70s-80s decade still recognize *The Oregon Trail* as a classic, and it is not difficult to find Apple II emulators and old digital copies of the game by doing a research on the Internet.

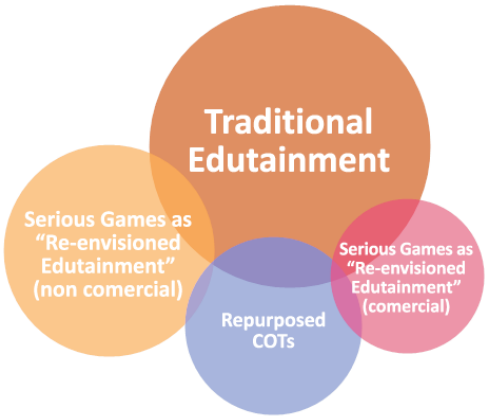


Figure 4: Games for Education Taxonomy (Sawyer & Smith, 2008)

Like other serious games from different categories, educational games can be either commercial or non-commercial, or COTS (Commercial Off-The-Self) reused for educational purposes, sometimes modified by the instructors (Figure 4). They can also be classified as Edutainment, the crossing between entertainment and education, although games marketed as "so fun you will not even notice you are learning" do not usually have a good reputation (Papert, 1998)

[9] Retrieved 27th January, 2010, from http://ldt.stanford.edu/ldt1999/Students/kemery/esc/otMainFrame.htm

2.4.5. Designing Educational Games

Seymour Papert (1998) once explained the main problem with edutainment games, was that most of them turned out to be *Shavian Reversals*: what educators wanted was something that could merge the good qualities from games and education, but ended with the opposite, a game which either is not fun to play, or does not provide enough challenge, or learning with it is not any better than assisting a lecture. This happens because there is lack of information on both educators and developers sides.

The same way there are constructivist guidelines to follow during the game design, there are also basic game design rules. And Malone (1980) outlined three important elements which can make an educational game successful, entertainment, and with effective learning outcomes:

Challenge: The player should feel challenged and pursued to go through the game until the end. One aspect Papert criticized in those edutainment games was the lack of challenge. The game should not too difficult, but it should not be easy either.

Fantasy: The learner may prefer to be engaged in a fantastic, but not absurd environment instead of a realistic one. Whatever theme is being used in the game, if the learners feel like he has an important task to do inside the game, he will be more motivated. The narrative plays an important part, and can be spiced up with drama, humour or suspense, to make the game more interesting. A good example is *Portal*, which is recalled not just for its unique game play, but its story of a girl locked inside a facility, with nobody else around besides the AI monitoring her progress.

Curiosity: What is behind the door, what is inside the box, the learner should question the environment and be driven with curiosity, since it is the key to keep him exploring, in search of answers. Players will want to finish a level because they want to see what their reward is, or what the outcome of the plot story is.

3. EMPIRICAL RESEARCH DEVELOPMENT

To create a game which is supposed, once completed, to be used through an entire school semester during several years; it takes at least one year to make it vast, complex and well defined. And while it was only possible to create a prototype with a pair of simple puzzles, there are elements already defined for the eventual expansion of the game such as the narrative and interface.

3.1. Research Methodology

As it was dictated in the first chapter, the investigation-action approach was the methodology chosen for this project along with the bibliographic research already executed and previously presented. To better understand the problematic behind this project and best execute it, the research and development of the game prototype to be used in the investigation took place in the Department of Physical Education and Sports Science of the University of Thessaly in Greece, where the 'Information Technology' course is taught to the undergraduate students. In the Department, it was possible to discuss project details with the course instructor, construct the game design document which would be used as the basis for the game prototype, and also integrate puzzles especially developed by the instructors with accordance to the course curriculum.

3.1.1. The Course

'Information Technology (Computers)' is a compulsory computers course for the undergraduate students from the Department of Physical Education and Sport Science of the University of Thessaly, Greece. It is taught two hours weekly during the first semester.

In the Computers' course, students acquire ICT knowledge and improve skills involved with the use of computers, office applications and Internet. The theoretical segment of the course comprises topics about: computer types; basic computer functions; hardware of a personal computer; software types; computer networks; the Internet; Internet connection types, the Web services; the email service; computer viruses and network security. The department is well equipped with several classrooms with computers available for the students, including a computer laboratory where the computer course classes take place.

During the semester, the students are required to work on three individual assignments and pass two examinations in order to pass the course. The assignments are prepared outside course hours and the examinations consist of multiple-choice questions about ICT concepts and of various tasks (e.g. word processing tasks, file management tasks, information search tasks, among others.) that students have to perform on the computers.

3.1.2. Game Design Document

Game developers cannot stress enough the importance of constructing a game design document before getting started with the actual game development. The Game Design Document is, as Roger Pedersen (2009, p. 295)described it, the *"designer's entire vision spelled out in detail"* where the game's elements are defined such as the game type, genre, the target audience, the game's purpose and objectives, the presence (or lack) of a narrative, interface, menus, and many other details which once recorded, can be consulted during the development. Game design documents are unique, different for every game and different for every team (Schell, 2008), and for this reason there is no predefined template in existence, no "magic formula". However, it is possible to find templates created by developers in web portals dedicated to gaming such as

Gamesutra, and select the one which is more fitting for a project, or the developer as the choice of designing its own document with the required elements.

The game design document is meant to be followed by programmers, artists, audio specialists and game testers (Pedersen, 2009). If, for example, a new feature is added to the game, it has to be described in the game design document. It can also be improved before proceeding with the project's continuation after the evaluation tests. This chapter can be considered as part of the game design document, where it is explained how the current narrative, characters, interface and gameplay came to be.

3.2. Conceptualization of the Game

3.2.1. Narrative

With the game having a strong text component due to the present knowledge base and computer science basics theory, the same mechanism used to transmit such text snippets is also used for narrative purposes and dialog progress between characters and object interaction.

A good narrative is essential to make this game more appealing to the students who will play it. First of all, once the game is finished it is supposed to be integrated during a full semester course and used as part of tools for learning, which means the game might become a compulsory activity for all students if the instructor wishes so. But play, according to Huizinga (1955) is free, it is a volunteer act. Turning this game into a mandatory activity goes against this definition of play and may result in a not so satisfactory activity, so it is important to introduce elements which will captivate the students and make them play the game, regardless if it is compulsory or not. Second, with the narrative comes the element of fantasy which once related with the course material enables players to invoke *"analogies between their existent knowledge about the fantasy world and the unfamiliar things they are learning"* (Malone, 1980, p. 164). Also, the presence of a narrative can create a supportive context for necessary interpretation and order inside the game (Nitsche, 2008) and make sense of the elements and puzzles, related with both the story plot and the course material to be taught.

At the same time the players are acquiring computer science basics knowledge, they are also following a storyline structured with a beginning, development and a conclusion at the end of the final puzzle. Such narrative needs to make sense and invoke enough curiosity to move on to the next chapter.

The initial story written down described a theft occurred during the Olympic Games of Athens set in 200 years in the future: an ancient computer (the equivalent of nowadays recent models) was stolen from the Museum of Technology and it was up to the protagonist and his sidekick robot to investigate the incident. Being the game composed by several chapters, the player could retrieve the stolen computer pieces as rewards for completing each level (PC box, keyboard,

motherboard, GPU, and other components). As the player advanced in the game and connected the computer parts, he would also learn the reasons behind the artefact's theft: the computer contained a special program used in the Olympics for anti-doping testing and no other advanced program ever managed to obtain the same accuracy as the 200 year old program, only run in that precise computer.

The narrative changed when it became necessary to implement the puzzle collection developed by the instructor. Due to the nature of such puzzles it was no longer possible to follow the same scheme of chapter division proposed before. The setting continued to be the Olympic Games but without the computer theft incident. Instead, the player finds himself amidst the chaos caused by disturbances on the technology present in the Olympic Stadium and ITC rooms which turn to be caused by a sentient computer virus. A description of past events makes the plot setting sound more believable to the player and explains the presence of outdated and still functional equipment mixed with advanced technology in the scenarios. With this story development it is possible to justify the presence of old computers with which the player can interact with, since it is necessary to introduce elements in a futuristic setting that can be related with the current present technology.

3.2.2. Characters

Most characters' background is only revealed with enough interaction during the game, and there may be information present here that will not be told inside the game (like the line of production of the OGTOURISM-02 robots). Yet, writing these story elements about each character was important to establish personality traits made evident during the dialogs and in the case of the protagonist, introduce a realistic character as a sport sciences student with who the players can identify themselves with.

The "Hero"

Figure 5: The "Hero"

At the time of the prototype, the main protagonist remained unnamed and simply nicknamed as "Hero" in the dialog boxes. No name was given because there was the possibility for the players to choose how to name their character which has yet to be implemented. There was also the possibility of choosing between a male or female protagonist, but for the prototype's dialogs only the male protagonist was considered. On another note, it is not possible to see the main character directly during the game because of the first person perspective, but there is the possibility of including artwork of the character during cut scenes so the player can see how he is like.

Aside of the genre, the protagonist is a sports science student (Figure 5). This detail was established since the initial concept as another element the students could identify themselves with, supposedly making it easier for them to "immerse" inside the game. Presenting the male/female character option and custom name would help this simulation where the player is the character. The protagonist is also a volunteer for the Olympic Games, another detail explaining his involvement with the events happening in game.

In the initial concept, the character was made aware of the computer theft in the beginning of the game and set off to search for its lost parts based on clues, driven by curiosity of the computer's contents and reasons to be stolen. With the new storyline the character participates in several tasks related with computer science basics and helps staff members with the equipment during the Olympic Games, but eventually he also enters in the investigation of the consistent system crashes and glitches.

The Robot

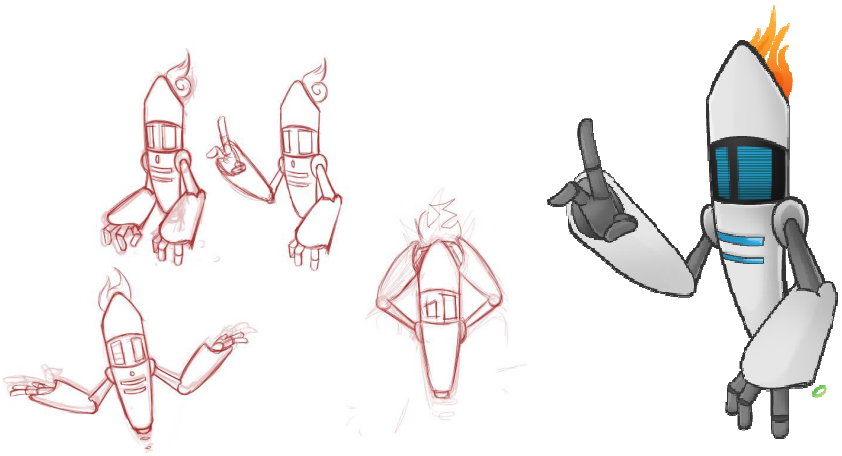


Figure 6: The Robot

Unlike the protagonist, there are no plans to allow the player to edit the robot's name. A new name/nickname may be arranged in the future versions of the game and only his series code number is known so far. There are more robots in this storyline setting and it may be possible to interact with other robots later in the story.

