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Dinotopia a visual serious game  
An application for education purposes

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## Abstract:

Games in education have always been a tool for increasing motivation and interest of the students. What is presented here is a serious game with a purpose to motivate the student to learn about paleontology. The game is developed for Android OS, which nowadays is the most well-established platform for mobile devices. Through a virtual world with visual dinosaur's models, students are able to move around and "meet" with some of the most known species of Mesozoic era by using various interaction abilities of the game such as moving, eating, sleeping and even attacking that probably make these models more realistic.

The present thesis develops a virtual game for the Android OS based platform dedicated for the elementary kids who wish to explore and learn about a lost world that no longer exist: The world of dinosaurs.

The actual purpose of this game is not just the interaction of the students with the dinosaurs but the knowledge that would be acquired through the interaction with their figures. Learning through fun could be the actual description of this work which is trying to meet some of the educational standards of learning and educating such as basic information's of these ancient animals. Through gaming experience students would be able to distinguish the shape, the body anatomy, and the way these dinosaurs used to move and react. Of course, this game can't replace the books or any teaching methods. This serious game proposes is to prod the students to learn more about this ancient period of time.

The developed game is not entirely completed to be given to schools for learning. Instead, it is an example of how serious games with lots of afford can be developed by individuals or groups and make students to be inspired to learn through entertainment. This game as a basic pattern and a pilot for further development.

## Introduction

Gaming has always been a fun way for the people and especially for the students to learn new things and acquire skills (Prensky, 2003). Towards the end of the past century, video games become a worldwide phenomenon and are still taking an important place in various cultures. While games have been used throughout human history mainly for pure entertainment, they are now introduced in serious areas such as education. Serious games may serve as excellent tools to engage and motivate their players for learning (Hamdaoui, 2014). Games which few years ago were impossible to be handled by a mobile device now with the CPU development, processing became fast and easy. Tablets and mobile phones are about to replace the PCs (Personal Computers) and laptops because nowadays are powerful enough to do most of everyday schedules and moreover are cheaper than used to be few years ago.

This work concerns the development of a serious game that gives the ability to the students to get some basic knowledge about dinosaurs by combining both knowledge and entertainment. Learning through fun could be the actual description of this project which is trying to meet some of the educational standards of learning and educating such as basic information's of these ancient animals and also through gaming the appearance, the body anatomy, and the way these dinosaurs used to move and react. The scenario of the game takes place in an ancient exotic world where no human beings exist, and the ground and the surroundings were designed with lively colors and tall trees for being more attractive to the eyes. The educational part of the serious game was given through information buttons about the animals and quizzes. The entertainment part of the game was the thought of including a game within the serious game. The information for these ancient animals was taken from various scientific well-established documents and sites, while the scenario had to be in line with known learning theories. The application which is developed in the context of this work concerns mobile devices based on Android Operating System.

At the next chapters of this work, references take place about the propose of this paper. The first chapter is dedicated to electronic games the categories the most common characteristics of them and the advantages and the disadvantages of them as a teaching method in the classroom. The second chapter is dedicated to the serious games and their characteristics. There is also a small reference about game engines and how they work. The third chapter deals with the terms gamification and game base learning and the differences between them. The forth chapter is focused in detailed on game engines and the programming language which has been used for the development of this application. At the fifth chapter a description of the game takes place and also the methodology which has been used for the development of



it. At sixth chapter a search takes place on the internet, about similar games with this application. At this chapter the advantages and disadvantages of this serious game application are presented and an evaluation of it from the students. Finally, at the seventh chapter, conclusions and the prospects of this game development takes place.

## Chapter 1 Electronic Games

### 1.1 Characteristics of the electronic games.

The main element of the electronic games that makes them quite addictive is the element of fun, which is provided. According to (Prensky, 2003) a typical electronic game is consisted by six main characteristics. These should be:

- Rules
- Goals
- Challenge
- Interaction
- Scenario of the game
- Outcome and feedback

The rules of a game give the guide lines to the gamers to follow specific ways for being fair for all these players who will also play the game. Moreover, the rules are the driving force that keeps the player moving to action and to continue to play the game.

The interaction helps the players to see their progress and the achievements of their goals. To be able to do that, players should be capable to interact and change an element given by the game. The interaction should be immediate and able to inform the player whether the goal has been achieved or not.

The interaction can be achieved in two levels. The first one is the interaction of the player with the computer, mobile device or a platform. This also could be related with other players' interactions. This could easily be seen with games such as «World of Warcraft» (Blizzard, 2017) , «Lineage» (Ncsoft, 2017), «Second Life» (Secondlife, 2017) , and other similar games. Nowadays games such as these take the lead of the student choices. It is more than obvious that the interaction with other players makes a game more attractive to be played.

The conflict, the challenge and the competition are some of the elements that a game should have for being “addictive” to the player. One more element of what makes a game interesting is the imagination that should be implemented to the scenario.

## **1.2 Categories of the electronic games**

Due to the large variety of the electronic games, there is no any general category to include all the types of the electronic games. The electronic games are classified at four basic categories according to Prensky (Prensky, 2003):

- (a) the competition games,
- (b) those that are based on luck,
- (c) simulation games and
- (d) action or movement games.

There are newer efforts on classification of electronics games. In 2005, Hurst (Hurst, 2015) proposed a list of categories which are presented in detail in the following paragraphs.

### **1.2.1 Adventures games:**

At the adventure games the players have the leading role on a story where is “demanded” and usually have to solve different kinds of riddles and puzzles in order to be able to move forward and complete the game. The first adventure game used to have only text but with the progress of technology images and visual effects enriched the games and made them even seem more attractive to the players. Some of the most famous serious games are, «Day of the Tentacle» (Lucasfilm.ltd, 2017), «King’s Quest» (Sierra, 2017), the «Monkey Island» (Lucas arts - Disney, 2017) and others.

### **1.2.2 Educational games:**

The purpose of these games is, of course, learning. By saying learning that doesn’t necessary means that it was developed only to younger ages, on the contrary, these kinds of games referring to all ages, from three years old, teenagers and adults. There are numerous educational games each of those is referring to a specific level of knowledge and education and they are also called “serious games”. Most known examples of these kinds of games are the «Mavis Beacon Teaches Typing» (J.Sala, 2017) and the «Oregon Trail» (classicroad, 2017).

### **1.2.3 Fighting games**

This kind of games are usually focusing on the martial arts and the players have avatars with which compete each other, player versus player or player versus computer. There are many games to be mentioned. Some of the most popular

games from this category are the «Street Fighter» (Capcom, 2017), «Tekken» (Bandai Namco, 2017) and the «Mortal combat» (Midway Studios, 2017).

#### **1.2.4 First Person Shooter games**

The First-Person Shooter (FPS) games are mainly dominated mostly by male players. FPS games are also very popular because this kind of games raises the players' adrenaline up especially when the game is settled as player versus player and that makes it more interesting and competitive. At these games, gamers usually "see" through the eyes of the avatar which they control through keyboard or gamepad. This avatar usually uses a large variety of weaponry which is called to use for combat. These games are designed to give the player the feeling that is where the battle takes place. Some of the most popular games of this category are the «Doom» (id Bethesda, 2017), the «Half life» (valve, 2017), «Halo» (Microsoft, 2017), «Unreal» (Epic Games, 2017) and others.

#### **1.2.5 Massive online games or multiplayer on line games**

At these kinds of games, virtual on-line worlds have been created in order the players to have the ability to explore these worlds with their avatar characters. Players usually complete missions or fighting each other. Players can also interact to each other with many ways such as talking to each other via internet using programs like «Skype» (Microsoft, 2017) or typing messages if it is supported by the game itself, moreover players are able to complete missions or exploring the virtual game world, together. Two of the most popular games of this category are the «Line Age 2» (Ncsoft, 2017) and the «World of Warcraft» (Blizzard, 2017). Such popular these games are that lately a movie inspired based on the «World of warcraft».

#### **1.2.6 Music Games**

The challenge of these games is the player to be able to follow some musical sequences and to be able to develop specific rhythms. Some of them require from the player to compose melodies using a joystick or the pc keyboard. Lately these kinds of games can also be found at mobile platforms such as mobile phones and tablets. Two of the most Known games of this category are the «Dance Revolution» (Konami, 2017) and the «Guitar Hero» (Activision, 2017).

#### **1.2.7 Racing Games**

These types of games need no detailed presentation because they are quite popular. Usually the player sits on the driver's seat or has a spectator view of the car which controls. Usually players drive very expensive racing cars and have to compete against time, other players or combination of both. The racing games made their

entrance to our lives at the 70s and still are more popular than ever (Ign entertainment, 2017). Two of the most known titles are the «Gran Turismo» (Gt sport company, 2017) and the «Need for speed» (Ea inc, 2017).

### **1.2.8 Simulation Games**

There are many categories of games which could be presented as examples of how electronic games have been part of our lives. Since the propose of this thesis is not to present all the electronic games categories a small reference will take place of two categories of them which are considered to be the closest of what is called serious games. The purpose of the simulation games is, as their title refers, to simulate a specific activity as realistic as it could be. This means that physical and real-world restrictions are applied to a game of this category so as to be as realistic as it can be. Most known games of this type of games are the «Microsoft's flight simulator» (Microsoft, 2009), and the «Sims» (Ea games, 2017) series games.

### **1.2.9 Strategy games**

These games aim to achieve victory against other players or the computer artificial intelligence through strategic planning and management of the recourses which the game provides. It could be said that is a model of how real world works. That makes these kind of games, quite serious as well. Younger ages are not usually able to play this kind of games because it requires higher abilities of thinking and acting. Strategy games are divided into two subcategories, the real time playing category and the turn-based playing category. At the real-time strategy games, the players are able to play at the same time, the opposite happens to the turn-based games where the players waiting for their turn in order to play. Most of them are war games. Most known of these games are the «Age of empires» (Microsoft studios, 2017)and the «Starcraft» (Blizzard, 2017).

## **1.3. Electronic games and real world**

The games and a part of science are both games (Mayo, 2007). According to (Gee J. P., 2007) when playing a game, gamers usually follow some kind of rules and restrictions which give us the hind of how this specific world (game) works and why it works this way. By taking the scenario that we play a game for the first time, mistakes will be made but through them we become more experienced to be more efficient. Assuming, that a player tries to play a war game, the player should be able to think his moves and make guesswork for achieving the game goals. At the end of this process the player would probably have at least a general idea of how things work better in game and partly of the real world!

Software developers create world models more simplified than the real world, simply because the real world is quite complicated. These simulation models have the ability to train the gamer or the scientist. In science when a problem needs to be solved the scientists usually make a model that simulates the nature of a problem or anything else that they would probably study. By running this model scientists take results which lead them to continue their research. The difference between game simulations and science simulations is that the science's simulations usually are observed for extracting conclusions and results. That helps them to move forward their research by taking fewer necessary risks (Fishwick, 1995). Strategy games are a good example of how thought and conclusion work.

### **1.3.1 How games effect the way of thinking.**

The whole idea is to show how a game “a serious one” could make children's thoughts to be challenged by learning.

As science implies human brain works defiantly depending of the environment that we are usually live, work or study (Mithen, 1997). The mind is the ultimate tool which is used to make simple or complicated things possible. In our mind, we people, play games when we have challenges ahead for being prepared for them. Feelings, images and conversions that we have are the patterns for making a possible scenario for our next possible decision about a matter that concerns us.

A game often offers a kind of social interaction between people. A game is more than a software code in a box. It is software which helps people to cooperate, compete, create communities and generally helps to interact with each other (Μυσιρλάκη, 2014).

Games especially the serious ones and the science share the same two contributions values:

- The first one is that, in science and games, the knowledge is shared. The knowledge is not to be preserved to one or to the few only. In order the knowledge to be able to grow, the scientists just like the game players need to know how to combine and unite their knowledge to move forward.
- The second contribution is the cooperation which takes place among scientists or players. Each of them player or scientist, has a separate role, depending of the purpose which needs to be achieved. So, when a member of a team achieves even the smaller part of what needs to be done, in order the game or the research to be complete, that helps all the other members of the team to come closer to their purpose. No matter if that is gamers' team or scientists' team, it gives the feeling that it is rather safer being all together than each one of its own

accord. Nowadays our world becomes more and more complicated. What we need is to understand these complex systems that our world consists. The innovation, the critical way of thinking, the cooperation and the understanding lead people to the right way for facing challenges.

### **1.3.2 Modern teaching and learning theories**

Even nowadays most of the schools teaching methods unfortunately lacks the means to do so or the means which are used are limited. So, it is difficult for the students make the knowledge their “property” but that fortunately is starting to change as time passes (Οικονόμου Β, 2017).

Generally, knowledge is an aggregation of activities and experiences, otherwise the words which are read from the books or the computer devices will just stay typical words at student’s minds. That is one of the reasons why the students are not easily able to pass from theory to implementation of what it is taught in the classroom. That is connected to information processing learning theory which are focusing on how the students attend to environmental events, (such as classroom), encode the information to be learned and relate it to knowledge in memory. This memory is divided in two parts, the short-term (working) memory and the long-term memory (storage, retrieval). So, this learning memory is basically activated when learning involves forming associations between stimuli and responses of the students (Schunk, 2012).

For this reason, schools lately are starting to import serious games to their teaching methods for making their students more capable of learning things through visual experiences. (Arnab, 2012)

An example would be a geography class lesson. Let’s suppose for a moment that students are to be taught about the history of London. The traditional way of teaching would be able to implant the knowledge to the student’s minds only for a short time because as mentioned before words without any combined experience are not meant to be memorized for long enough into the students’ minds. For example, the combination of the conventional way of teaching (which is still partly an efficient way of teaching and will be), with a visualized London city in a computer using also in the same game a visualized time machine and a goal for the students to achieve in game. A goal could be to correct the historical past through decisions, students will have to take. So, what would be the result of this process of learning is easy to be answered: memorized learning through fun.

To the question of how this process works, the answer would be that it’s due to a triple interaction between the visual character which the player controls, the goals of

the game and the visual world itself. Accordingly, depending on how a serious game is designed to be played, “meaning the limitations, the rules and game abilities” that a game possess, the player has to find a way to achieve his goals. These game goals are usually given by increasing the difficulty of the game levels as player goes on playing the game. This gives the player the opportunity to increase his skills and understanding of how a problem can be solved (Robertson, 2008).