The protagonist's sidekick is part of the OGTOURISM-02 series prototypes, which are being tested in Athens as tourist guides for the Olympic Games. The first batch of robots was tested with success during the previous Olympic Games, and a second batch of 100 robots with several improvements was "released" around Athens. How the protagonist ended up with the robot following him is unknown and irrelevant.

An operating system with various software is uploaded to the OGTOURISM-02 series to be used to construct their knowledge and personality. Initially, the uploaded content (consisting of: Greece and Athens History; City maps; Monuments Curiosities) was supposed to be useful during the protagonist's exploration of Athens. Since the characters now barely leave the Olympic facilities, this content does not come in much use during the game.

All robots' personalities are designed to be as polite, helpful and friendly as possible. They also follow certain protocols and cannot allow tourists to enter forbidden areas. In the previous game concept, the player had to trigger a game with the robot in order to advance in the game and enter the forbidden zones.

The OGTOURISM-02 and the previous series were designed to look like Olympic torches with a holographic image simulating the flame (Figure 6). Those robots have a body where most of their sensors are located, and two arms with three grip fingers each. They move by levitation, can pick up small objects, and they are able to identify locations and some objects.

The purpose of the robot who accompanies the protagonist is to help him in different situations and provide an explanation when presented with an item or puzzle. The robot knows a couple of concepts related with computers but this knowledge is incomplete. In the first puzzle,

the robot is able to identify the puzzle as a model of the programmable data processor, but in the second puzzle the robot does not realize how two computer process different output when given the same input.

Alexis, the Geek Friend

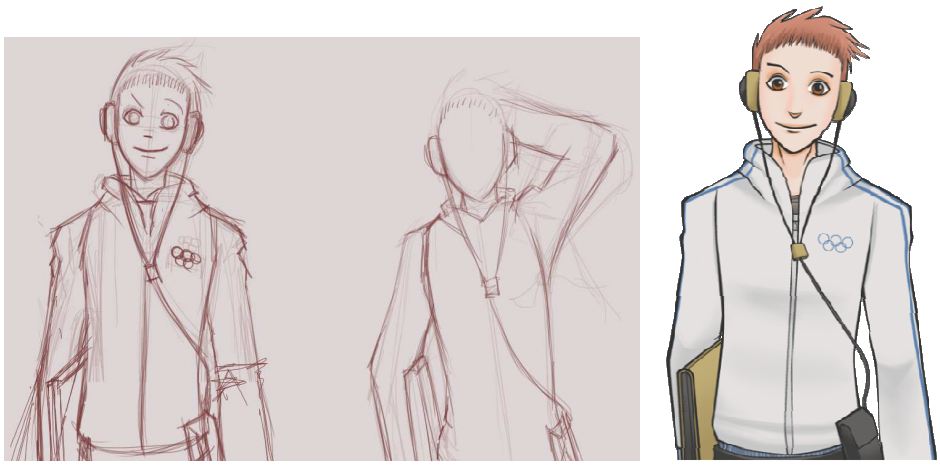


Figure 7: Alexis

Alexis is the secondary character with frequent interaction inside the game (Figure 7). He is one of the main sources of computer basics knowledge inside the game as evidenced during the second puzzle where he explains to the protagonist and the robot how two identical computers can produce different outputs when given the same input (2nd puzzle) and introducing them to a programming language (3rd puzzle, not implemented).

In latter parts of the game if it is considered the possibility of introducing various interactive scenarios instead of just one per act, this character could remain as a source of vital knowledge without which the player cannot proceed in the game. The character is not meant to be used as an obstacle in the game like the robot and staff members, but can make multiple choice questions to the player to test what he learned in exchange of a reward (ex.: an application).

Alexis and the Hero studied together during high school before departing to different universities: While the protagonist enrolled in sport sciences, Alexis studied computer sciences. They both meet each other during the Olympics as volunteers inside the ITC room, with Alexis as a system administrator's auxiliary.

Staff Member

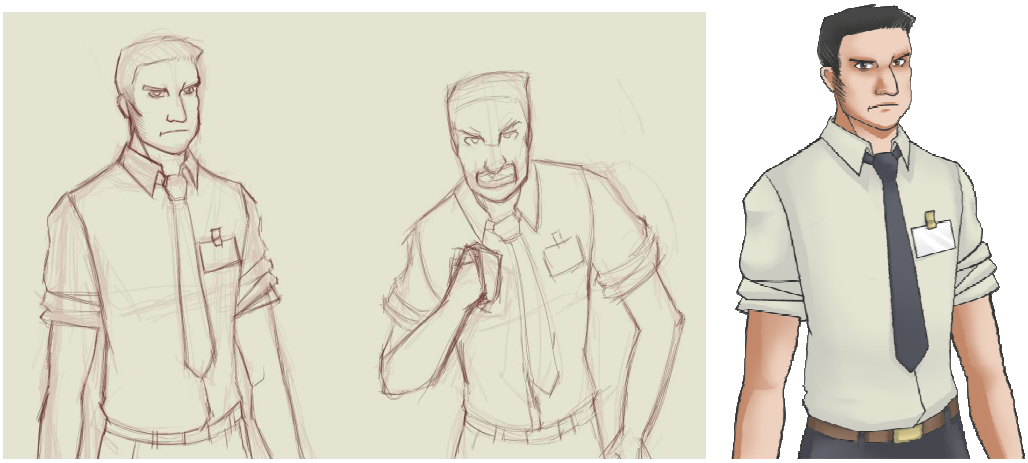


Figure 8: Staff Member

Secondary character introduced in the first puzzle of the game. An older individual who is obviously stressed with the commotion caused by the events preceding the first act, he does not look friendly or helpful (Figure 8). The character was introduced to give the Hero a task: calculate the scores for both basketball teams, and give him an information chip and a paper containing Greece and Spain's points. The future presence of this character in other puzzles has not yet been decided, since there should be more than one staff member to interact with inside the game, but if so, this character can introduce the player to new tasks to be accomplished before advancing (ex.: fix a problem inside a computer; interact with a anti-doping program, and other problems.)

Detective Girl

The detective was meant to be a secondary character and possible antagonist. She was present in the initial concept as a detective and technology expert working for the police and investigating the case of the stolen computer. The protagonist and the detective would cross paths frequently, leading her to suspect of him and block his progress with challenges (mini games, questions about computer basics, and other puzzles). Since Alexis replaces her as one of the sources of knowledge about computers in the newest game concept, it is unclear if she will be present or not, perhaps as part of one of the advanced puzzles.

3.2.3. Interface

During the game, the protagonist encounters certain puzzles which need to be solved with the aid of his portable device and collects items necessary to move to the next act. In order to allow the player to interact with these elements it was necessary to design a simple interface with

shortcuts directing to the inventory, minicomputer and a hint system using interactive icons representing the elements mentioned before.

Figure 9: The Slide Menu

The result is a slide menu (Figure 9) which stays concealed from view in the screen until the player approaches the mouse pointer to the right side of the game screen. When the slide menu opens the player has access to the three icons of the Hint System, Mini Computer and Inventory. This menu interface was designed to be concealed when it is not being used because the player needs to interact with the scenario as well. There was the option of building a vertical or horizontal sidebar permanently on the same place, but it would reduce the space left for the scenario background.

The player also interacts with the dialogue box present during the cut scenes (Figure 10). The character with who the protagonist is talking with is displayed in the background while the text appears at the bottom of the screen. Clicking on the box while the text is still loading will force the text to be completely loaded; clicking again will jump to the next portion of text. Because of the strong theoretical component about computer science being implemented inside the game, this approach was considered to be the best while developing the prototype in order to display information and theory for the player to learn, as if the character in the background was a teacher.

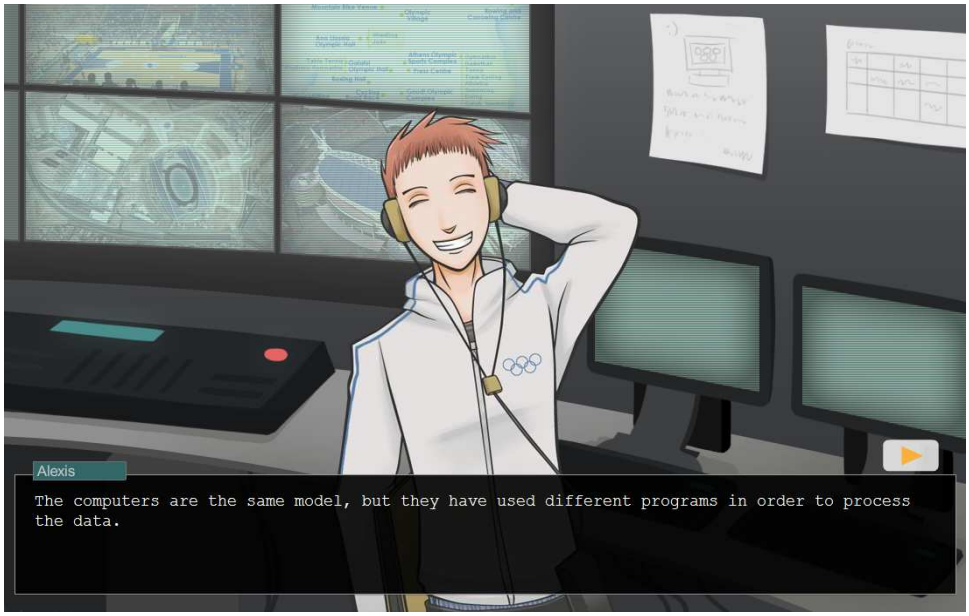


Figure 10: Game Screenshot: Alexis explaining about programs.

Hint System

The Hints system can be repurposed as extra help during the game. In the situation where the player finds himself stuck and does not know what to do next, clicking on the robot icon in the slide menu will initiate a dialog with the robot where it will give a specific hint. The hints vary with the location and current puzzle.

In the prototype there was no need to implement an advanced hint system since the first levels are basic enough.

Mini Computer

Figure 11: Game Screenshot: MiniComputer Interface.

The protagonist carries with him a MiniComputer (Figure 11) he brought in second hand prior to the events in the game. While the device's appearance is modern and similar to actual PDAs and other multitouch devices, the software is antique and has a retro feel noticeable by the lack of a complex colour palette.

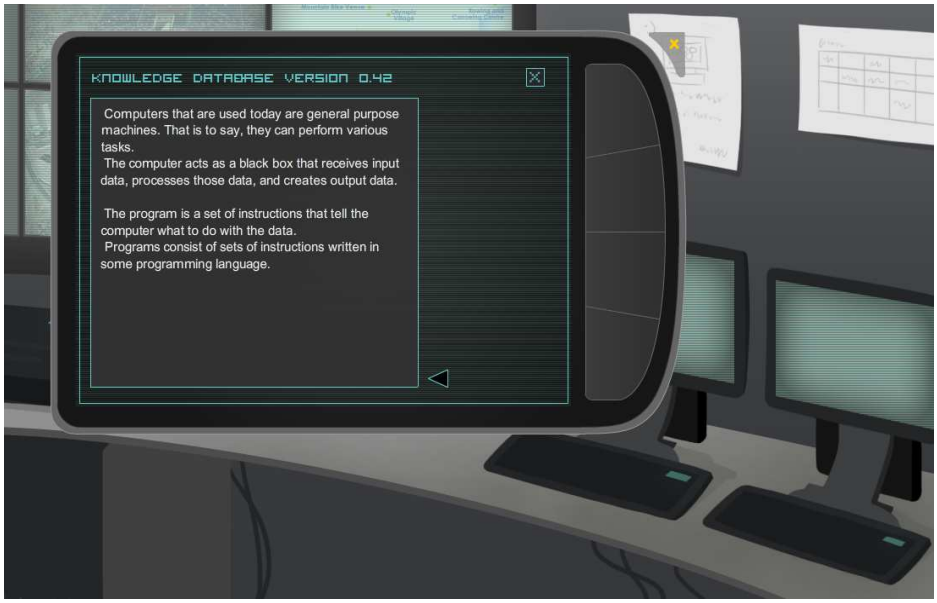


Figure 12: Game Screenshot: Knowledge Database.

The MiniComputer plays a vital part inside the game since it is used to solve many puzzles and stores the knowledge base of data collected so far (Figure 12). In the beginning there is only one available application, which is the knowledge database itself but without any content inside it. As the player advances in the game, solved puzzles unlock new applications such as calculators and content for the knowledge database.

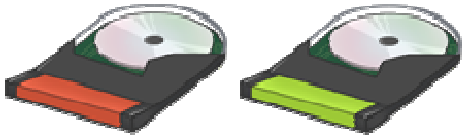


Figure 13: The chips used to unlock content in the Mini Computer.

Inserting chips (Figure 13) on the minicomputer allow the player to unlock new content from extra applications to new content for the knowledge database.

Inventory

Figure 14: Game Screenshot: Inventory.

The inventory system (Figure 14) shows the items and memory chips acquired during the game and can be consulted at any time in the game as long the slide menu is available.

Clicking any item present inside the inventory will bring two options:

The *"View"* option will initiate the dialog box (Figure 15), and the protagonist and/or the robot will describe the item they have. This may be accompanied by an image of the respective item.

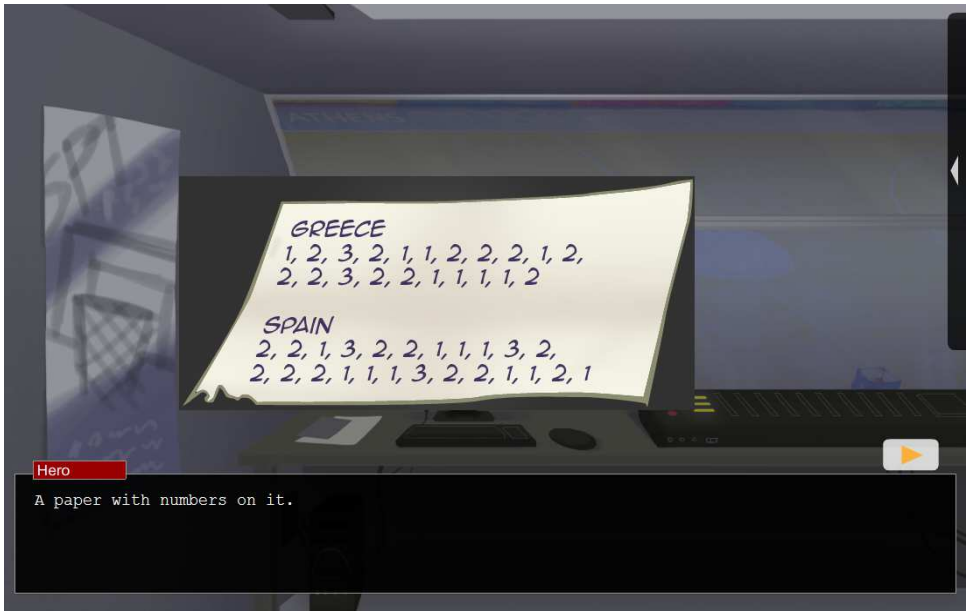


Figure 15: Game Screenshot: Closer look of an Inventory item.

The *"Use"* option brings different outputs depending on the item. If the item is a computer chip, it will be inserted on the minicomputer the protagonist carries with him. It is not always possible to "use" an item, and a dialog box will be triggered instead explaining why it cannot be used at the moment.

Memory chips are the most common items inside the game. They are mostly used in the minicomputer, but they can be also used in other elements within the scene. The chips' content varies from applications to puzzles and other data.

3.2.4. Level Design

Scenarios

Scenarios had to be in tune with the game's narrative and include elements easily noticeable for the player to click and explore them.

At least seven scenario backgrounds were defined for the first part of the game; two of them were drawn for the game prototype: the hardware backstage room from the basketball stadium for the first act, and the Information Technology Centre (ITC) for the second act. These two scenarios had to be drawn in a special angle like they are seen from the eyes of the protagonist.

The hardware backstage (Figure 16) is dark and filled with technology considered to be outdated (by the game's timeline). The player can see part of the stadium behind a giant window and interact with several objects. If the player interacts with the computer, it will trigger a short summary of past events as told by the Hero, explaining why there are old computers still available with much more advanced technology at their disposal. Interacting with this scenario is not necessary to unlock the puzzle.

Figure 16: First Scenario, the hardware backstage

The ITC scenario (Figure 17) possesses a technological feel to it. The player sees nothing but a section of what is supposed to be a vast complex, in this case the protagonist is visiting the sector where his friend works. The equipment present in this scenario is more advanced compared with the old one from the first scenario. In this scenario it is necessary to interact with the two computers present in it after the protagonist receives a new chip.

Figure 17: Second Scenario, Information Technology Centre

First Act

The first act of the game begins with the basketball match between Greece and Spain. The game is experience from a first person point of view with the protagonist commenting about it and later arguing with the robot. The background of the basketball field is switched to the score boards displaying random characters instead of the actual score, an event which persuades the protagonist and robot to check the hardware room in the stadium where they are given a chip and a piece of paper by a staff member. After the item collection the player can explore the scene and be familiarized with the slide menu, menu and inventory, but the only way of unlocking the act's puzzle is to use the chip via the inventory, unlocking an animation in the minicomputer. The player is presented with loose pieces of a diagram (Figure 18), which he must organize and form the diagram of the computer. The addition application (Figure 19) is unlocked after the diagram is completed and the protagonist realizes he has to use the application to calculate the current score for both teams.

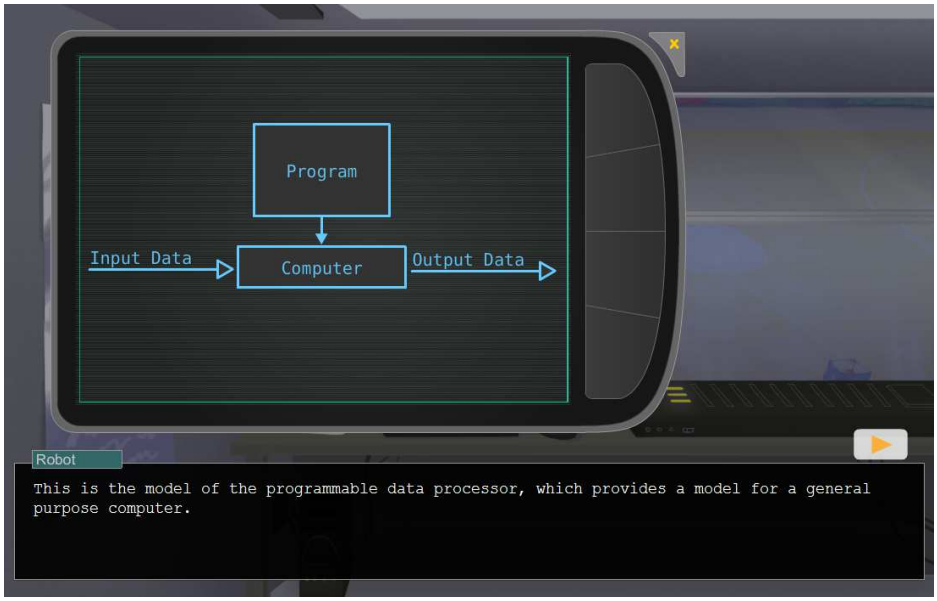


Figure 18: Game Screenshot: Diagram Completed.

Because the minicomputer and the piece of paper (containing the points from each team) could not be displayed at the same time due to screen size restrictions, the protagonist dictates the points in the dialog box for the player to see and is advised with a hint box to calculate the scores, memorize them, and turn off the minicomputer after he/she was done with it. The staff member appears and questions the current score, repeating the question in case the player gives the wrong answer. With this, the first act is completed and the screen fades to black.

Figure 19: Game Screenshot: Calculator

Second Act

The second act is much simpler than the first one yet it possesses much more dialogue. The protagonist and the robot find themselves in the ITC two hours after the basketball match and meet a friend of the protagonist, Alexis, who tells them about a system crash affecting all computers and servers from the Olympic network. Alexis hands over a memory chip to the protagonist and leaves the scene, allowing the player to explore this new environment. If the player checks his minicomputer, he/she will find the addition application has been unlocked and can be fully used at any time now. Using the new memory chip via the inventory will cause the protagonist to connect it to the minicomputer but that is not the objective. The solution to this puzzle is to click on the two computers in the background currently displayed and getting different output produced with team scores from each one of them (Figures 20 & 21).