Unfortunately, even nowadays most of the people underestimate the teaching role of a game whether is serious or not. Whether people accept it or not, the serious games are a quite old and a successful way of teaching.

### **1.3.3 What can make a serious game successful**

At 1930s there was an idea that started firstly as an entertainment game, called “Link Blue Box Flight Simulation” but later has been used to train pilots at the Second World War; a model of this construction can be seen from Figure 1. Nowadays this kind of games is a reality for the pilots, military or not (Air Victory Museum, 2017).



*Figure 1-Link Blue Box Flight Simulation*  
(Museum, 2010)

The key word is the motivation which is the most important factor that would make a serious game attractive to a student. A good motivation could rouse students to play a serious game and even make it popular (Wouters, 2013).

When the motivation is not strong enough to keep the student interest then the learning process through this game is not efficient enough to fulfill its cause.

At games which have the multiplayer ability through internet, the players have the feeling that they take part to a long-distance action without being there. That's something that helps the body and the mind of the player to feel more active. For achieving the maximum player participation in a game, the gamer should be also able to control the character of the game as realistic as it could be. That could lead the player to make more decisions as the game process moves on, the player



becomes more attracted by the progress of the game, so this game becomes more “addictive” in a good way of course (Gee J. P., 2003).

Players through electronic serious games could have new experiences which couldn't be offered as easily to the real world. That could with its turn make them smarter and thoughtful. (Gee J. , 2004).

There are fourteen teaching points that a game is required to include in order being a successful serious game: (Gee J. , 2007)

- 1) Identity:** Every beginner player has to receive a new identity. The player should be bound with this visual identity. In this new visual world, the player should learn and react through his new identity.
- 2) Interaction:** The books are a passive way (but important) as mentioned before, for everyone to be taught any kind of knowledge. On the other hand, the books can't speak with us, in a way as an actual dialog takes place. The games can do it. The games answer to the players' actions and feedbacks new problems or solutions.
- 3) Productions:** The players have the role of the producers and not the one of the consumer because they take part of the action. Schools should work this way also.
- 4) Risk Taking:** A good electronic game gives the player the ability to take more risks with fewer consequences because they have the option to save the in-game progress. This process encourages players to make and try new things. Being failed in a game is something good because the player is forced to use his mentality in order to find new ways to achieve his goal. At school on the other hand there is not much space for failure and exploration.
- 5) Customization:** A game often can be adapted to the player needs and style. These kinds of games have usually different levels of difficulty and many other games have the ability of giving the player the choice of solving a problem with more than one ways. At the role-playing games each player within the limitations (game rules) of the game has his own way of playing the game which is affected by the level of the risk taking. That would be a good example of how the curriculum should be adapted accordingly of the player needs and interests.
- 6) Agency:** all the previous methods of teaching give the students the feeling of the ownership. That they are part of the school and they are subjected to the teaching methods which are used for learning. The serious games must be

configurable to the student's needs. Moreover, a serious game should be able to be configurable by the teachers also, because student needs and requirements change from time to time.

- 7) Well-order problems:** It has been noticed that when the students have to face a difficult and complicated problem on their own, they usually fail, and this failure can easily be seen even with the problems which are easier to be solved. Now, the well-structured electronic games are programmed with levels of difficulty. This means that the player should start with the easier problems and progressively solve the most difficult ones. So, an easy start gives the player time to think, act and finally solve the problem right. Leading students thinking to the right directions is the key also for a good method of teaching.
- 8) Challenge and Consolidation:** A good electronic game has a package of challenging problems which lead the players to solve them accordingly. The real challenge would be to summarize all the knowledge and test it in a head challenging problem. In games it's usually called "the boss" where players face this challenge for proceeding forward. The players now have the opportunity review what they have learned so far and teach themselves something new. This new knowledge is conquered with the knowledge repentances and that it's called "Cycle of Experience". At school, sometimes the most "weak" students don't have the opportunity of the knowledge repentances, so they are unable to conquer the knowledge and the good students accordingly don't have the challenges that will be useful for moving forward.
- 9) On demand:** Information and instructions are available most of the times but needs time to access them by the times that are needed. One more disadvantage of these manuals would be that sometimes are confusing and misunderstood. At games almost always, the information is given the right time when the player needs it. So, there is a good usage of this information and schools should provide information with the same way.
- 10) System thinking:** Games have the ability of encouraging the players to think the relations and the connections between the challenges and the problems and avoid a narrow way of thinking. Players now realize that their actions have effectiveness to other players' actions. In our world this way of thinking should be crucial to everyone.
- 11) Explore, Think Laterally, Rethink Goals:** One more thing that the games do is to help the player to rethink and evaluate the goals of the game and take more wise decisions. This also gives the player the opportunity to enhance his

progress faster. Unlike school, with games, students achieve their goals faster and more effectively.

**12) Smart tools and Distributed Knowledge:** Usually game characters are smart tools. They have their own abilities and parts of knowledge which are available to be used by the player. Let's take for example a game in which visual soldiers can move and act in a scene. The player has to command them and give the right instructions in order the soldiers to move and act. The knowledge that a player possesses is distributed between him and the soldiers. At a multiplayer game, players usually work within teams and each of the team player contributes with his own abilities. The knowledge at this point of the game is also distributed between real people and the visual characters of the game. Smart tools and distributed knowledge is the key for being the teaching successful to the modern schools.

**13) Cross – Functional Teams:** As it is written just above players in a multiplayer game usually use their own individual skills in a team work to achieve the team's goals. Each individual player understands his capabilities and weaknesses and tries to cooperate with his fellow players. In the play there are no race, nation or sex boundaries. All players are just a member of the team. So, union through teamwork should also be applied to the modern schools.

**14) Performance before Compete:** The well build electronic games have a principle which is quite the opposite with the one provided by schools. The player can act within a game before he is capable or experienced enough, simply because the game can help him to make his first steps. This kind of games usually uses smart tools, for example tutorials. In many cases more experienced players helps the beginners to take their first in game steps.

#### **1.4 Serious games applications in the classroom.**

The uses of the educational electronic games at the teaching process are gaining each day more and more ground. Research has shown that the electronic games help the player to develop his skills at studying, understanding and learning. This also applies to the games that were not meant to be created for educational proposes but still they are partly serious. As has been mentioned before a serious game could be any game that holds part of knowledge.

Here is an example of a list of games where a player can learn things from games that are not meant to be taught in the classroom.

- **Tropico:** (worldoftropico, 2017), The player here is asked to rule nations which are situated in islands. Building structures, harvesting resources and exploring are the challenges which the player has to face.



Figure 2- World of tropico

Here can be seen the actual control panel of the game and some of its functions

- **Sim earth:** In «SimEarth» (WONTEK, 2017), the player can vary a planet's atmosphere, temperature, landmasses, etc. furthermore players have the option of placing various forms of life and watch them evolve.



Figure 3-Simearth

Here can be seen the actual control panel of the game and some of its functions. The information is given to the player by images and texts.

- **Pirates:** (Meiers, 2017) Where the player revives historical periods and how the fights between these historical ships were taken place.



Figure 4-Pirates

The player can control his ship from different viewing angles using both keyboard and mouse to control the ship.

- **Apotheon :** (trap, 2017) A new game where players travels back in time in ancient Hellas and its ancient mythology in order to save the world.

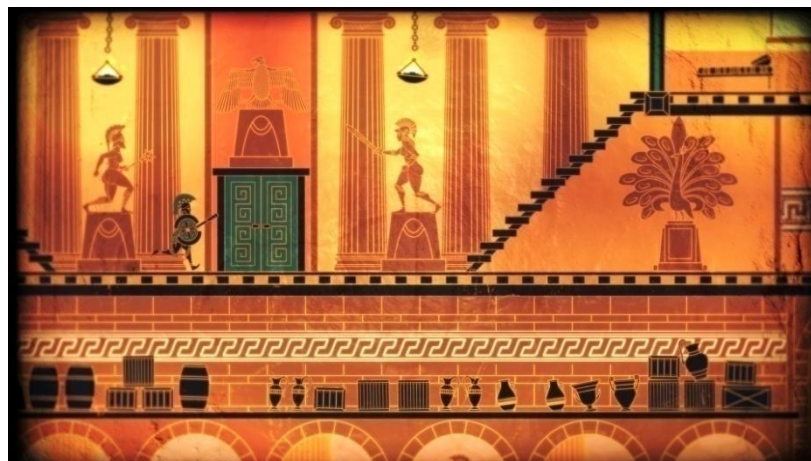


Figure 5-Apotheon

Here the player controls the figure of an ancient Greek warrior.

There are numerous of electronic games at which you are asked to manage a zoo, restaurant or even control an ancient army in order to rule and conquer (“Caesar series” (Activision, 2006) , “Age of Empire series” (Microsoft studios, 2017), etc.).

#### 1.4.1 Using electronic games in the classroom and the evaluation of them

Nowadays, the electronic games are in a period where they are being developed with the progress of the technology. So, it's not strange that through the electronic games a player can create entire new civilizations, explore new worlds, educate himself or being informed about matters of his interest.

According to (B.Βασιλείου, 2009) the electronic games can help the student to:

- Simulate the natural environment and observe the effects of their actions at the natural world.
- Inform themselves about culture, history, society, etc.
- Observe the process and the progress of any information like the ones above through time. Games can easily be programmed to travel a user in time.
- Have a three-dimension experience of the environment.
- To simulate their own prospective of the natural world or a system for analyzing and comparing the effects at it.

Nevertheless, there are plenty of difficulties of how the electronic games can be a part of the everyday teaching. A first one is that the ministries of education and more over the schools' teachers have limited information about the benefits of the electronic games. The teachers also used to have difficulties to perceive how a lesson should be taught in order to easily be linked with a serious game (Stege, 2011). The lack of time would be another issue for the familiarization of the teachers, with the right process of learning. Teachers should be able to know how to import a serious game at the class. Secondly, the Official School Program restricts the initiatives of bringing new innovating teaching methods to the class. The usual excuse is that time is short and precious for the things which are mending to be taught according to the teaching schedule. Another issue would be that a serious game is not always one hundred percent compatible with the teaching lessons.

## **1.5 Advantages and Disadvantages of the electronic Serious Games in the class.**

### **1.5.1 Advantages of the serious games in class:**

Nowadays, it is very common serious games to be applied for most of the mobile devices. Most of the students already own a mobile device as it is not that expensive for someone to buy such a device nowadays. Most of the schools cannot afford to spend money to buy electronic equipment so it is easier to use or develop a serious game and distribute it to the students for the class needs with almost no cost, except

for buying or develop a serious game. Connolly (Connolly, 2012) summarizes the advantages and disadvantages which the electronic games may have when applied in school environment (K.Καλέμης, 2016)

The advantages would be:

1. The development of basic learning skills, like the logical way of thinking and the independent way of thinking.
2. The encouragement of the interpersonal relations, which helps the students to combine their skills through competition and finally achieve the desirable outcome.
3. The potentiality of creating different visual characters which helps the players to develop tolerance to the diversity between them.
4. Activities which would be rather expensive or difficult to perform in the classroom now are way cheaper by being applied by a serious game.
5. Games that would be able to simulate the working environment of different kinds of jobs, could have been rather educational of students' future jobs.
6. Combatively games within the educational limits could help the students to relax themselves and balance their aggression.
7. Development of natural skills especially for the students which may have difficulties in movement.
8. Evolving mind abilities, for example the skills of problem salvation, the decision making and strengthen the short-term and long-term memory.
9. The combination between in school and out of the school activities. A combination like that could encourage the students to develop their skills out of the school environment.
10. The creation of a visual artificial environment in which the students with low self-respect would be able to feel more secure to explore, learn and express themselves.

### **1.5.2 Disadvantages of the serious games in class:**

On the other hand, serious games need to be applied within the educational limits and learning because otherwise they may have different results of the expected. The overuse of an electronic game could lead the students to low self-esteem and aggression. Moreover, it can occur the detachment of the students from focusing to

the class learning goals. That could occur easily because gamers most of the time are focusing to the goal of the game and not to the knowledge that they can have from it. By spending more than necessary time playing an electronic game, students may be distracted from their homework. Serious games ought to be very well designed especially for the younger ages because especially elementary students usually tend to mimic behaviors and could easily be confused between reality and a virtual environment. By spending excessive time with an electronic game, physical body symptoms could occur, like pain in the back or at the joints. Many of the games which are produced nowadays (hopefully not the educational ones') are tending to be violent in many ways and have a bad influence on the kids. Some of them are quite addictive and affect the gamers in a negative way, like having low self-confidence and being social self-isolated without being in mood to communicate with the fellow students or gamers. Most of the electronic games are aiming to be played by one of both sexes. That makes the both sexes to be kind of isolated from each other no matter if they are students or not. To sum up the games just like most of the things have both a negative and a positive side. (Gee J. , 2007). Of course, it is not expected from students to know it, but teachers should be able to show to the students the right usage of the serious games in order not to be at the expense of the teaching but being part of it.



## Chapter 2 - Serious Games

Serious games are considered as an excellent way to deal with motivational enhancements, so they can be used for learning (Hamdaoui, 2014). Serious gaming is, thus, games that engage users in their pursuit and contribute to the achievement of a defined purpose other than pure entertainment. Serious games also help in adapting the teaching process according to students' interests and capabilities (Breuer, 2010). Additionally, serious games must integrate pedagogical and learning objectives and that is a challenging task for the development of this kind of games (Gros, 2015).

### 2.1 Serious Games -description

The answer to the question of "what a serious game is", is easily answered, especially nowadays with the all this progress of the modern visual technology. An applied game or in other words a serious game is a game designed for a primary purpose other than pure entertainment. The "serious" adjective is generally referring to products which are used by industries like defense, education, scientific exploration, health care, emergency management, city planning, engineering, and politics.

Usually, serious games are designed to be simulations of the real world or designed for purposes of solving a problem or copy the behavior of a natural object such as weather elements or even cities. An example is a simulation game of how a city grows and prospers and is called «Sim City» (Origin, 2017). In a way this game is a model of a serious game. Serious games also considered to be a category of games of their own with different purposes. Serious games count back to the twentieth century. Decades before our time at 1960s and 70s the use of paper-based educational games used to be quite popular.

Serious games are considered to be helpful not only for the students but also for the teachers. To be more specific, one of their goals is to make teachers work easier. Of course, teachers should be aware of what a serious game can do for improving the educational methods. As far as we know the traditional way of teaching, (the one with the blackboard or marker board) still holds the lead even if the lessons tend to be kind of boring. Teaching tends to be boring not necessary because it's the teachers fault, or the lessons subject may not be as interesting as it should be, but because the students usually are mainly listeners, without any further interaction during the learning progress. Serious games could also easily be used for medical treatments especially with people which are disabled or may recover from an accident. Using a regular personal computer with motion sensors attached and equipped with a training serious game, people would be able to exercise their hands.

Catching for example a virtual object and moving it to the right position as the serious game requires. Virtual reality could easily be used for this purpose, but the expense is rather high for the time being.

It is also well known that serious games are often used for military purposes such as training at weapons, simulating a battleground or even training for war airplanes as can be seen from the flight simulator at Figure 6.



*Figure 6-Military flight simulator*

(Cubic, 2017)

Here it is shown an actual military flight simulator

In fact, the serious games belong to a new category of the electronic games and made their first appearance at the beginnings of the 21st century where the American government wanted to develop low cost simulation games for military purposes. There were two the basic motivations for the needs of their development (Mansour, 2008).

1. The first one is of course the cost. Simulating a part of the real world and being trained in it of course it costs less than acting in real scenery.
2. Secondly, is the element of entertainment. The purpose of the electronic games should be educated but without having the element of the entertainment the serious games would become simply boring. Entertainment is the key to make these kinds of games being attractive to the users.

## **2.1 Classifications of the serious games**

According to (Edutechwiki, 2017) the online encyclopedia, the serious games are classified at the following categories.

**Advergaming:** games with purpose the advertise. These kinds of games are usually developed from companies (interactional most of the times) for advertising their products. As can be seen from the Figure 8, the “m&ms” (m&ms , 2017) company

has developed a game which a player has to combine the colors of the m&ms sweets for completing the game levels.



Figure 7-M&Ms Game

(Funny games, 2017)

Here is shown the actual panel of the game with the colorful m&ms sweets.

**Edutainment games:** Games which combine both education and entertainment. Usually the information which is given at these games is as precise as it can be, that helps the player to decide his next move. As can be seen from the Figure 9, the player controls a character whose mission is to cover a distance with his wagon. During this “road trip” the player considers the weather conditions the food and other obstacles and needs for completing the trip.

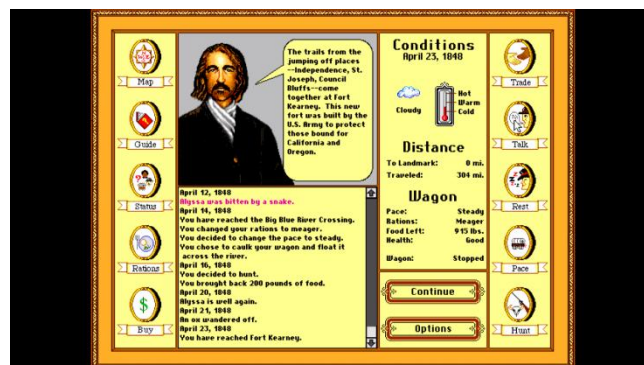


Figure 8-Oregon Trail Game

(Gaming Death, 2017)

Here is shown the panel which provides the player all the necessary information to complete the task.

**Science based learning games:** These are games with a dedicated learning content. These kinds of games keep a balance between the learning content of the game and

the knowledge of the user for taking the right actions. These actions should lead to a result which could be applied also to the real world. As can be seen from the Figure 10 the player has to create an antibiotic treatment for each different infection.



Figure 9-Virulence Game

(Boardgamemaniac, 2017)

At this game, students are having the opportunity to understand better how a virus works and what kind of treatment is needed.

**Edumarket games:** These are a combination of AdvergAMES and Edutainment games. As can be seen from below, (Figure 10) the player is asked to fill in the empty boxes with the right “Cisco” (Cisco, 2017) device which will help the network to communicate properly.

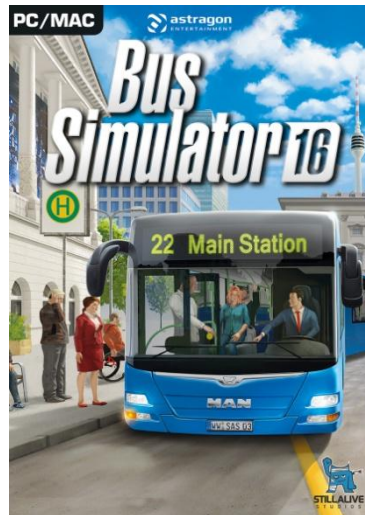


Figure 10-Cisco Game

(Serious game classification, 2017)

The figure 10 shows networks and they are connected.

**Simulation games:** These games are used to learn or develop gamer skills as if he was at a real environment. At the simulation game in Figure 11 the player has the role of a bus driver. So, the player can learn about the traffic code and drive his passengers safely to their destinations through five characteristic city districts.



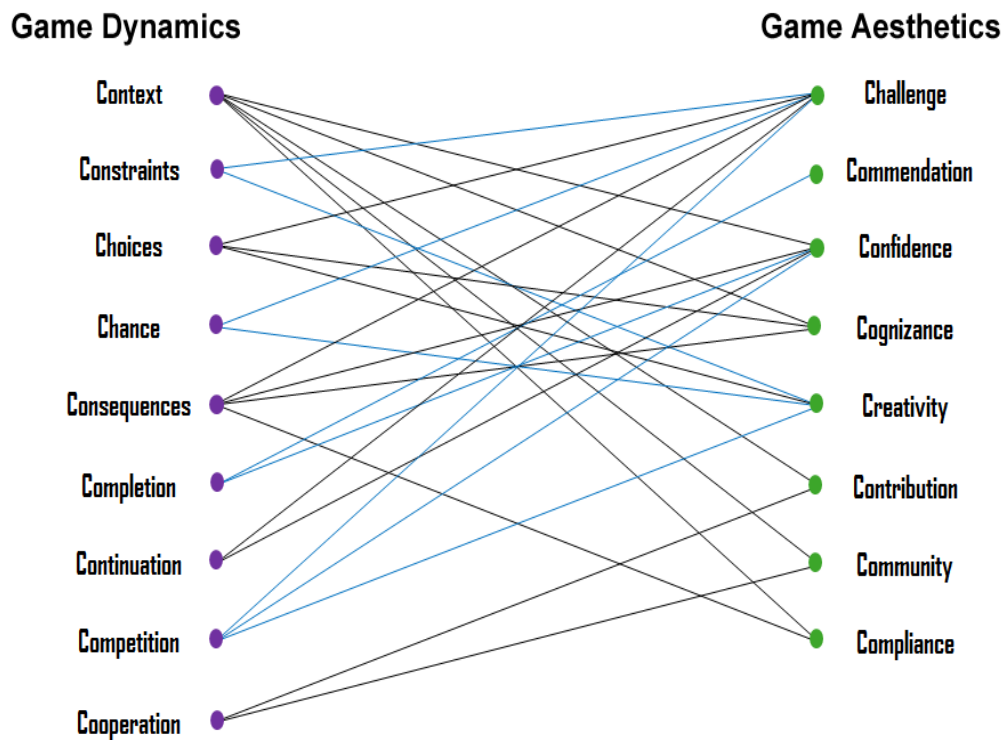
*Figure 11-Simulator Game*

(Bus simulator, 2017)

Many bus manufacturers such as Mercedes-Benz and MAN helped to design the buses as realistic it could be.

**Organization-dynamic games:** These games are usually designed for the specific purpose of further–personal development and character building, particularly in addressing complex organizational situations. When a managing change or an innovation diffusion in a company takes place, a game can help employees in the organization for introducing productive collaboration patterns, managing difficult meeting situations, etc.

Most of the games and especially the serious games consist of both dynamic and aesthetic elements. The dynamic elements represent of how a serious game is developed. Most of the serious game developers “plant” to their programming the elements of choice, competition, cooperation and many others as can be seen from the Figure 12. Each one of these elements is direct connected with one or more game aesthetics. For example, the dynamic game element of cooperation provides the player with the elements of community and contribution. So, the student has the chance to be part of a bigger group of students and learns how to work together to achieve a goal.



*Figure 12-Organization Game*

(Martin, 2017)

Here is a diagram of how some of the basic game principals connected to each other

**Games for Health:** These games have a medical content such as knowledge about medical treatments, restoration to a health state, etc. Games for health have a desired health outcome that can be either specific or general. Specific health outcomes, such as rehabilitation games, are easier to design and measure, but have a much smaller impact on the general population. General outcomes, such as exercise games (exergames) are much broader in scope and so have the potential for influencing the health of large parts of the population (McCallum, 2012). As can be seen from the Figure 13 for the developing of a serious game of health electronic or not, takes a lot of effort and expertise to be materialized.

## Games for Health Game Jam

- Gathers people with all kinds of backgrounds together for 24 or 48 hours co-creation event
- Combines health and gaming technologies, fast prototyping and community participation
- Promotes entrepreneurship and provides platform for cross-sectoral collaboration

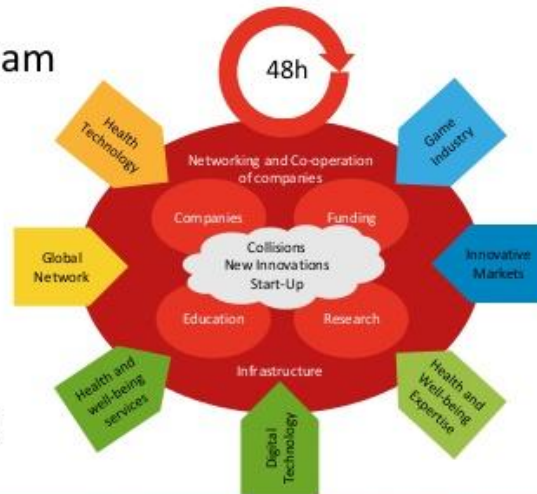


Figure 13-Health Games

(Kuopio innovation, 2014)

This schematic shows of combination of the modern technology with the game industry and medic science

**Art Games:** These games are used from the gamers to express their artistic ideas and materialize them. A good example would be the game with title ArtGames 2.0 by the “Albright-knox game development company” (Albrightknox, 2017) (Figure 14), which strives to harness young people’s enthusiasm for video games and interactive experiences. This game motivates the students to engage with modern and contemporary art. This game also aspires and creates new models for learning about art and developing visual literacy through gaming.



*Figure 14-Art Games*

(albrightknox, 2017)

Combining elements of fantasy, a creation.

## **2.2 Electronic Games versus Serious Games.**

According to the definitions which have been written above, a serious game is not fully dedicated to entertaining. On the other hand, when someone reads or hears the word game, expects the element of entertainment. It is expected and essential the element of entertainment to be part of a serious game, otherwise user will lose his interest of playing this game. Of course, the main feature of an electronic serious game should be the element of education. The element of education includes all these characteristics which pass the knowledge and creativity. Serious games are said that “steal” knowledge because the knowledge acquired through them can be transmitted globally without being noticed by the user (Χατζηαλεξιάδου, 2012). Players of these games can be educated in a safe protected environment (e.g. school environment) with significant less expenses which should be required if the school had to spent at an expense educated equipment. The serious games do not demand high-end graphics or a high processing unit to run, so most of the mobile devices could easily be used to play them (Φωκίδης, 2017).

An electronic game usually consists of these three basic elements:

1. The scenario (story).
2. The art.
3. Auditory the software.



When an electronic game is designed to be produced, the development team combines these three elements and produces the final product. The scenario team writes the story combined with elements of entertainment. The art team designs the multimedia components (visual, auditory, etc.) that would provide to the player the feeling of attraction to the game, and finally the software team writes the code of this game. The serious games include all these elements from above plus one, the element of learning. As written before this learning element distinguishes the serious games from all the other games. A serious game should be interesting first, so the element of entertainment comes first and that helps to enhance the educational element of the game. Finally, a team of educators, like teachers and scientists are cooperating with the developers of the game for making its content education oriented (Abeele, 2012). Because of this, this kind of games usually takes more time to be developed. The following diagram (Figure 15) shows a general model of the procedures which need to be followed for developing a serious game. For this propose there are several teams which are specialized at software, art, story and pedagogy development of a serious game.

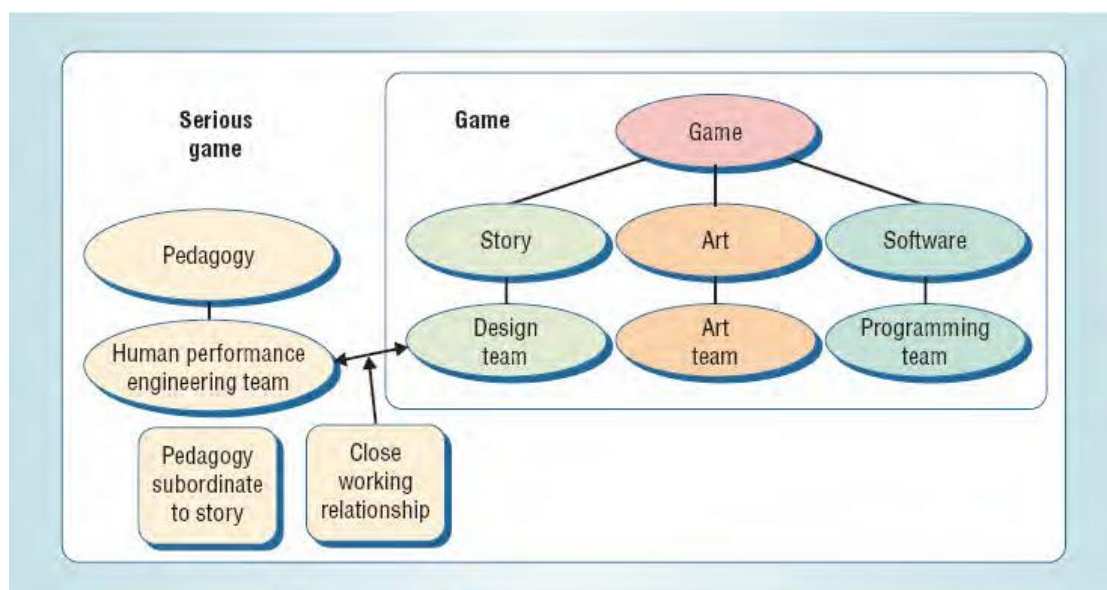


Figure 15-Serious games diagram

(computer.org, 2017)

Diagram of the development of a serious game.