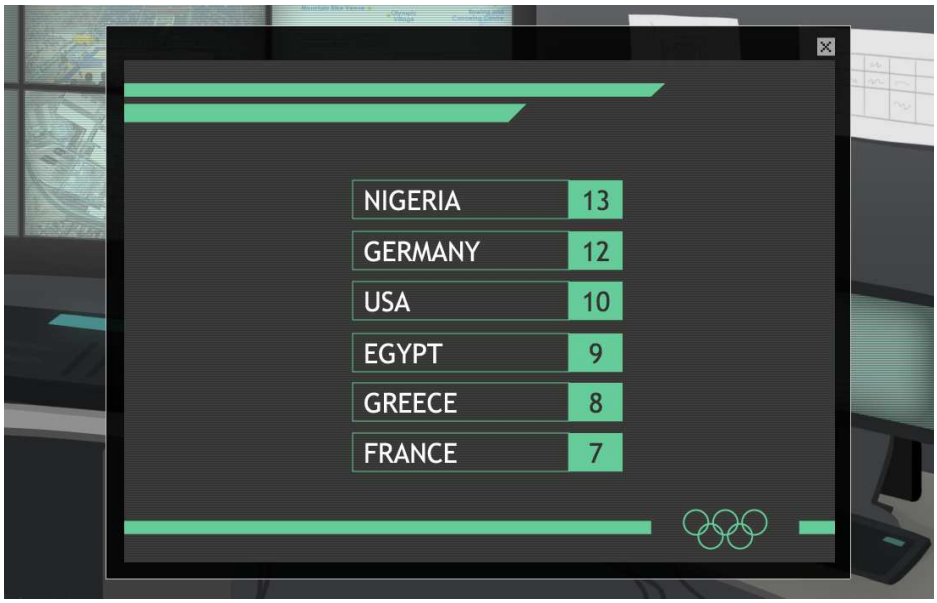


Figure 20: Game Screenshot: The screen of the first computer.

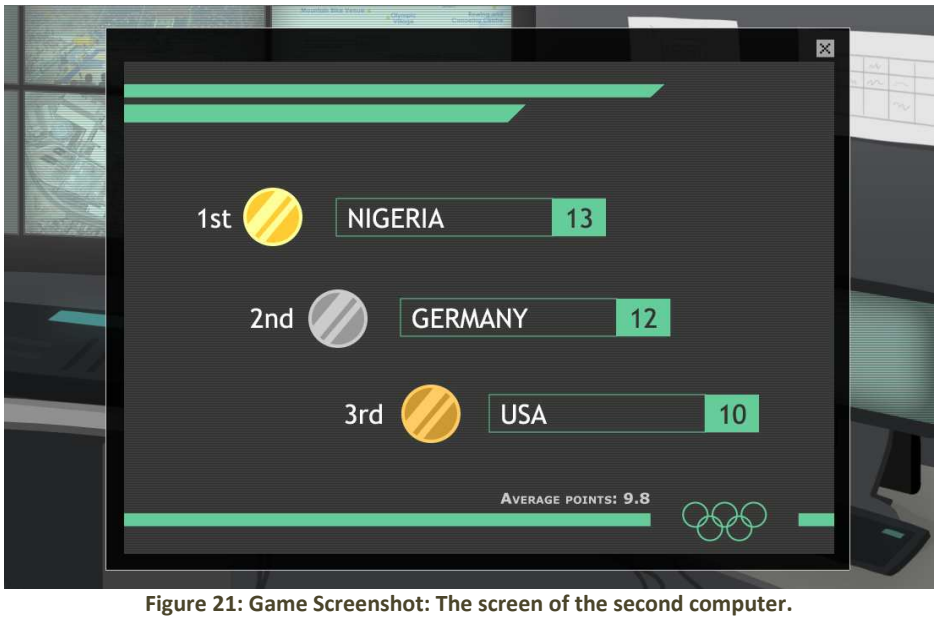


Figure 21: Game Screenshot: The screen of the second computer.

After clicking on the two computers, Alexis returns but the robot is in a state of confusion, not understanding why two similar computers produce different outputs when given the same input, to which Alexis provides a lengthy explanation about how computers process information. The protagonist is then invited by Alexis to return to the ITC in the following day to receive programming lessons, the first step for a third act. Since no more acts were produced, a "Thank you" message is displayed at the end of this act, but the player can click and remove the message, and continue exploring the scene, including the unlocked information inside the minicomputer and the Easter egg hidden in the console.

3.2.5. Game Mechanisms, Gameplay and Rules.

Several elements from known game genres are incorporated within the game: the dialogues function in a similar way as seen in most basic RPGs, certain scenes are explored by clicking on items and activating switches, like in some mystery solving adventures, and there are puzzles and quizzes, most with multiple choices. Specifically, after a brief introduction to a new act with the inclusion of dialogs and explanations, the player can: start exploring the environment, interact with elements in the background, check the current items in the inventory and their uses, consult the knowledge database in the minicomputer, and unlock applications. At a point where the player will have advanced enough in his/her investigation, he/she will unlock a puzzle. Solving the puzzle will initiate the act's conclusion and the player will proceed to the next act.

The game's progression follows a linear path, and the puzzles are solved in a static order, but in later parts of the game it becomes possible for the player to explore various scenarios instead of a single one and to perform experiments. For now, there is no "game over" implemented in the game. The player can try, fail and try again without being penalized. And after successful events and challenges, the player is rewarded with items and information chips, which when introduced in his PDA device, unlock information bits about computer science basics, a feature which should prove to be useful for players, as advanced puzzles will require knowledge acquired previously.

The game is planned to include three levels. At this point, the planning documents are being developed in detail for the first level, which includes 24 puzzles and its respective plot story and dialogues. As an educational tool, the game is meant to be divided in acts and solved gradually within a semester of classes. The instructor can give students access to the acts after they have finished a specific subject. The students will be able to save the game progress online where the instructor can consult and identify who has solved the puzzles and advanced.

3.3. Development of the prototype

3.3.1. Development Tools

The entire game was produced in ActionScript 3.0 using Adobe Flash CS4. Initially the game's prototype was to be produced in ActionScript 2.0, but the inclusion of functional text boxes and inventory required the use of advanced functions only possible with the latest version of Flash's programming language.

ActionScript 3.0 and Adobe Flash were chosen over other programming languages and tools due to the easy implementation of graphics and simple coding. While ActionScript 3.0 is much more advanced and less designer-friendly than Actionscript 2.0, there is a wide collection of tutorials in the Internet for AS3 and communities where doubts and problems about Flash can be solved by experts. Flash is also widely used in the making of successful games, as evidenced in large flash gaming portals like *Kongregate* and *Newsground*.

Recognizing the need to translate the text from English to Greek in a near future, special actionscript files were created to include dialogues and texts exclusively apart from the remaining files and code. These files can be easily edited as long they follow the proposed format as specified in the notes.

Artwork was produced with Adobe Photoshop and Illustrator and drawn by the investigator herself. Several images including those from the stock photo website *stock.xchng* were used as references or edited into scenarios. The sound effects and music for the acts was retrieved from the web portal *Flashkit*.

3.3.2. Development Period

The development of the concept and game design document began in the beginning of March 2010. The document was subject to alterations by April with the introduction of the puzzles set by the instructor and a need to change the gameplay and flow of the game. Development of the game started as soon the basics of the new game design document including the narrative for the first puzzles were defined. However, the development suffered setbacks due to certain factors, including the need to change to ActionScript 3.0 to implement the necessary features. After reviewing the calendar with the coordinators, it was decided to proceed with the tests in September instead of May/June.

By the end of June, the main features such as the dialogue box, inventory and minicomputer were successfully implemented in the game, and by the end of August, the prototype was finished and ready to be tested.

3.4. Tools for data collection

3.4.1. Equipment

For the testing of the game prototype and data collection from the test subjects it was necessary one or more computers. The Department of Physical Education and Sports Sciences (DPESS) possess a computer laboratory with all the conditions for the students to have class in it. The only requirement imposed was to have Flash Player 10 installed on them. Other features and programs were unimportant.

The conditions were slightly different in the Department de Communication and Art (DeCA). To proceed with the game testing, a laptop and a computer from the laboratory was used for game testing and questionnaires respectively. Students were also invited to use their own laptops to access the online version of the game and questionnaire available for a limited period of time.

3.4.2. Questionnaires

Different questionnaires were handed to students of DPESS and DeCA. Our prime target were the Physical Education and Sport Science students, since the game prototype was developed specifically for them, yet the students from the master degree of Communication & Multimedia could also provide an useful game review as an expertise. In the questionnaire for the DPESS students they were asked to fill in about their motivation towards the Computers' class and appeal of the game as an educational tool for their class, while the DeCA students were asked about the prospect of using games as educational tools in their own classes.

Before the construction of the questionnaires a table was made with a list of elements to be evaluated during the tests (Table 3).

Table 3: Elements to be evaluated during the game prototype testing.

The Class

What I want to evaluate	Question to do
Motivation towards class.	Are you looking forward for the Computers' course?

Computer Habits

What I want to evaluate	Question to do
Computer habits	How many hours do you spend at the computer per day?
Computer interests	What do you use the computer for?

Gaming Hobbies/Computer Games

What I want to evaluate	Question to do
Computer /video games as a hobby.	Are computer games/ video games part of your hobbies?
Hours of gaming.	How many hours do you play per day?

Game Prototype

What I want to evaluate	Question to do
Overall appeal of the game.	Did the game prototype appeal you so far?
Knowledge gathered with the game prototype's first two puzzles.	Do you believe you have acquired any worthy knowledge about Computer Sciences with this game? Do you think a game like this one would help you learn more about Computer Sciences?
Interest in the game as tool of motivation for the course.	Do you think a game like this one would keep you motivated for the Computers' course?
Acceptance of the game as a learning method for the course in contrast to other learning tools.	Would you prefer this game as an educational tool instead of other traditional tools? (ex.: reading extra books, other applications)
Interest in playing the game outside of school time.	Would you play this game during your free time (at home, and in other situations)?
Appeal of individual elements from the game.	On a scale of 1 to 5, rate the appeal of the following game elements:
Detect conflicts in the game/possible difficulties.	Is the game interface confusing?
Interest in the story development.	Are you curious about the plot story inside the game and what will happen next?

3.5. Data Collection

3.5.1. Schedules

The prototype testing and questionnaire fulfilment of the DPESS students was meant to be executed by the end of the school year of 2009/2010 in May or June, yet technical difficulties during the design of the prototype lead to a rescheduling of the tests for the beginning of the new school year of 2010/2011 with the new incoming students. This brought one advantage as the first levels from the game could be tested with students who were just getting started in the course. With the investigator absent from the scene, the course instructor supervised the tests and questionnaires on September 29th of 2010.