## 2.3 Virtual worlds

At the past paragraphs the word “virtual” mentioned many times for the explanation of the content of the games, serious or not! Virtual world at (Coffman, 2007) is

defined as a computer-based simulated environment populated by many users who can create a personal avatar. A game which is called “Second life” (Linden Lab, 2017) is a good example of this kind of games. The “Second life” been used not only for gaming but also for educational purposes. The virtual world of «SecondLife» is created by its inhabitants. Residents have the potential to build meaningful objects, such as the Eifel Tower or a Revolutionary War community. Avatars appearances can have a human likeness, robotic, or animal likeness to represent them within the virtual world. You will also find colleges and universities creating environments within the virtual world.

The constructivist learning theory moves from experience to knowledge and not the other way around. In a constructivist classroom, the activities lead to the concepts; the students construct the meanings. So, constructivist learning dictates that the concept follows the action rather than precede it. The activity leads to the concepts; the concepts do not lead to the activity (Cooperstein, 2004). By utilizing a constructivist approach to learning within this community, students have the potential to discover content and create meaningful connections with the content through creativity and imagination. This ability to create learning environments whereby students can immerse themselves in the content has the potential for students to transfer lessons learned within the virtual environment back into their real-lives, thereby creating meaning with the content and ultimately connections with the concepts being taught (Coffman, 2007).

## **2.4 Virtual game engines**

A game engine is a software framework designed for the creation and development of video games. Developers use them to create games for consoles, mobile devices and personal computers. Visual Game engines usually provide a rendering engine for 2D or 3D graphics. Physics could also be provided as well as collision detections. Moreover, the sounds, the artificial intelligence, the animation and other techniques come to complete the whole package (Trenholme, 2008). In the next chapter some alternative game engines will be presented briefly for having a closer look of the options a game developer has for creating his own game. What Figure 16 represents is the “tree” of the evolution of the known engine, “Quake” engine. Based on this engine many game titles had been developed such as “Quake series” (Quake Video Games Series, 2018) and “Half-life series” (Valve, 2018) .

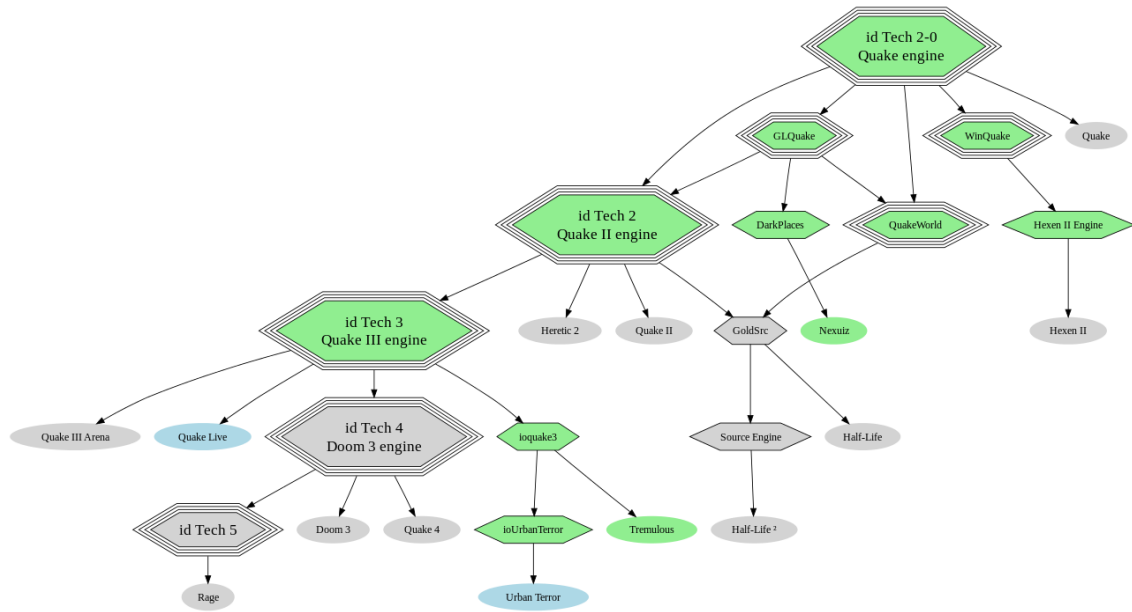


Figure 16-The Quake engine

(wikipedia, 2017)

Some game engines experience an evolution over time and develop a family tree. This schematic shows the development of the virtual engine “Quake” and the games that had been developed based on that engine.

## Chapter 3 - Gamification and game base learning

### 3.1. Gamification

If children are asked, “What is work?” They will say, “School and homework!!” But if they are asked, “What is play?” Many of them will say, “Video/games!!”. According to (Chou, 2013) the concept behind the term “Gamification is the combination of both learning and playing. So, Gamification is the idea of adding game elements to a nongame situation. Corporate reward programs are a good example. They reward users for certain behaviors. In the classroom, gamification has been integrated in a more authentic manner as some classrooms have become a living, breathing game. Students create a character, play as part of a team, and earn experience points and rewards based on class-related behaviors. Students are rewarded for helping other students, producing exemplary work, etcetera. Likewise, students can receive consequences for behaviors that are inconsistent with the desired the learning environment. Quests and tasks can be set from the teacher in order the class team to work together for achieving the educational outcomes. What follows are some screenshots of the game that show how «Classcraft» (Classcraft, 2017) is constructed and works.

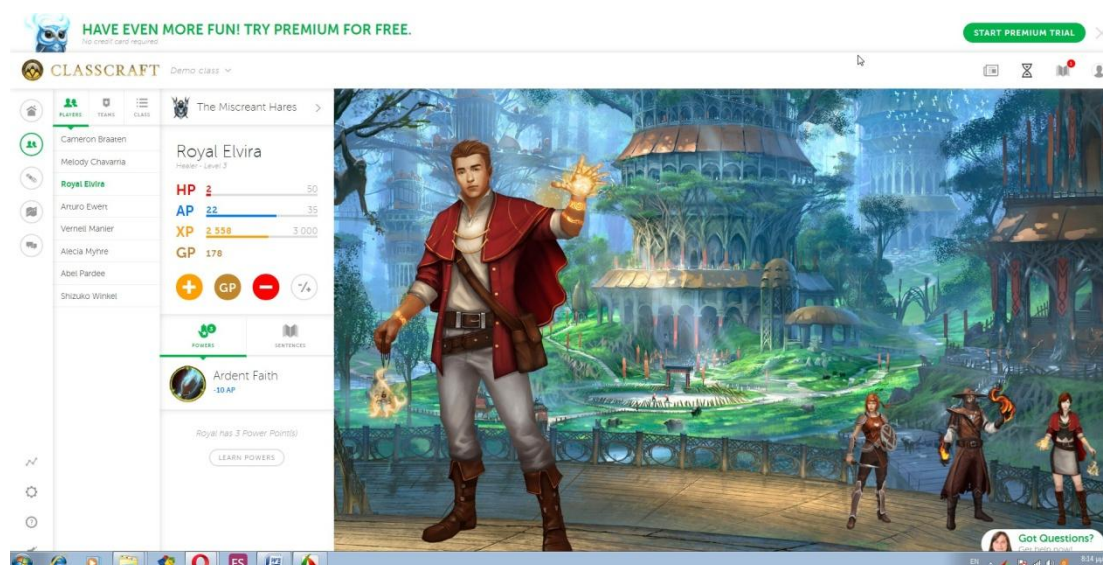


Figure 17-Classcraft game

(Classcraft, 2017)

The main interface of the game

Here is one of the avatars (Figure 17) of which a student can choose, if wishes to become an active member of this game. As can easily be seen from the screenshots

below the teacher as a game master is able to upgrade or downgrade the characters of the students depending of what has mentioned to the paragraph above.

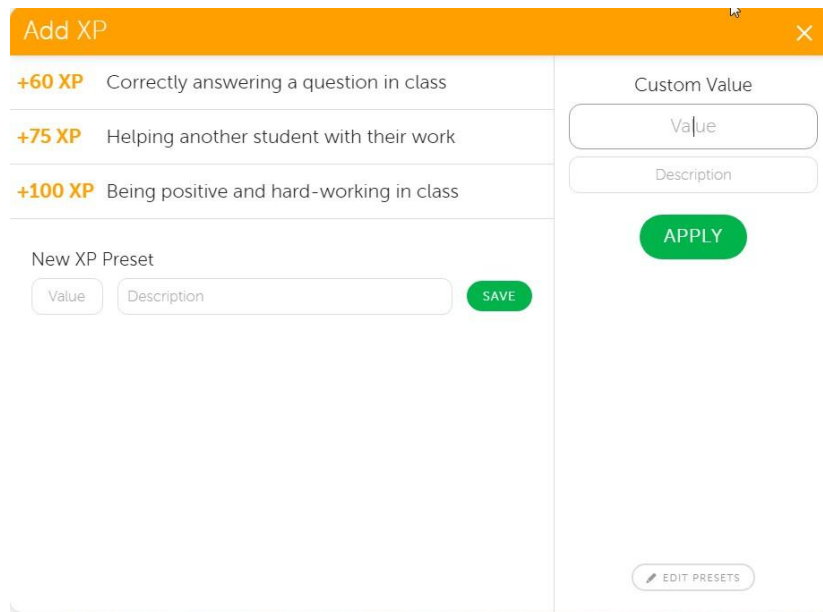


Figure 18-Classcraft screenshot 1

Adding points to student profile

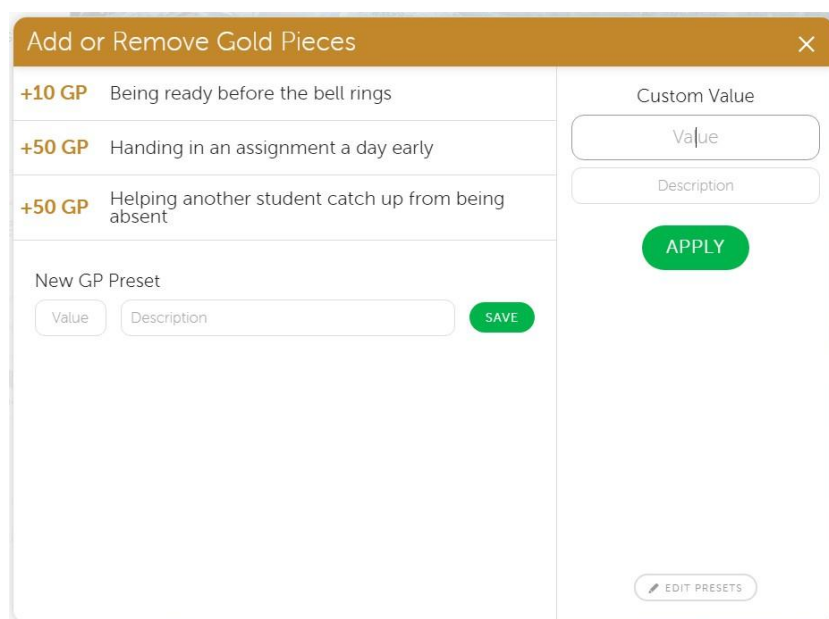
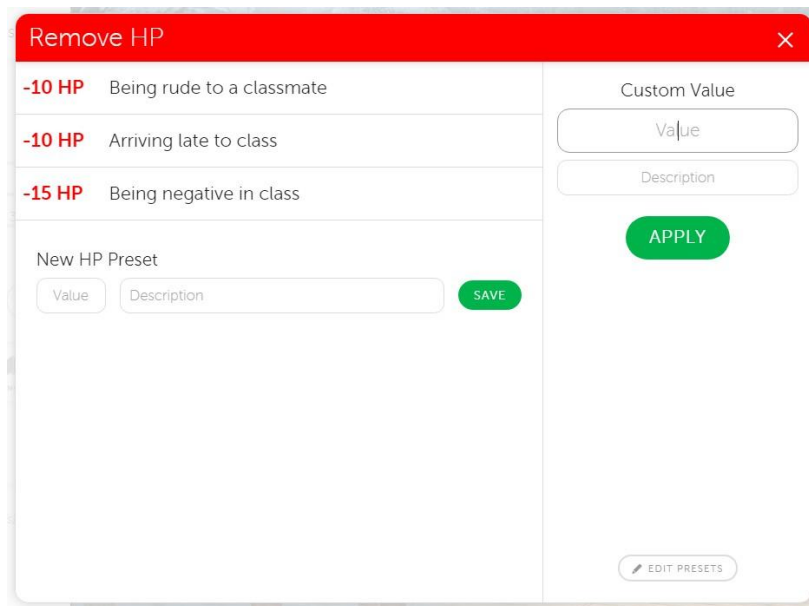


Figure 19-Classcraft screenshot 2

Giving or removing rewards, depending on student behavior in class

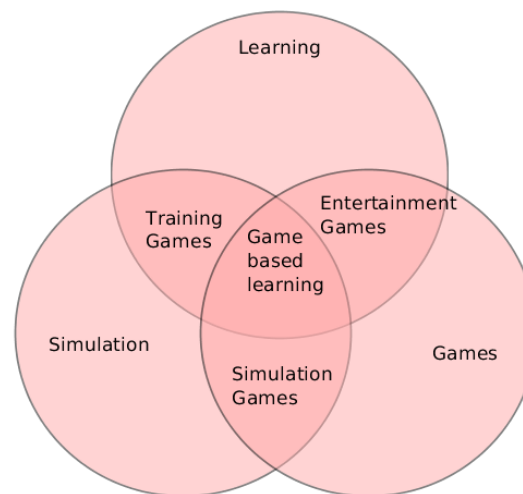


*Figure 20-Classcraft screenshot 3*

Removing rewards, depending on student behavior in class

As we can be seen from Figures 18,19 and 20 above a non-game situation becomes a game experience situation (gamification) within class with many elements of a role-playing game. This application can also be installed on mobile devices. So instead of courses consisting mainly of textbook learning and lectures, classes are being built using game mechanics such as badges, experience points, levels and leaderboards, boost student engagement by allowing students to choose from “quests” and progress at their own pace through a series of educational activities.

### 3.2 Game-Based Learning



Interplay of pedagogy, computer science and games, Martens et al 2008, p.174  
in Ulicsak, M., and Wright, M., 2010. Computer games and learning.  
Bristol: Futurelab, Figure modified by D.K. Schneider

*Figure 21-Game based learning*

**(Martens, 2014)**

This figure shows that the game-based learning includes aspects from both learning and gaming.

Unlike gamification, (Isaacs, 2015) game-based learning (Figure 21), relates to the use of games to enhance the learning experience. Educators have been using games in the classroom for years. Students don't need more time in the classroom to learn how to think and perform in the face of real-world challenges. Students need effective, interactive experiences that motivate and actively engage us in the learning process. This is where game-based learning comes in. As it turns out, for many years, videogame designers have been producing and refining highly motivating learning environments for their players to enjoy. Good game-based learning applications can draw us into virtual environments that look and feel familiar and relevant. This is motivational because students can quickly see and understand the connection between the learning experience and their real-life work. Within an effective game-based learning environment, students work toward a goal, choosing actions and experiencing the consequences of those actions along the way. They make mistakes in a risk-free setting, and through experimentation, students actively learn and practice the right way to do things. This keeps students highly engaged in practicing behaviors and thought processes that we can easily transfer from the simulated environment to real life (Hauge, 2012).

In contrast, traditional, passive training approaches drill students on certain narrow procedures, and then evaluate them on their memory of what they were told. Even if successfully retain the lesson's facts and procedures, their behavior in true-to-life

situations remains untested. At this point it is worth to be mentioned the “Civilization” (SID Meier's, 2017) game series. At these games series the player has the leading role of building cities and generally civilizations and make the them expand and prosper. One of the latest releases of this kind of games is called “CivilizationEDU” (Figure 22) (Carmichael, 2017).

# CIVILIZATION **EDU**



Figure 22-Civilization edu game

(SID Meier's, 2017)

The game map and the controls of the game

The developers’ description about the “CivilizationEDU” is that it provides students with the opportunity to think critically and create historical events, consider and evaluate the geographical ramifications of their economic and technological decisions. Also, it gives opportunities for engagement in systems thinking and experiment with the causal/correlative relationships between military, technology, political and socioeconomic development. In addition, GlassLab Inc. has added a learning analytics engine to “CivilizationEDU” to capture students’ progress and assess their problem-solving skills harnessing the popularity and innovation of interactive entertainment and turning it into a powerful tool for the classroom and alternative to standardized tests. Teachers who use “CivilizationEDU” have access to an online dashboard that will provide reports on students’ progress, demonstrating how in-game accomplishments relate to problem solving; developer diaries; gameplay tutorial videos, and instructional resources. Also includes an in-depth



gameplay guide and lesson plans aligned to academic and 21st century standards. What follows at the next chapter is a presentation of the implementation of a serious game (this project), which is called “Dinotopia”.

## Chapter 4: Game engines, programming language and OS.

### 4.1. The Unreal Engine

The “Unreal Engine” (Unreal engine, 2017) is a game engine developed by Epic Games. This game engine is chosen because it is well known from the games which have been made since 1998. The games “Unreal” and “Unreal tournament” (Epic Games, 2017) are two of the most known first-person shooter electronic games which has been developed by this visual game engine.

#### Features of the unreal game engine:

- Photoreal Rendering in Real Time.
- Robust Multiplayer Framework.
- VFX & Particle Systems.
- Extensive Animation Toolset.
- Full Editor in VR Mode.
- Advanced AI.
- Built for VR (virtual reality) and AR (augmented reality).

This game engine provides projects with several tools as it can be seen from Figure 23 for helping a user with little experience to start creating a visual game easier.

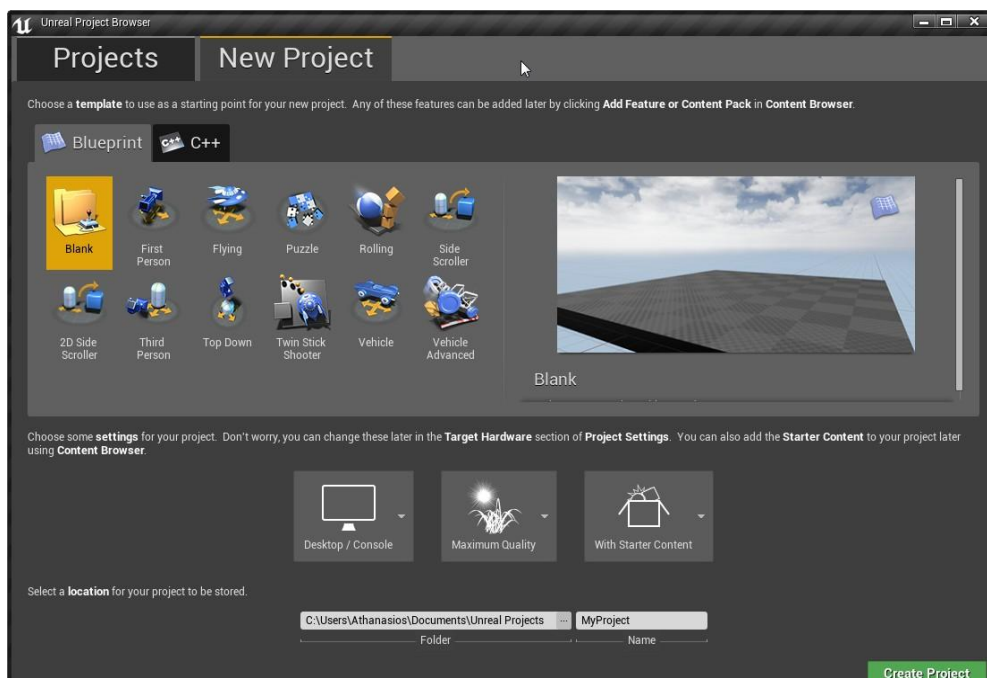


Figure 23-Unreal game engine

There is a variety of options for a developer to start with.

Also it provides a lot of tutorials (Unrealengine, 2017) which are available for a game developer to use if it is needed and videos with examples. Some extra screenshots have been attached (Figures 24 & 25) presenting the tutorials which are provided in the official web page of the unreal engine (Unreal Engine, 2017) .

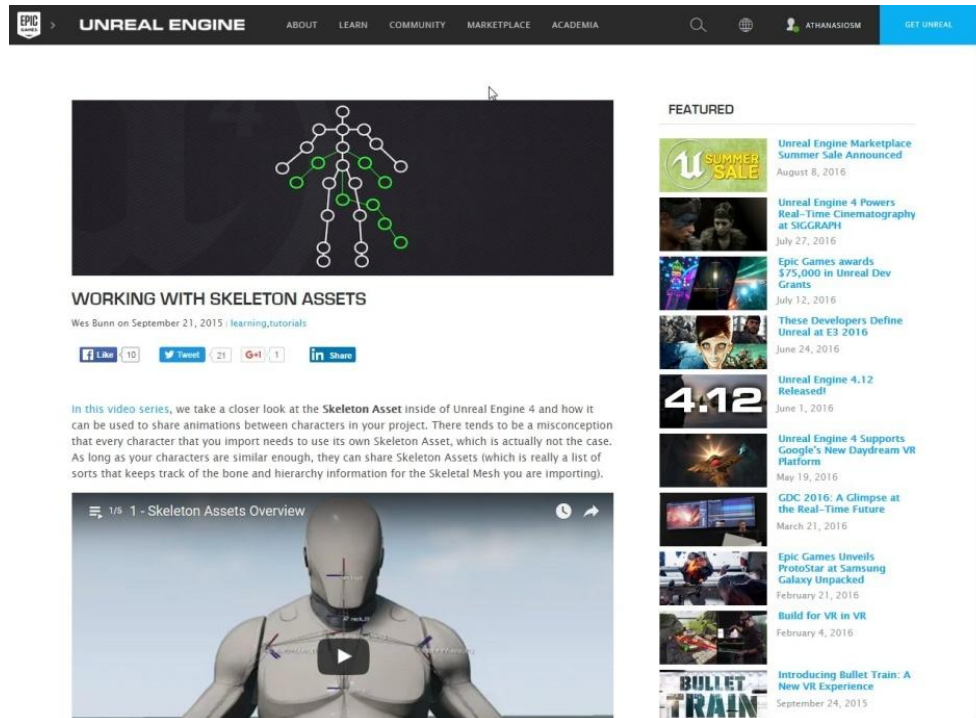


Figure 24-Unreal tutorial screenshot 1

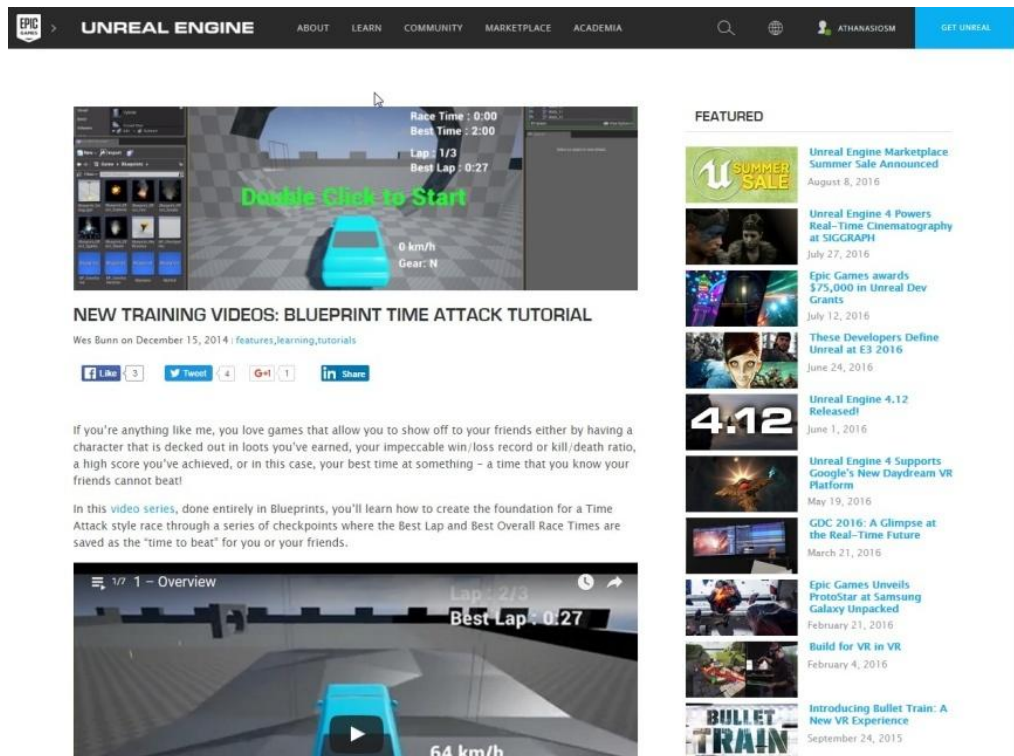


Figure 25-Unreal tutorial screenshot 2

## 4.2 The Cryengine

The "CryEngine" (Crytek, 2017) is a game engine designed by the German game developer Crytek. A series of games were created by "CryEngine" known as "Far Cry series" (Ubisoft, 2017). These games used to be and still are very popular. "CryEngine" is still producing many of the most graphical realistic games. Except the "Far Cry" series the developer also produced many spin-off games, including all Far Cry series games.

### Features of the CryEngine:

- Physically based rendering.
- Material Editor (physically based materials).
- Cinematic Editor.
- Character Technology (Detailed determination of every wrinkle of the skin and every hair on the head of characters).
- Advanced Physics.

- Efficient Build System.

At the user interface which is presented below (Figure 26) the developer names his project and chooses the programming language of his choice. There are two options, for programming languages: C++ and C#.

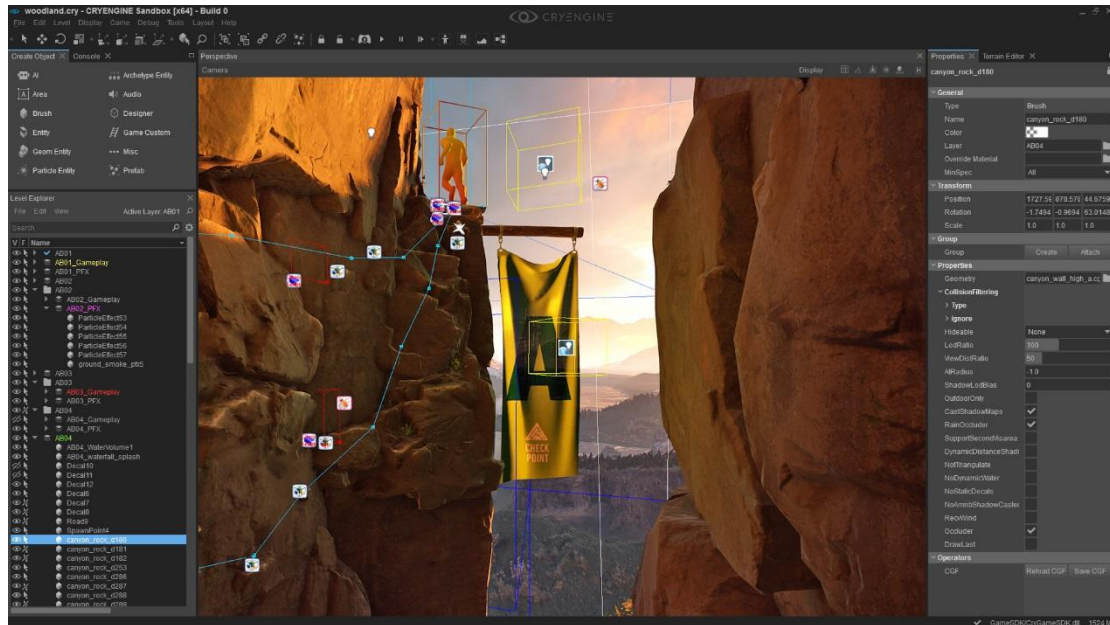


Figure 26-Cryengine

This is the actual console where a developer starts to work with this engine. As it can easily be seen, there is a similar “philosophy” with the “Unreal” gaming engine, so as with the “Unity” engine which is presented below. That’s quite normal considering that the needs of a modern game are actually the same, the environment, the scenario, and the physics. Just like “Unreal” engine, there is a marketplace full of assets and packs of them (Figure 27). That is very important for some who don’t want to start from zero or for someone who wants to get some new innovative ideas. CryEngine has a variety of tools for helping the user to develop its own game.