The tests carried at DeCA were executed around the same time with a slightly different method and the investigator was present to interview the students and watch them play. The tests occurred on October 1st and 8th of 2010 during class time, and without disturbing the flow of the current class they were in, the students were invited to test the game in an appropriated laptop or access a temporary link in the investigator's blog to play the game in their own computers, as long they had Flash Player 10 installed.

3.5.2. Tools for data retrieval

The questionnaires for DPESS were distributed to the students who played the game by the instructor who translated from English to Greek before printing. After the session, the questionnaires were scanned, sent to the investigator and reorganized in digital format using Microsoft Office Excel.

DeCA's students filled the similar questionnaire in English. The questionnaires could be found in a Google Docs webpage, once submitted it would be automatically processed in a sheet document. After the last session the documented was exported to Excel.

4. PRESENTATION, ANALYSES AND DISCUSSION OF RESULTS

After the test sessions were over, the data was retrieved from the forms the students filled in. The questionnaires filled in by the students of DPESS were scanned and sent via email to be reorganized in digital format, while the contents from the questionnaires from DeCA's students were downloaded from Google Docs. The data from both questionnaires was formatted in graphics and is present in this chapter. And once again, the purpose behind the execution of tests with two different groups of students from distinct university departments was not to compare the results but to get different feedback based on the background and experience with computers of each selection of students.

4.1. DPESS

The student sample from DPESS consisted of 19 students, 12 male and 7 female, with the age range between 17 and 20 years old (Table 4). As first Grade College students, most come directly from the high school, with 14 of the students coming from Theoretical science courses, 2 from Positive science courses and 3 from Technological courses (Table 5). According to the course instructor, in the Greek secondary education system, students who choose the Technological path are taught mostly match, physics and to some extent programming subjects; students from the Theoretical path are taught Greek literature and history and Latin, and unlike the Technological Path, there was no presence of computer science in the subjects being taught. The Positive path leads the students to mathematics, physics, medicine and biology course, but again there was no presence of computer science related subjects.

Table 4: Gender of the Students of DPESS

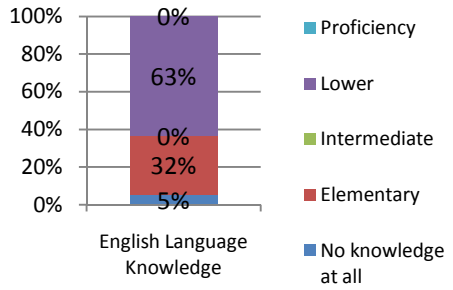
Gender	M	F	Total
	12	7	19
	63%	37%	100%

Table 5: Academic route of studies during secondary education of the Students of DPESS

Secondary Education Orientation	Theoretical	Positive	Technological	Total
	14	2	3	19
	74%	11%	16%	100%

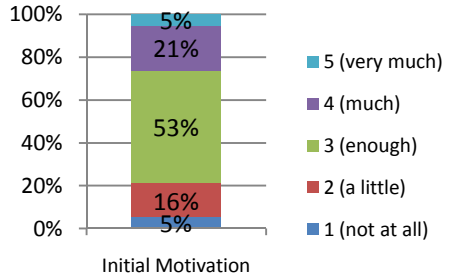
Their proficiency with the English language is limited. According to the questionnaires, 63% of the students consider their knowledge of the English language to be low, while 32% claim they possess an elementary knowledge (Graphic 1). Only one student affirmed to possess no English language knowledge at all. The investigator was already aware of the language issues the game could arise for those with a weak grasp on the English language, which is why the instructor who supervised the tests also worked as a translator for the students without interfering with the puzzle thought process. The English Language is a compulsory course from the third grade of primary school (when students are 8 years old) until the age of 15, but there are students who prefer to attend private language schools.

Graphic 1: Level of English Language proficiency (DPESS)



As part of the introductory selection of questions, students were asked about motivation towards this new course. And their initial motivation so far is good as there are very few students not looking forward for this course (Graphic 2). But again, this is their initial motivation: their interest in the course may not be the same during the semester and considering the problematic behind this project it is likely the students' motivation will decrease.

Graphic 2: Level of Initial Motivation towards the Computer's Course (DPESS)

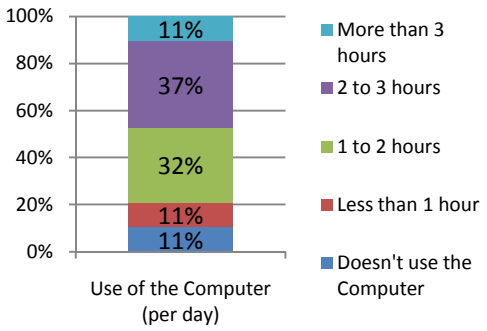


4.1.1. Computer and Gaming Habits

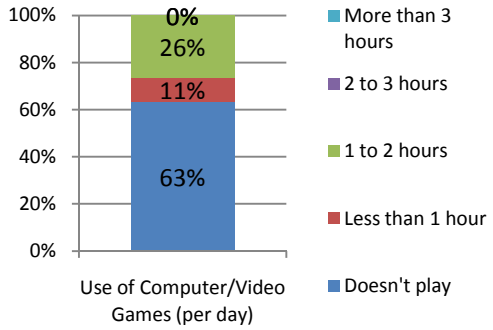
Knowing the students' computer habits is important for tracing a general profile of the students and how familiarized and attached they are to the new technologies. It could be assumed a person who seldom uses the computer will have more difficulties with a certain game or application than a person who uses the computer daily, yet those difficulties can be rendered null if the application has an interface simple enough to interact with.

From the sample of 19 students, 17 claim they use the computer as part of the daily life, and the majority (53%) admits using the computer during two or more hours per day (Graphic 3). As for gaming habits, only 7 (37%) students consider computer and video games as part of their hobbies and do not play more than two hours per day (Graphic 4).

Graphic 3: Use of the Computer (per day) by the Students of DPESS



Graphic 4: Use of Computer and Video Games (per day) by the Students of DPESS



Regarding computer related interests, the students mostly use the computer to get involved in the social networks like Facebook and Twitter, followed by studies and research (Table 6). Besides the academic and social activities, 53% of the students also use the computer for gaming purposes; however it was clearly stated before that 63% of the students do not consider computer and video games as part of their hobbies. This means there are students in the classroom who do not classify themselves as gamers yet often indulge themselves in gaming related activities when using the computer.

Table 6: Computer Interests from the students of DPESS

Subjects	Studies/ Research	Social Networks	Chat	Gaming	Information searches for personal purposes	Other purposes
	12	15	10	10	12	2
	63%	79%	53%	53%	63%	11%

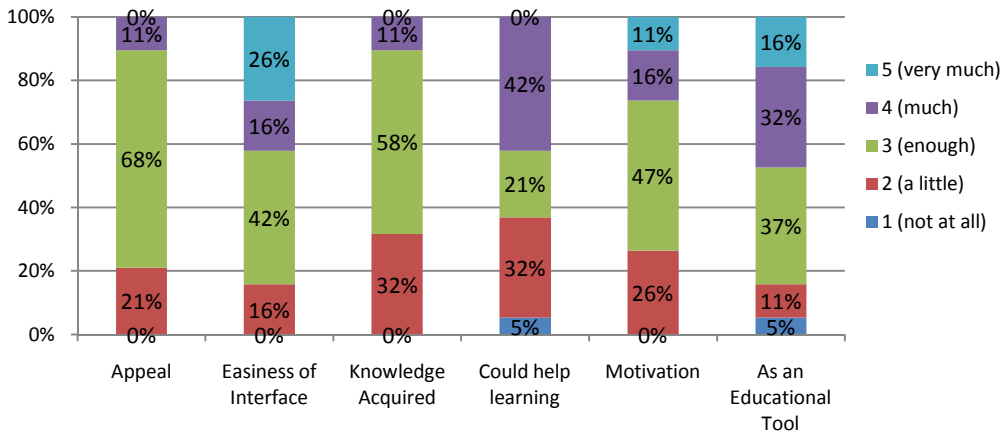
4.1.2. Appeal of the game

Students were asked to classify on a scale of 1 to 5 the game's appeal and purpose – as seen in Graphic 5. In a general consensus, most students (68%) agreed the game's appeal was average, with no extreme opinions. On the easiness of the interface, 26% consider the game very easy to use. When asked about what they managed to learn with the game, 58% say they learned just enough, but when questioned about how helpful this game could be to teach computer basic concepts, 42% of the students express a positive reaction.

The use of the game has an educational tool sprouted more diverse opinions compared with the previous element evaluations: at least 5% of the students think the game does not stand out as an educational tool compared with other traditional tools, 37% think it was on pair and 16%

think it is a much better alternative. Overall, the game's purpose is seen with optimism, as an educational tool and as a motivational tool.

Graphic 5: Classification of the game's aspects and educational purpose by the students of DPESS



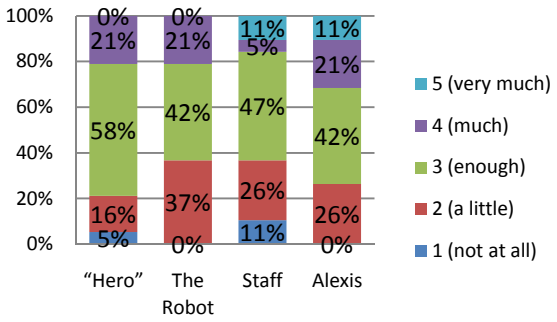
4.1.3. Game Elements

Students were also asked to evaluate several elements present within the game, such as the interface, storytelling, characters and gameplay. By calculating the average of each evaluated element it is possible to identify which aspects were most preferred by the students. For example, out of the four characters present in the demo – Hero, Robot, Staff and Alexis, the latter one achieved a higher score while the Staff member was the most disliked one (although the robot was criticized for being annoying in the development questions). Although the score differences between the characters is not too much apart (a difference of decimal values as demonstrated in Table 7), it helps to see which characters needs improvement in case they are reused in the following game puzzles. The character Alexis is one of those that are meant to be present during most part of the game as one of the sources of computer science knowledge and if students gave that character good ratings, it is worth to keep the character around because it was well accepted inside the game's context. The character Alexis and the Staff member were the only ones to receive a high score (5) by some students, while both the Hero and again the Staff member received the lowest score (1) from other students (Graphic 6). The robot and the Hero still need to be improved: the Hero's presence inside the game needs to strengthen (by switching from first person to a third person perspective, for example) in order to become more meaningful for the students to relate themselves with, and the robot's personality needs adjustments.