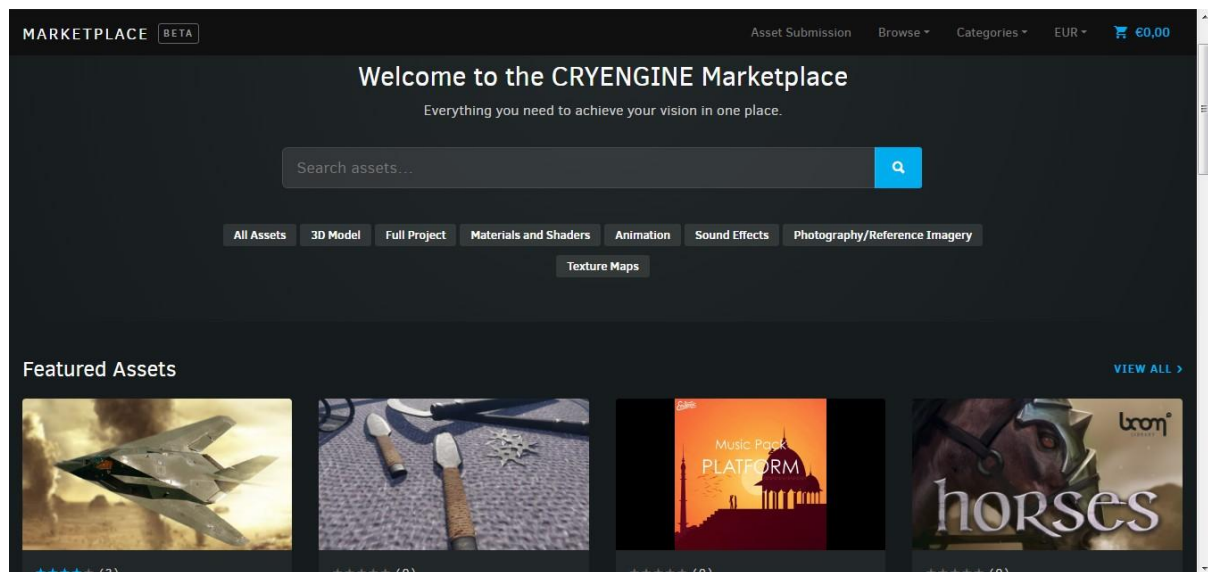


Figure 27-Cryengine marketplace

Here can be seen the search option of the Cryengine market place.

### 4.3 Unity engine

(Unity, 2017) is a cross-platform game engine developed by Unity Technologies and used to develop video games for PC, consoles, mobile devices and websites. First announced only for Operating System “OS X”, at Apple's Worldwide Developers Conference in 2005; it has since been extended to target 21 platforms. It is the default software development kit (SDK) for the “Wii” (Nintendo, 2017) . The term cross-platform means that this gaming engine can be implemented on multiple computing platforms. Cross-platform software may be divided into two types; one requires individual building or compilation for each platform that it supports, and the other one can be directly run on any platform without special preparation. Unity is the game platform which has been used which has been used to develop the software of the present project. The main user interface can be seen from Figure 28. It is selected because it is a well-tested tool which can be applied to many platforms.

#### Features of the Unity Engine:

- Rich & Extensible editor
- Graphics Rendering
- Virtual and Augmented Reality
- Multiplayer support
- Performance optimization
- Art and Design tools
- Multiplatform capabilities

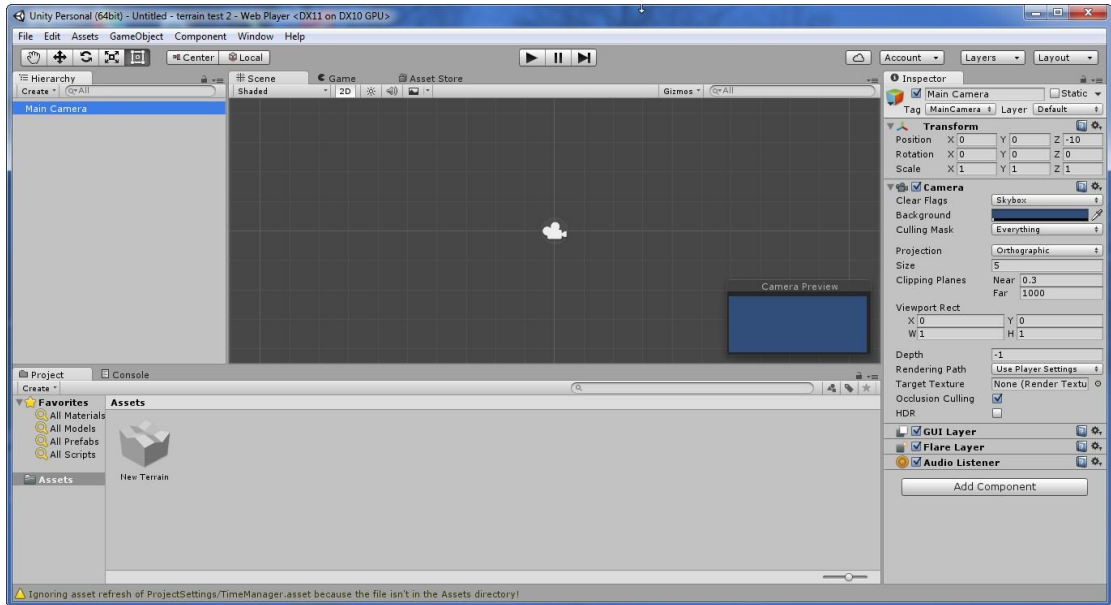


Figure 28-Unity engine

The screenshot above shows the first screen which appears on screen.

This game engine also provides a large variety of assets for game development. It is easy to create an asset or import as it can be seen from the screenshot below, (Figure 29).



Figure 29-Unity engine screenshot

This asset imports trees and cactus models for Unity Engine

One of the reasons “Unity” engine has been chosen is that, it has a vast variety of models and packs of scenes forests, rivers, towns, animals and plenty more.

#### 4.4 A few words about language C#

The program language which has been used for the development of the software application in this project is C sharp (C#). This general-purpose language was originally designed by Microsoft to be used for developing applications on Microsoft's platforms. Many developers love this language for being pleasant to use and well-designed also C# is often the recommended language to use when making games through Unity Game engine. C# was designed to be simple and easy to use, since C# is a high-level language, it reads somewhat closer to English. In addition, C# abstracts away (i.e. handles for programmer) most of the complex details of the machine so user can focus on programming instead of worrying about the little details many consider both tedious and difficult. C# is a statically-typed language, which means your code will be checked for errors before it gets built into an application. Errors will be easier to track down, and since statically-typed languages are also stricter with how a programmer codes something; the codebase in general will be more consistent and thus easier to maintain as it expands in size and complexity.

The following is a very simple C# program, a version of the classic "Hello world" example:

```
using System;

class Program
{
    static void Main(string[] args)
    {
        Console.WriteLine("Hello, world!");
    }
}
```

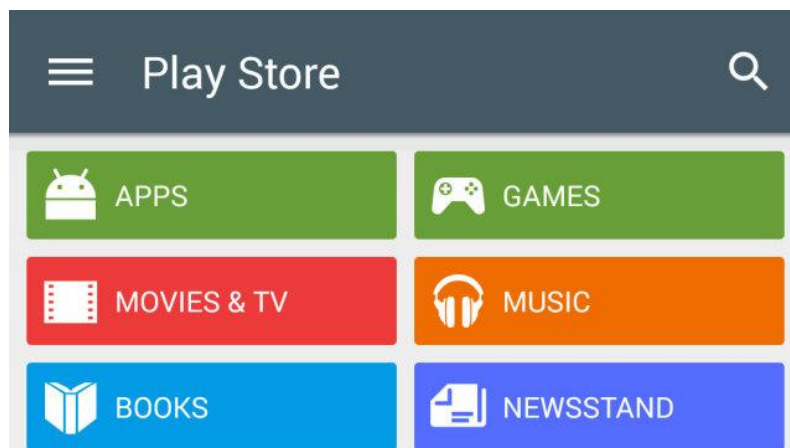
What will display on the program is: Hello, world! Each command line has a purpose, but this is just a small reference about this programming language that has been used for the software development of this project.

#### **4.5 A few words about Android OS**

Android is a mobile Operating System (OS) developed by Google, based on the Linux kernel and designed for touch-screen mobile devices such as smartphones and tablets (wikipedia, 2017). Android OS is basically a piece of software which allows hardware to function. The Android OS, gives access to applications (apps), including many of Google's own creation. These allow users to look for information on the



web, play music and videos, check your location on a map, take photos using your device's camera and plenty more besides. What makes Android OS so popular is that Android phones are highly customizable, so they can be altered to suit to everyone's personal preferences and needs. One of the many reasons which make the Android OS so popular is that a user can download easily without any charges from the Google play (Figure 30) thousands of applications.



*Figure 30-Google play store*

(Google Play, 2017)

The front-page menu of the Play Store

## Chapter 5 - Dinotopia

### 5.1 Description of the game

Dinotopia is the name which is chosen to be given to this game. There is a TV series which is also called by the same name (IMDb, 2017). The main characteristic of the movie, (Figure 31) is the existence of the dinosaurs but apart from that, there are not any other similarities between this project and the movie.

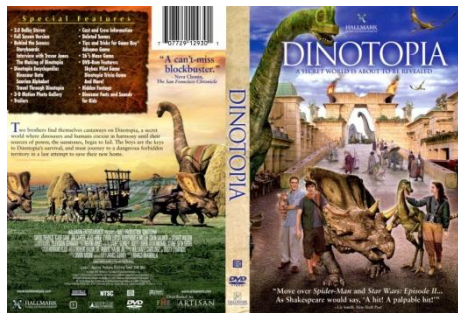


Figure 31-IMDP

(imdb, 2017)

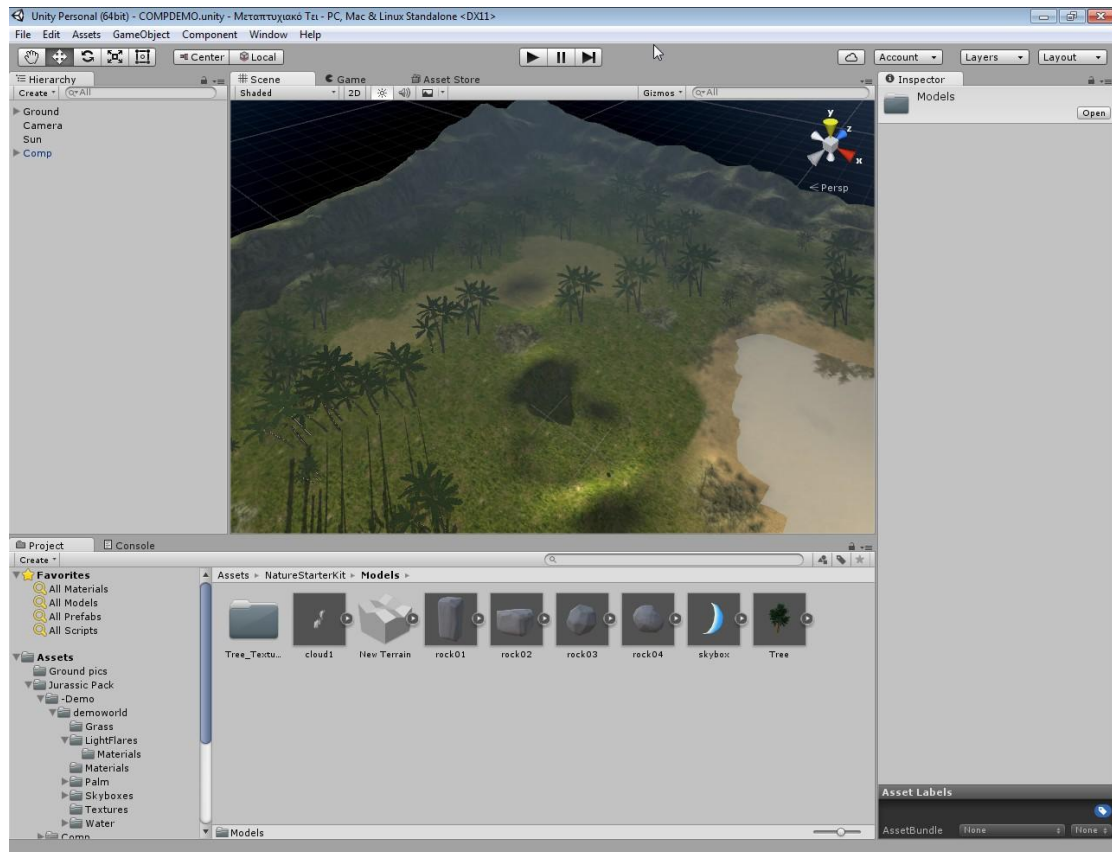
The cover page of the movie

The application of this work has been developed as an educational game with the objective to teach students some basic information about these animals.

During the development of “Dinotopia” game, what was realized is that the paleontology is a big part of science. According to (Sereno, 1999) paleontology is the scientific study of life that existed prior to, and sometimes including, the start of the Holocene Epoch (roughly 11,700 years before present). It includes the study of fossils to determine organisms' evolution and interactions with each other and their environments.

There is plenty of scientific information online which can anyone find about these ancient animals and that helped game’s development a lot in materializing this project. As explained before a game considered to be serious because it combines both knowledge and entertainment. For this reason, dinosaurs should be accompanied with data, in other words, information for every species individually plus the element of the game play. Unity engine (Unity, 2017) was chosen to bring these ancient animals to “life”.

Firstly, it had to be decided how the environment should be. The landscape has been designed in Unity and the necessary dimensions were given for the animals to be and move in it.



*Figure 32-Unity game engine environment*

This is a part of the actual terrain sightseeing.

Unity has the ability like most of graphic engines to form the virtual environment. As can be seen from Figure 32, trees planted, and the water element also added in the scenery to make it look more realistic. As the purpose of this work was to develop a basic serious game, the natural models, land, trees, water, sky and many others (3D or not), were not created from scratch, but the ground of the terrain.