Table 7: Average Score for character preferences (DPESS)

Characters	"Hero"	Robot	Staff	Alexis
	2,95	2,84	2,79	3,16

Graphic 6: Scores distributed for character evaluation (DPESS)

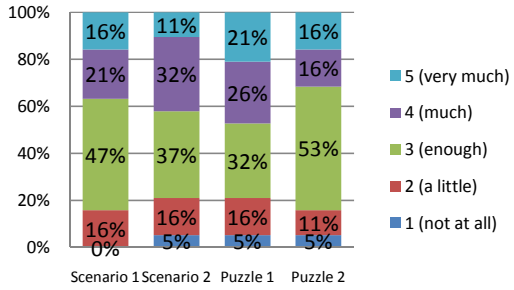


The students also preferred the Scenario 1 (3,37) to the Scenario 2 (3,26) and the Puzzle 1 (3,42) to the Puzzle 2 (3,26) – seen in Table 8 With the support of the written comments and the score distribution (Graphic 7), this means the students enjoyed and preferred working around the diagram puzzle than interact with the following act and discover where to connect the memory chip. This is interesting because the second scenario is graphically better than the first scenario and it has more interactive objects (clicking in elements of the background can invoke a conversation with another character; the computers can be accessed to see team scores; and there was the hidden secret). But the students were more appealed by the first puzzle, which can be considered to be more challenging than the second puzzle.

Table 8: Average score for scenarios and puzzles (DPESS)

Scenarios and Puzzles	Scenario 1	Scenario 2	Puzzle 1	Puzzle 2
	3,37	3,26	3,42	3,26

Graphic 7: Scores distributed for scenarios and puzzles (DPESS)

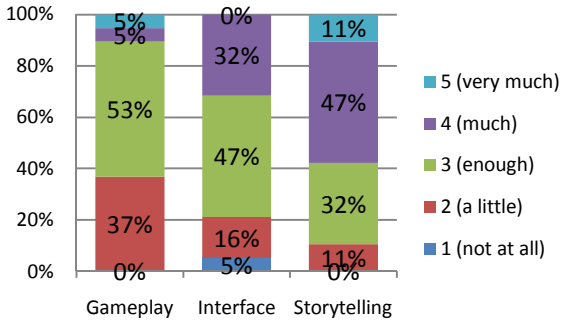


Between the gameplay, interface and storytelling (Table 9), the students preferred the story present in the game, which achieved a higher score (3,58) than gameplay (2,79, lowest) and the interface (2,79). From these results and the score distribution (Graphic 8), two conclusions can be drawn: the storytelling, including the introduction of a sports student and a main character and the plot around the system crashes does appeal to the students, but the gameplay still needs to be improved to be as appealing as the story.

Table 9: Average Score for Game Aspects (DPESS)

Game Elements	Gameplay	Interface	Storytelling
	2,79	**3,05**	**3,58**

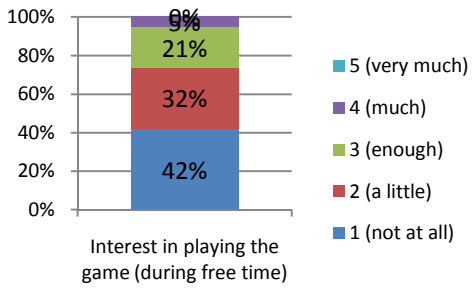
Graphic 8: Score Distribution for game aspects (DPESS)



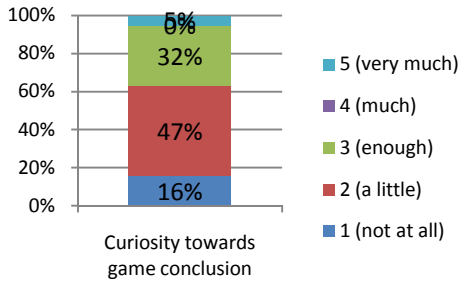
4.1.4. Opinions

Despite the general positive reactions regarding the game, the students do not find themselves interested enough to take this game home and play it during their free time. Only 26% (those who voted 3 and more, shown in Graphic 9) are interested in exploring the game outside of college. And although they consider the storytelling appealing to them, their interest in knowing the conclusion of the extended plot is low, with 37% interested in finishing the storyline and 42% little care about its conclusion (Graphic 10).

Graphic 9: Interest in playing the game outside class hours (DPESS)



Graphic 10: Curiosity towards storyline conclusion (DPESS)



Students were allowed to write out what they liked most and least inside the game and give their output about how this game could be improved. The students praised the plot story, the first puzzle and enjoyed using this game as an education tool:

"The fact that the game combines the learning of basic information with entertainment, puzzles and game."

"The diagram because it gives you the opportunity to think and create something"

"That it made the things that we had learned at school (at the technological part of studies), which they seemed difficult and complicated, simple."

The plot story was enjoyed by most students but the quantity of dialogues and text was considered excessive and often described as "boring". Certain dialogues in the game are very long due to the integration of course matter to be transmitted to the student (ex.: exchange of knowledge between Alexis and the Hero). The robot was also very disliked by the students and considered "irritating" and did not enjoy the way it functioned.

"The role of the robot, because sometimes it made me loose the flow of the game."

"Variety. If it were more difficult with greater plot, I would find it more interesting."

"Too many dialogues"

There were also some comments regarding the humour present within the game (not enough of it) and the constant use of the mouse to move to a new dialogue.

To improve the game's quality the students suggest more puzzles and fewer dialogues, the inclusion of program creation, use of the keyboard to move in the game apart of the mouse, better graphics and plot story.

4.1.5. Difficulties detected during the tests

According to the instructor Dr. Marina Papastergiou who accompanied the students through the tests, there were no pertinent difficulties demonstrated by the students while playing the game prototype. But the instructor also worked as a translator for game since the students lacked

or possessed weak English skills. It is difficult to know how the students would have progressed in the game without the instructor's translation. Their most common comment, according to the instructor, was about the lengthy texts present within the game, and about how they wished the game had less dialogue and more puzzles.

4.2. DeCA

The students from the Master Degree of Communication & Multimedia are a much diverse group than the young students from DPESS. The test sample was composed of 14 students, 6 male and 8 female, with ages between 20 and 48 (Table 10). Some students came directly from licentiate courses from the University of Aveiro, such as New Technologies of Communication and Design, while others come from other universities. The older ones have careers of their own, having finished their course years ago. Within this course one can find programmers, designers and even journalists who work in organized small teams during the semester and accomplish several projects. The master degree lasts two years and is divided in two paths: Interactive Multimedia, the pathway for the graduates in the area of Communication Science and Technologies, where the students work with multimedia projects to be used in different domains from educational to organizational, artistic and entertainment; and Digital Audiovisual, dedicated to recent developments in the audiovisual field such as the new means of diffusion of audiovisual signals, from mobile phones to television and videocasts on the Internet [10]. During the second semester the students develop their dissertation projects either in the university or as part of an internship.

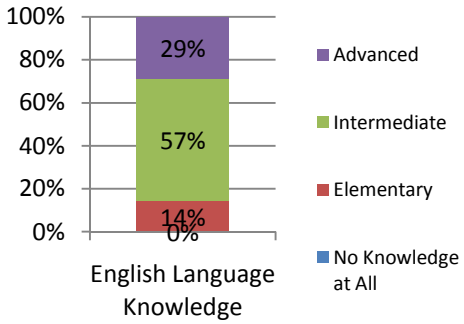
Table 10: Gender of the Students of DeCA

Gender	M	F	Total
	6	8	14
	43%	57%	100%

Knowing English is considered to be very important in any technology related course due to the vast quantity of resources and study material only available in English, especially in the Internet. And it is clear the students of the master degree are much more familiarized with the English language than DPESS' students. To confirm this proficiency, 57% consider their English to be of an intermediate level while 29% affirm to have reached an advanced level (Graphic 11). During the tests nobody required assistance with the text translations.

[10] Course information retrieved 29th November, 2010, from http://www.ua.pt/guiaonline/PageCourse.aspx?id=101&b=1&lg=en

Graphic 11: English Language Proficiency (DeCA)



4.2.1. Computer and Gaming Habits

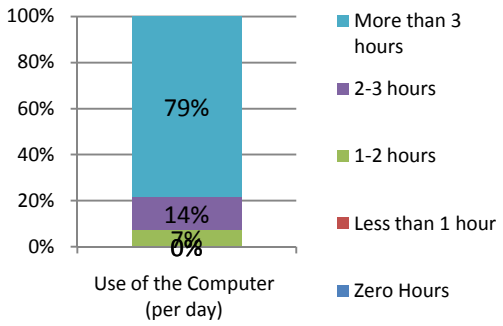
The computer is an indispensable tool within the technologic courses such as New Technologies of Communication and the Master Degree of Communication & Multimedia, independent of the path chosen. It does not come as a surprise when 79% of the students claim they spend more than 3 hours in front of the computer per day (Graphic 12). All students use the computer for both studies and social networking, followed by social interaction using chat applications (such as MSN and Gtalk). Half of the students also admit using the computer for gaming entertainment (Table 11).

Table 11: Computer Interests (DeCA)

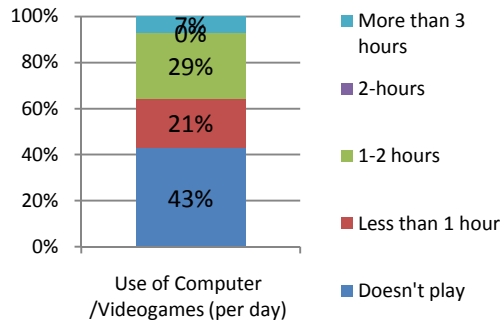
Subjects	Studies/ Research	Social Networks	Chat	Gaming	Information searches for personal purposes	Other purposes
	14	14	12	7	9	8
	100%	100%	86%	50%	64%	57%

According the data retrieved, 57% of the students have computer and video games as part of their hobbies, and with 50% admitting to play between 1 to 2 hours per day (Graphic 13). As a side note, the students from the Interactive Multimedia path have access to the compulsory course of Narrative and Interactive Games where the students are taught game design principles, definitions of game and play, analysis of digital narratives and interactive games between other topics lectured during the second semester of the first year.

Graphic 12: Use of the Computer (per day) by the Students of DeCA



Graphic 13: Use of Computer /Videogames (per day) by the Students of DeCA

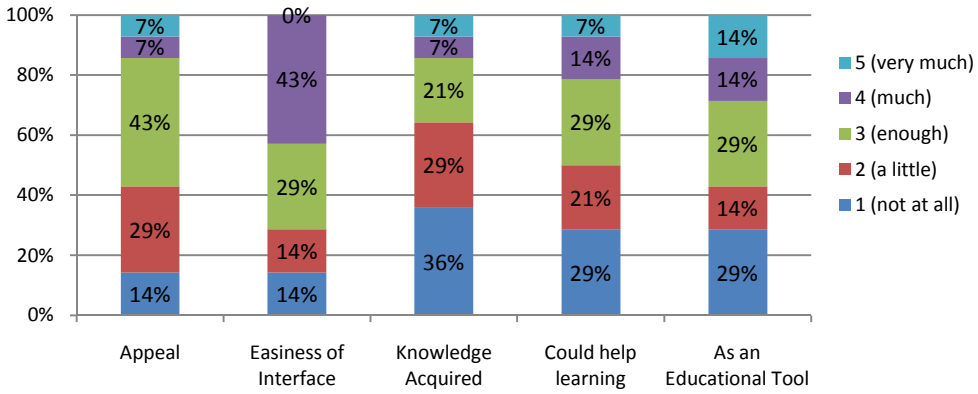


4.2.2. Appeal of the Game

The students of DPESS did not get in extreme opinions while evaluating the game, meaning they always tended to classify between 2 and 4 with seldom exceptions where they voted 1 (not at all) or 5 (very much). That was not the case with the students of DeCA whose experience with applications and games was made evident through the game and provided a much more diverse classification of the game's appeal and use as an educational tool.

Concerning the overall appeal of the game - seen in Graphic 14 - 7% of the students say it was a very appealing game prototype while 43% think it was just about average and 14% consider the game is not appealing at all, and 43% of the students find the interface easy to use.

Graphic 14: Classification of the game's aspects and educational purpose by the students of DeCA



4.2.3. Game Elements

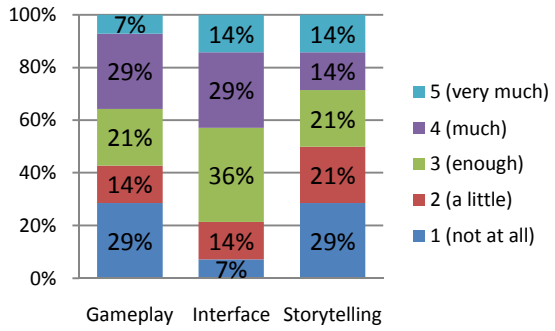
By comparing the score calculation of gameplay, interface and storytelling, it can be confirmed the students of DeCA liked the interface (3,29) more than the gameplay (2,71) and the storytelling (2,64) present inside the game (Table 12). It can be understandable why the storytelling was not

interesting enough for the students, since the story was developed for the sports science students. But the gameplay element's score was as low as the score set by the students of DPESS. And because DeCA's students are much more familiarized with gaming than DPESS students, this is a good reason to review the gameplay and make the necessary changes before proceeding with the inclusion of more puzzles. The score distribution gives a different perspective not possible with the average score calculation since it shows how the students had very varied opinions about the gameplay, interface and storytelling (Graphic 15).

Table 12: Average Score for Game Aspects (DeCA)

Game Elements	Gameplay	Interface	Storytelling
	2,71	**3,29**	**2,64**

Graphic 15: Score Distribution for Game aspects (DeCA)

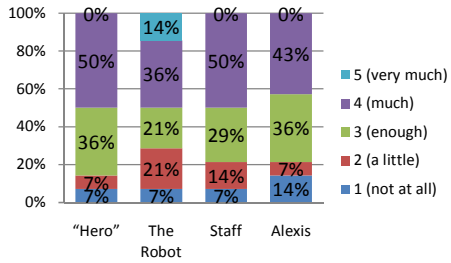


Because the students of DPESS answered these same questions, the favourite character among DeCA's students was the robot, and the least liked character was Alexis (evidenced by the score calculation in Table 13). This result is interesting because there was the possibility for DeCA's students, especially those who came from the new technologies branch to relate themselves with the character in the same way sports science students could relate themselves with the protagonist. The score distribution (Graphic 16) shows that the majority of students voted higher than 3 (half of the students voted 4 for the Hero and Staff member), meaning they're overall satisfied with the characters, and there were also no complains about the robot being annoying.

Table 13: Average Score for character preferences (DeCA)

Characters	"Hero"	Robot	Staff	Alexis
	3,29	3,29	3,21	3,07

Graphic 16: Score distribution for character preference (DeCA)

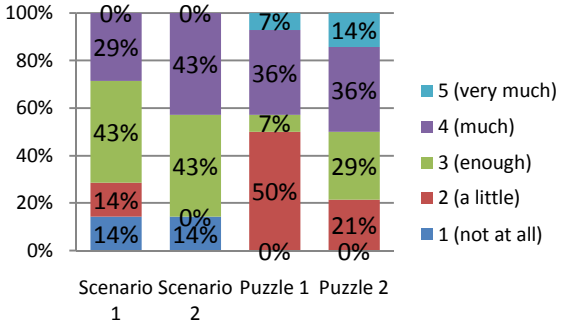


The students also preferred the scenario 2 over scenario 1 and the second puzzle had a higher positive feedback over the first one – evidenced with the score calculation in Table 14 and the score distribution in Graphic 17. These results can be justified with the performance witnessed during the tests: the students had difficulties with the calculator from the first puzzle.

Table 14: Average Score for scenarios and puzzles (DeCA)

Scenarios and Puzzles	Scenario 1	Scenario 2	Puzzle 1	Puzzle 2
	2,86	3,14	3,00	3,43

Graphic 17: Score Distribution for scenarios and puzzles (DeCA)

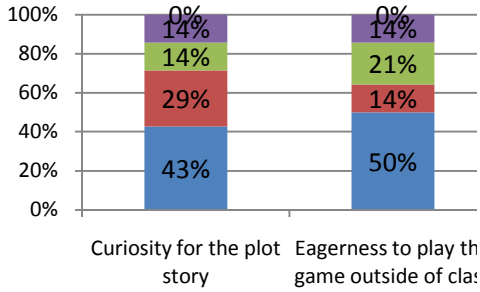


4.2.4. Opinions

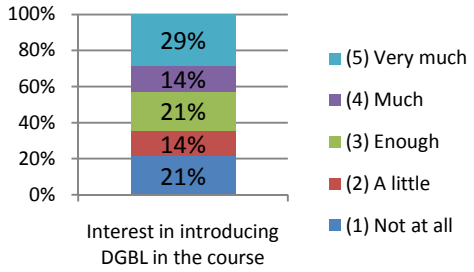
The curiosity for the game's plot conclusion is not enough to keep the DeCA students interested in the game: according to the questionnaires, 43% are not curious for the ending at all, there are few actually interested in knowing how the plot is going to end (Graphic 18). And if this game was part of their course as an education tool, they would not rush to play it outside of the

course, as half of the students are not interested in adding the game as an extra activity for their free time (Graphic 18). However, the students from the master degree course got to answer an extra question: *"Would you like to have a digital game based environment as a tool integrated in your course?"*. The answers were varied, with 29% very interested in including a game as part of their course (Graphic 19).

Graphic 18: Score Distribution for curiosity and interest to play the game outside of class (DeCA)



Graphic 19: Score Distribution for Interest in introducing digital game based learning in the course (DeCA)



If the results of the tests done to the students of DPESS were to be compared to the tests done by the students of DeCA, it would be possible to notice different reactions. Overall, the reception of the game by the DPESS students was more positive than the DeCA's. However, they also express similar critiques. The master degree students were mostly appealed by the graphics and characters and disliked the quantity of text present inside of the game. When asked about how this game could be improved they suggested, like DPESS' students, more challenges and less dialogues, but also suggested adding more hints to the puzzles and identify interactive objects in the backgrounds and make them more noticeable in the scenario. Only one person suggested starting the game from zero and redoing everything.

Students with gaming experience explained they were used to fast pace games (ex.: racing games, FPSs), which justifies their eagerness in skipping the dialogues and get to the puzzles. The game did not have enough action to attract them, however the gamer students did agree on the effectiveness of games as educational tools and would like to have a digital game based learning environment introduced in their master degree course for certain disciplines.

4.2.5. Difficulties detected during the tests

The investigator was present during the tests executed in DeCA and took this opportunity to speak with the students and watch the volunteers play the game. And while observation the students the investigator detected several design problems and repetitive tendencies from the students.

Not all students exposed the same patience with the dialogue, and kept clicking the left mouse button to skip the text. By not reading the instructions detailed by the characters, they would get stuck in the puzzles, especially in the calculator part, where students skipped the puzzle without calculating the team scores and then did not know how to answer the staff member. The students also did not consult the knowledge database inside the minicomputer.

4.3. Discussion of the results

From both sessions from DPESS and DeCA it was possible to retrieve a good evaluation over the game and enough feedback to proceed with the game development. These results help us understand what the sport science and physical education students wish to find in an educational game developed for their computers' course and see how well they would adapt to the gameplay and game rules, considering this is a game to be played during the entire semester.

There were a number of expectations to what the students would answer in the questionnaire, such as low motivation, moderate computer usage with great emphasis on the social networks, and the presence of a moderate number of gamers. It was also expected for the students to accept the game as an alternative learning tool compared with the traditional ones and a high interest in the story plot, environment and characters since they were developed specifically for the students. As the results show, some expectations were confirmed.

A brief set of conclusions from the results of the tests and questionnaires from the students of DPESS:

- The initial motivation for the Computers' course is average, and expected to decrease during the semester;
- The students found the game easy to interact with and acceptably appealing;
- The students' favourite character was Alexis. The students also preferred the first puzzle over the second puzzle;
- The students praised the narrative and graphics but disliked the quantity of text introduced in the game;
- The students were eager for more challenges and puzzles.
- Despite the positive reactions to the storytelling, the students do not find themselves interested enough in the game's plot conclusion nor playing the game during their free time.

The level of motivation was slightly better than what was expected, and the storyline was well accepted by the students. Curiously, the students preferred the first puzzle which included the diagram construction and calculator, over the second puzzle which included the insertion of a

memory chip in two computers in order to get different outputs. The difficulty of the first puzzle is higher than the second one and requires thinking and concentration while calculating the scores for the basketball teams. It can be concluded the students are looking forward for challenges with higher levels of difficulty which will force them to think while solving a puzzle.

The dislike for the robot character was not expected. This may be due to lines of dialogue not appreciated by the students or the lack of a functional hint system for the first two puzzles. Apart from this, the overall elements from the game had an average to good reception from the students. If the game were translated in Greek, it could be possible the performance would have been better.

As for the students of the Master Degree of Communication and Multimedia from DeCA, the testers were more "critical" with the game evaluation. Again, the reactions and responses from the students of DPESS are the most important ones for the development of this game because they are the target audience, but the students of DeCA provided insightful commentaries about the game and suggestions to improve it:

- DeCA's students did not find the game as appealing nor think they learned something with it;
- The students had varied opinions about the use of this game as an educational tool;
- Their favourite characters were the Hero and the Robot; they preferred the second puzzle over the first;
- The students had little difficulty exploring the game except for the calculator part. No translation was required for them;
- Gamer students who are used to action filled games found the game to be too slow for them.