Of course, Unity engine provides the developers the tools to design almost everything a developer needs. Trees and rocks for instance were imported from packages which are shown at Figures 33 and 34. Specific procedures were applied that considered the details about dimensions of various items for fitting at the scenery.

The same procedures followed with the models of dinosaurs although here things begin to be more complicated. These animals' models shouldn't be static otherwise the game would be very boring. Appropriate C# code is used for making these virtual animals walk, sleep, eat and attack.

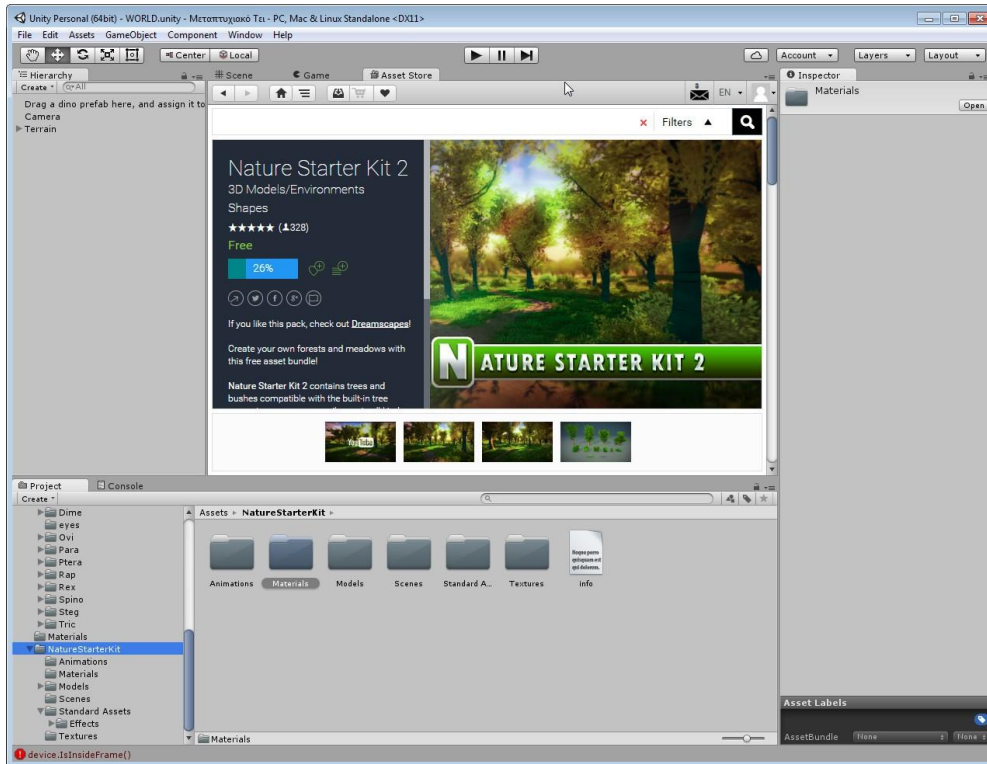


Figure 33-Unity asset pack

Importing an asset pack



Figure 34-Asset packs contents

Example of asset packs contents like trees and rocks.

## 5.2 Methodology

At this chapter a methodology of educational technology will be presented which is used for the proposes of this thesis. It is called ADDIE model and it is an acronym of the terms Analysis, Design, Development, Implementation and Evaluation. According to Allen (Allen, 2006), "The ADDIE Model", (Figure 35) was first created for the U.S. Military during the 1970s by Florida State University. The original goal of ADDIE was to increase the effectiveness and efficiency of education and training by fitting instruction to jobs—eliminating peripheral knowledge from courses while ensuring that students acquired the necessary knowledge and expertise to do the job. Instruction was to be provided in the areas most critical to job performance and was not to be wasted in areas having a low probability of meeting immediate or critical long-term needs. The ADDIE process prescribes a series of procedures that addressed decisions about exactly what, where, how, and when to teach the skills, knowledge, and attitudes needed to perform every task selected for instruction. Today's concerns include not only classroom instruction but also instruction that is exported to the job site using new delivery methods and technologies. New automated instructional development tools can make the instructional development more efficient. Building quality in instructional systems is a key concern. Other concerns are the concept of totally integrated training systems and how the ADDIE process works in different applications such as systems acquisition, education, management development, and technical training programs.

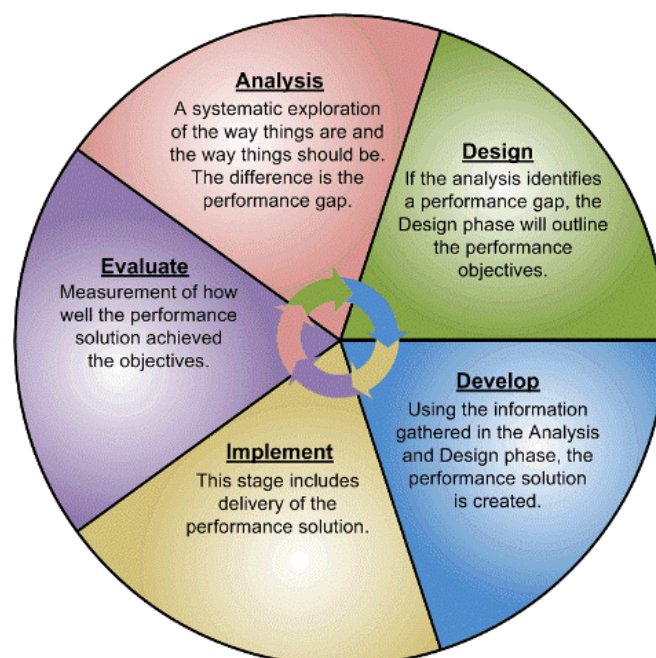


Figure 35-Addie model

(hlwiki, 2017)

At this figure can be seen the general contents of the ADDIE model.

### 5.2.1 Analysis phase

One of the main purposes of this game is the improvement of the knowledge of the students with this virtual game. In the Analysis phase of the ADDIE model the instructional problems the objectives and the identification of the learning environment are clarified. Moreover, the learner's knowledge and skills level are also crucial for the development of the project. For example, if students had a similar experience before with a serious game in class or it just is his first time! At this current project for example the design of this serious game ought to be as simple but not boring as it could be, because it refers to younger ages, students to be exact. What comes next is the desirable behavior and the reactions of the students before and after the interaction with this application, especially if the students had previous experience with a serious game.

The scenario of the game would take place in an ancient exotic world where no human beings existed, so the ground and the surroundings should be designed with lively colors and tall trees for being more attractive to the eyes. The models of the dinosaurs ought to be as realistic as it could be. The sounds of the animals are an extra feature which make the game seems more realistic. The educational part of this game is given through information buttons about these animals and through a quiz for testing the students' knowledge as well.

At this work the propose is the students to learn about dinosaurs through a three-dimensional graphical virtual environment. The game should include entertainment aspects such as the dinosaur models, rich landscape and realistic movements of the models. As for the learning objectives of the game, it should be learning about paleontology and students should develop their skills by playing. It is a kind a motivation for the students to learn about this great part of the science. Moreover, this game could be the spark for the students to develop their own games. Since students are from the early age in touch with advance technological devices such as laptops or tablets the familiarization with the present thesis application, wouldn't be difficult at all for them. The phase of analysis demands that learning from this serious game should be understandable from all the students. So, the provided content ought to be simplified and accurate. Large scientific explanations would be boring and misunderstood.

Another element that should be taken into consideration is whether this application is within pedagogical limitations. Surely images, scenes and content of the application shouldn't include any trace of advertisements or violence.

Finally, the learning theory used in the game is of major importance also. The information for these ancient animals should be taken from scientific approved papers and sites, more over the scenario of this serious game had to comply with these theories.

### **5.2.2 Design phase**

After the completion of the analysis phase the next step would be the elaboration of the design phase. At this point there is no need to mention once again the goals of this game, instead there is a need to refer of how this serious game should be assembled to support the requirements in analysis phase. The scenery of the game designed to be as realistic it could be. Trees, bushes and a lake implanted for the enrichment of the scenery. The edges of the scenery are filled with mountains. These mountains have decorative role and are part of the limitation of the scenery. The sizes of the trees and the bushes should match accordingly to the sizes of the dinosaurs. The dinosaur models ought to move naturally in the scenery and for this propose proper coordinates were given. The sizes of the dinosaurs fixed accordingly to the species and the voices of them. Finally, the control buttons of the dinosaurs and generally the user interface controls were placed. The controls buttons ought to be easy to use and easily understandable for the students to use them.

### **5.2.3 Implementation**

During this phase, tests of the application were taken place for fixing the bugs of the game before it is given to the students for evaluation. Some of the content menus were changed and some others enriched with more information and audio speech.

#### **Game development**

To start with, this game was built for mobile devices equipped with the Android operating system. As is well known this operating system is supported by most of the mobile devices. The game supports for obvious reasons two languages, Greek and English and this easily can be seen at the starting menu (Figure 36).

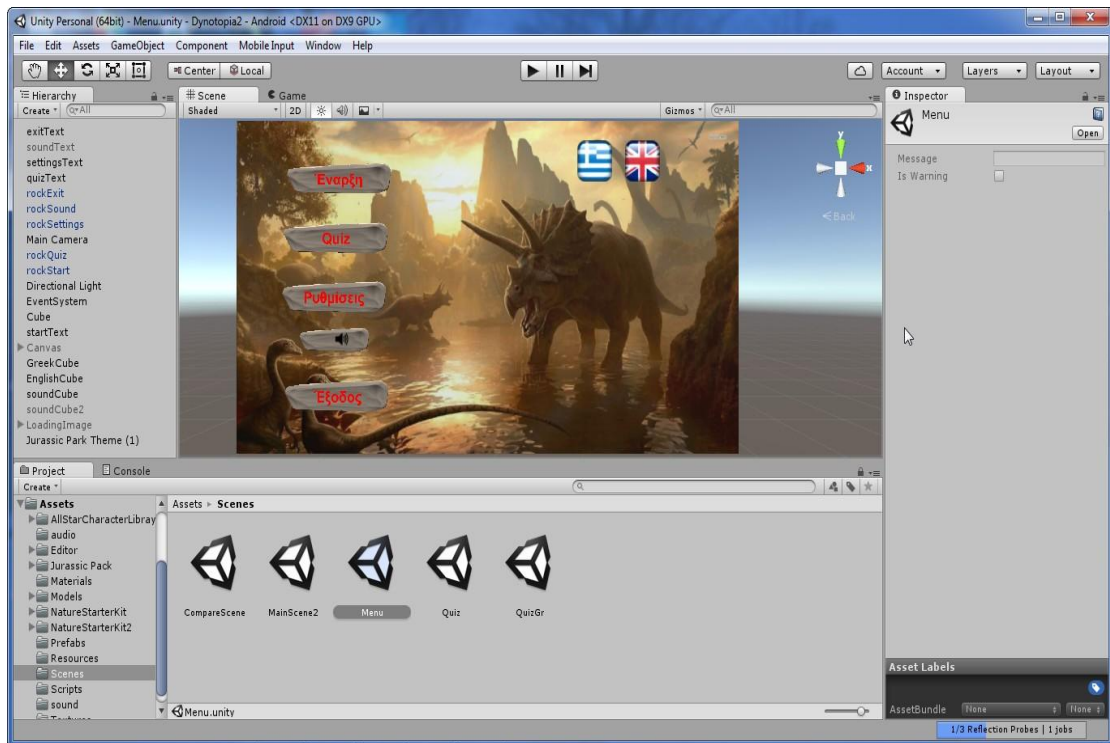


Figure 36-Dinotopia starting menu

Knowledge of “usability engineering” should be used, for creating as simple and understandable as it could be the menu of the game. The foundations of “Usability Engineering” are based on Nielsen’s ten usability heuristics (Nielsen, Ten usability heuristics, 2005). These heuristics are the following:

**1. Visibility of system status**

The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.

**2. Match between system and the real world**

The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.

**3. User control and freedom**

Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.

**4. Consistency and standards**

Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.



**5. Error prevention**

Even better than good error messages are a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.

**6. Recognition rather than recall**

Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.

**7. Flexibility and efficiency of use**

Accelerators -- unseen by the novice user -- may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.

**8. Aesthetic and minimalist design**

Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.

**9. Help users recognize, diagnose, and recover from errors**

Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.

**10. Help and documentation**

Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.

At this work some of the Nielsen's usability heuristics applied for making this game as user friendly it could be. For example, the buttons of the languages which are used in game are equipped with flags (Hellenic and English) as it can be seen from the Figure 36 above. The language buttons have been designed to be seen easily to any screen size. This applies to the "Help and documentation" and "Flexibility and efficiency to use" heuristics. Generally, the start menu kept as simple as possible, so students won't have any difficulty on familiarization with this application.

This also applies to "Aesthetic and minimalistic design" heuristic. The element of the easy familiarization between the user and the application was also implemented in game. Before entering the game at the starting menu there is the first element of

what this game really is about and that applies to “Match between system and the real world” heuristic. To begin with the game description, at the starting menu there is a quiz where ten multiple choice questions with four possible answers were given as can be seen from Figure 37. The colors and the background of this user interface chosen carefully for conforming at the following heuristics, efficiency of use, minimalistic design, helpful and easily understandable.