Predictably, the students of DeCA reacted differently to the game than the students of DPESS and their contribution is undoubtedly valuable for the improvement of this project.

5. FINAL COMMENTS

5.1. Conclusions

First of all, a brief recap of the objectives set for this project before the development began. The initial goals were to identify game design elements for an educational game following the constructivist learning theory, create a game design document with all elements defined, develop a functional computer game prototype and finally proceed with the assessment of the mentioned prototype. The proposed research questions were about how a computer game can teach computer science concepts to the students of DPESS and help them regain motivation at the same time.

Considering the research presented in the second and third chapters, the results from the forth chapter and the hypotheses dictated in the beginning of this project, it can be concluded it was possible to achieve the established goals: a game design document was created to support the game development, and a functional game prototype with the first two puzzles included was put in trial with the students of two distinct university departments, where it received a mixture of positive reactions and detection of game design flaws to be corrected in the future.

There could have been two possible outcomes from the design of this game and consequent tests while answering the proposed investigation questions: either the game was accepted positively and proved itself effective in helping the students learn about computer science concepts and motivated them for the rest of the course; or, the game would fail to achieve positive critiques from both research groups, becoming necessary to start from zero and construct a new game design document, develop a different game prototype and test the application with the students once again. According to the data retrieved from the questionnaires and tests, a complete renewal of the game design document will not be necessary but it still needs to be improved.

Thanks to the questionnaires a simple profile was traced for the students: the majority comes from the Theoretical sciences path from the secondary education and their initial motivation for the computers' course is reasonable; the students are well acquaintance with the computer and take advantage of it for research and social networking; few claim to be gamers, and there was a small percentage of students who play casually on the computer.

Following the reactions recorded in the questionnaires, the enjoyed the narrative but are also eager to experiment new puzzles and challenges. With the storyline, interface and basic level design already defined, now it is a matter of expanding the game and introduce the remaining puzzles.

5.2. Study limitations

This is a project with potential but still in its infancy. There were several limitations during the course of this project being the most meaningful one the language and culture barrier between the investigator and the sport science and physical education students. As it was proved during the game testing sessions, the students have a poor grasp of the English language and during the period the investigator spent working in DPESS there were few students with whom it was possible to establish a conversation.

Technical limitations were also present during the game development. Flash had already been chosen as the tool of choice for the game prototype, but in order to implement playable features in the game prototype it was necessary to switch from ActionScript 2.0 to Actionscript 3.0. For the investigator this meant learning a new flash programming language from scratch with the aid of tutorials found in popular online communities dedicated to Flash. The investigator also took care of all graphics present inside the game, complicating the task organization between programming and design.

The prototype was supposed to be finished by the end of June 2010, but a change in the game design document and the implementation of the puzzles proposed by the instructors led to a

delay in the schedules. Until June it was only possible to complete a tech demonstration with a functional dialogue text box, inventory and first puzzle but no dialogues were implemented.

Because the game test session in DPESS was delayed until September 2010, it was not possible for the investigator to be present during the event, observe the students play the game and record their reactions. The course's instructor fulfilled the job and kept the investigator updated with the latest results and the students' reactions to the game prototype.

5.3. Critic Reflexion

While the results so far have been positive and the students enjoyed this game prototype, one has to question if the project could not have been better handled.

The game prototype, although it bears only two acts out of twenty, still had a pair of design errors present in its interface and hint system. Because the investigator worked in both graphics and programming at the same time, there were features and graphic ideas which were not developed in the end. The second game design document developed after the request of implementation of the puzzles is still lacking of the same elements already fulfilled in the previous document.

The development of the prototype could have been more rigorous in order to eliminate programming bugs, achieve better graphics, animated characters and cut scenes, and implement more puzzles. But there are few individuals who have managed to code and design at the same time and create complete games with little or no assistance of a team.

The fundamentals of the constructivist learning theory were present in the game prototype: students were allowed to explore and could already interact with items and learn from the experience, but perhaps the implementation of this learning theory could have been better executed. The ideals of the constructivism need to be strengthened when the next puzzles are implemented. It is a game with a linear walkthrough, but it should be granted more liberty to students and allow them to experiment what they want. It should be a game which students will want to play more than once to review the course material and make different experiments.

This is a development project which will be better executed if a team of two or more programmers and/or designers work on it. The following puzzles require advanced code, and the ideal would be to have a team of two individuals, one programming the game and the other designing the new interface elements, scenarios and characters for the following puzzles. If the project is advanced with one individual only, it will last for too long.

5.4. Future work analysis

5.4.1. Corrections and Improvement

Creating this game prototype was a gamble. One of the objectives was to prove the efficiency of this game with the unmotivated students of the Information Technology' course and while it could be said such goal was achieved with the positive reactions with the students, much could be done to improve the game design before implementing the following puzzles.

There was the issue with the quantity of dialogues and text inside the game which was heavily criticized by the students of DPESS and DeCA who preferred more challenges and less text inside the game. The game only had two acts implemented, meaning there are still more challenging puzzles to be introduced, but there is also the rest of the compulsory computer science theory and subjects which cannot be explained with just a couple of words. The best course of action to solve with the excessive text problem is to cut with the dialogues and restrict the content of the text boxes to what is important and essential. One idea proposed by a DeCA student was to substitute the introductory dialogues of each act with a short animation based on comic styled scenes describing the story and what has happened so far with images instead of text. This is an idea worth exploring if the image sequences are short and brief yet keep the player well informed about the story progress.

The hint system proposed via the slide menu may not be enough to guide the player while he is getting used to the commands and interaction. Like the introduction of a small pop up window during the calculator part to remind the player to calculate the scores first before switching off the mini computer, there needs to be more of those popup windows serving as an introduction to new elements, with simple clues. For example, almost nobody consulted the knowledge database because they are not aware of its existence. Unless the player turned on the minicomputer on its own, nothing in the game would indicate the existence of the database. To solve this, the first acts should work more as a tutorial, the puzzles remain but there are one time descriptions of the slime menu items, minicomputer and inventory.

During the tests realized in DeCA, only one bug was reported from a student: one of the images from an object in the inventory remained stuck in the screen and made it almost impossible to interact with the background. Bugs aside, there was one game design error which was not corrected in time due to programming limitations and the very linear path of events: it should have been possible to reuse the calculator before entering in the scene with the staff member asking for the team scores. This problem was made evident during the tests in DeCA because many students skipped the dialogues too quickly and did not pay attention to the text pertinent to the calculator puzzle, ending up stuck when the staff asks for the scores because they did not calculate them. And other students did calculate the scores, but got the results wrong and then there was no way back to the calculator. The students from DPESS did not report this problem, probably because the instructor helped translate everything from the game and the

students inevitably knew what to do in the calculator puzzle, while DeCA's students grew too used to the constant dialogue skipping.

Although few physical education students complained about it, the game has to be inevitably translated to Greek for their convenience and for a much more effective learning process. Especially the dialogues which can be found in a separate action script document among the game development files and is organized in such way it easies the editing process. But editing an Actionscript document can still be a complicated task if the individual does not know the basics. Therefore it is equally important to export the dialogues and other texts to a new type of document (ex.: .txt format) and make them readable by the flash application.

Other improvements to consider:

- Add better keyboard support to the game removing the restriction to the mouse for gaming;
- Enable crucial keywords to be enhanced in bold or different colours inside the text boxes;
- Enhance interactive objects in each background with colour contrast or soft light;
- Have two or more characters in screen instead of just one when interacting. This way it is possible to introduce the Hero to the same screen while interacting with other characters instead of being an almost void presence which the player cannot see. Also, animated stances instead of static ones;
- Rethink the robot character. The easiest course of action is to rethink its actions and dialogues. A more drastic measure would be to develop an entire different sidekick to support the player;
- Add more categories to the Knowledge Database, such as an image bank and a list of hyperlinks to relevant websites;
- Add names to the items in the slide menu and Inventory.

5.4.2. Future Features

After registering what needs to be improved in the game design document, it would also be important to implement other features before going forward with the implementation of more puzzles and acts. It is possible with the Flash tools to create save files for the game progress, something important to consider whatever the player has access to the complete game or receives parts of it periodically, according to the curriculum.

One much discussed feature was the implementation of a multiplayer mode in the game in order to encourage interaction and cooperation between students during the problem solving process. Multiplayer mode is possible with the Flash tools and playable via web browsers in dedicated websites, but there are some issues and questions to discuss, such as: relation of the multiplayer mode with the original game mode (is it related with the story plot or does it follow an independent narrative); gameplay (students play in separate computers online, or play in the same computer); type of challenges (similar to the original game mode or unique and different); cooperation or competition.

While the original game mode has to strictly follow the proposed curriculum for the course, the same should not happen with the multiplayer mode. Instead, it could be used as a study tool for exam preparation where the student cooperate or compete through a line of randomly generated questions or puzzles. If the main game is used as a learning tool, then the multiplayer mode could be used as a study review tool.

It would be much useful for the instructor to have access to the student's progress remotely to keep track of those who have completed the puzzles in game. If the students' save files are saved in a remote server located in DPESS, it becomes easier to create tools to verify the data inside those files and translate it to the instructor. For this, students should be required to "sign in" the game with their credentials.

Character personalization is another feature to consider. To what the point the protagonist should be personalized by the student is something best left for the next developers to decide, but creating a female counterpart for the Hero character and add custom names set by the student would be essential.

5.4.3. Studies to consider

With this project it was possible to bring an answer to the proposed investigation questions with a game prototype, but it also brought more questions, some worth exploring. For example, would a different game prototype with a completely different gameplay be capable of achieving a higher success rate among the students than this game prototype? By developing two game prototypes with notable distinctions and a different learning theory applied to them and testing them with the same target audience, it will be possible to form conclusions about which learning theory proves to be more effective inside a digital game based learning context.

It is also worth exploring the multiplayer mode of this game concept as an extra research project. The proposal would be to create a competitive multiplayer mode with multiple choice questions which can function as an alternative study tool for the students before an exam season. It could be interesting to allow the students to upload their scores to a database which both instructor and other students can check.

The narrative of this game has proven to be effective, it is now a matter of removing the excessive dialogues and exchange them for animation, and also improve certain personality aspects of certain characters. But would a game similar to the prototype without the narrative element continue to be as effective? To what point is the narrative absolutely necessary for an educational game?

Either way, the project itself is far from being concluded. Once the game is finished with all the challenges implemented and the gameplay improved, it should be tested once again with the students of the Information Technology course. It will not be the same target audiences as before because new students will arrive every year, but the basic statistics should remain almost unchanged, except perhaps their proficiency with computers.

6.
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