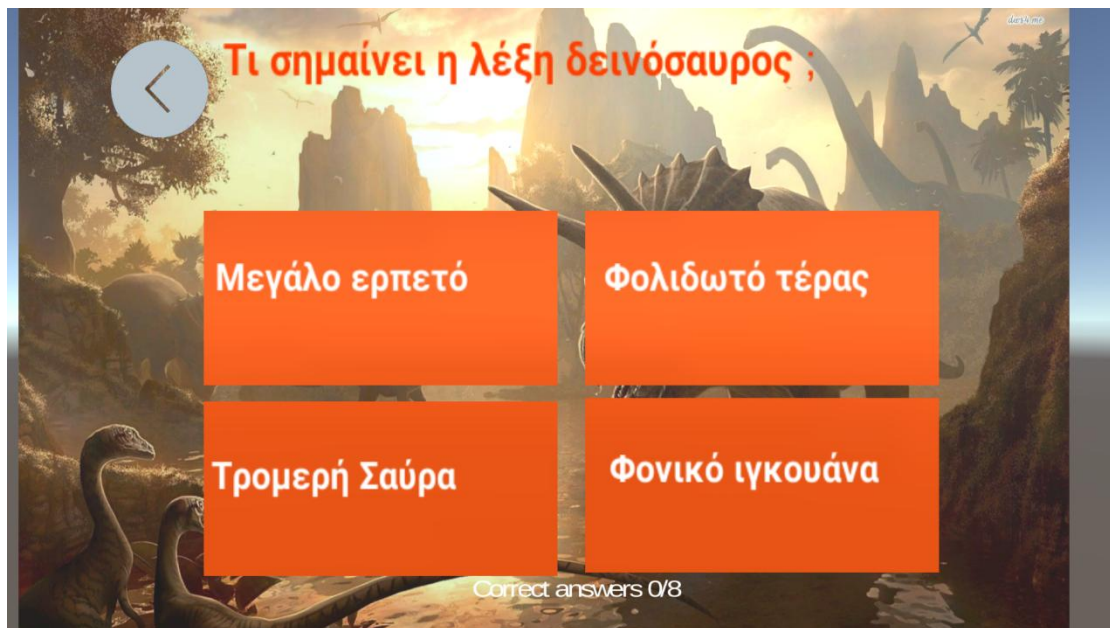


Figure 37-Dinotopia's quiz interface menu

The same Nielsen’s heuristics applied for the whole game. For this propose when entering the game there is an option menu for every dinosaur available. There the student or any user can choose the dinosaur of his choice. Now the user has four options to interact with these animals.

- Just play and move the animal without playing any game
- Play the game
- Read information
- Compare of dinosaur.

Any of these actions are given both by text and images for being easily understandable by the students or anyone who would like to play this game.



Figure 38-first version of the dinosaurs' user interface



Figure 39-The final version of the dinosaurs user interface.

The student can play and interact with a dinosaur through arrow shaped buttons where placed which allow user to move the animal model to all directions - “User control and freedom” (Nielsen, 2005). The only limitation is the size of the scenery. At the right side of the screen the player would be able to see four symbol buttons. These buttons as can be seen from the Figure 38, perform action commands, such as feed, attack, sleep and die. At the final version of this game the die button has been removed because it considered to rather inappropriate for young ages (Figure 39). These are the special moves of the visual animals and that makes the game more interesting. To make things even more interesting a game embodied to this application. This game is a race against time. The player should consume or eat (depending on chosen dinosaurs-avatar) as many plants (herbivorous models) or dinosaurs (carnivorous models) as he can in a limited period of time. This also applies to the Nielsen second heuristic about matching system and real world. Another challenge of this game is that there are specific targets which can be eaten. An exploration of the map would take place. These targets are in a red bubble as can be seen from Figure 40, so students won’t have too much difficulty of finding them.

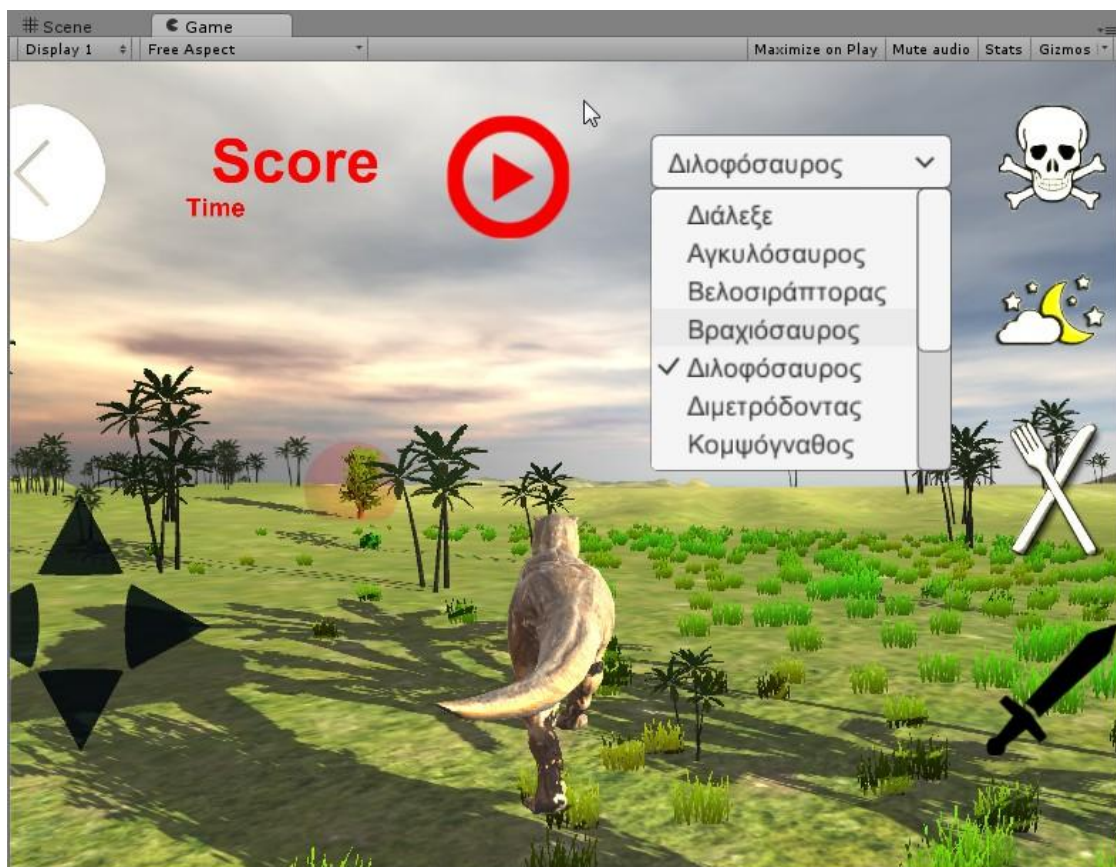
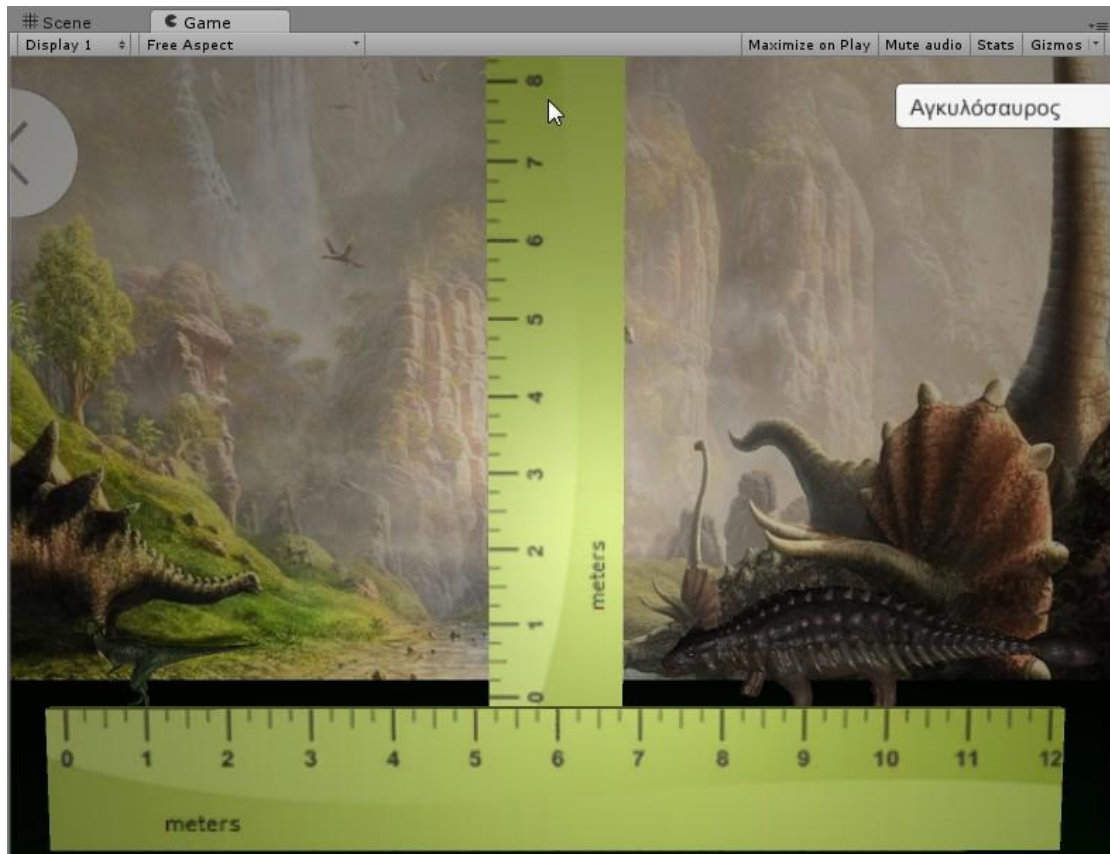


Figure 40-user interface of the dinosaurs’ options menu

When the player chooses a dinosaur of his choice four options are given. The first one is the information button. This button opens a window where some basic information is given so students could to learn about these animals. The idea is that, when playing a game with a specific dinosaur the students would be able to know its basic background. The second-choice button hosts the comparison option. This option simply makes the comparison between sizes of the real dinosaurs. Students now would be able to compare and understand better the sizes of these ancient animals. Finally, the return button puts the player back to action.



*Figure 41-first version of the dinosaur comparison scene*

Figure 41 show the basic concepts of the comparison scene between dinosaurs. Instead of using a static picture as background with the meter scale as can be seen from the picture above (Figure 41), a scene from the actual environment of the game is giving a sense of depth (Figure 42).

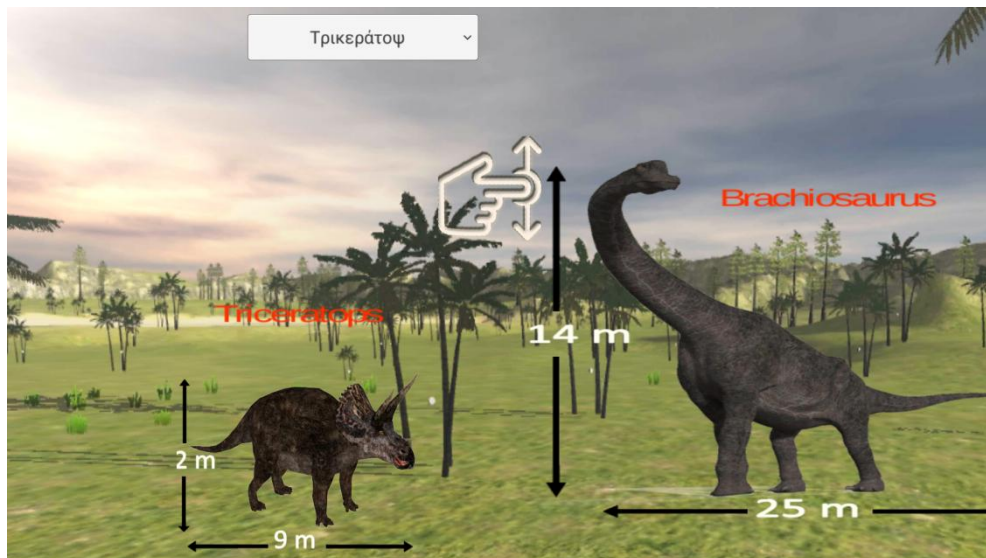


Figure 42-second version of the dinosaur comparison scene

The sizes of the dinosaurs are given by text information, attached to their figures so now the only thing which the student has to do is to swap up or down the dinosaur models in order to make the comparison. What must be mentioned is that the information about the dinosaurs is also given by audio and text. Now the final scene of this game is given at the Figure 43 below.

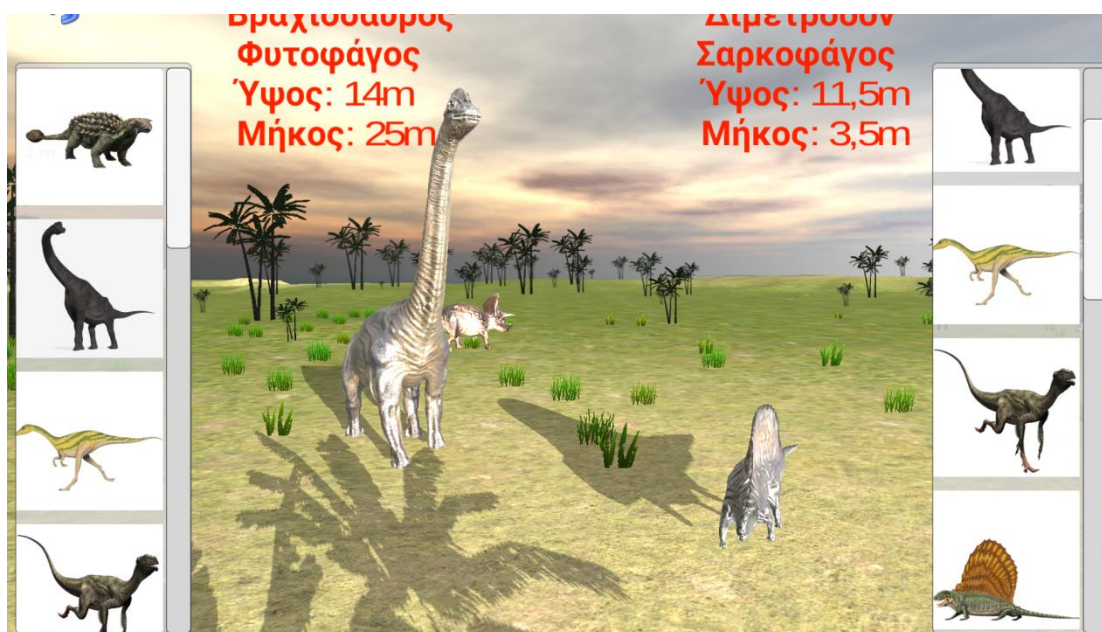


Figure 43-final version of the dinosaur comparison scene

At this final version as can be seen there are two columns left and right at the screen where a user can easily pick the dinosaur to compare. Like previous versions of this game scene the information about each dinosaur species are also given simply by picking them (Figure 44), which applies to Nielsen seventh heuristic about flexibility and efficiency to use.



Figure 44-interface of the given information about the dinosaurs

A new development also took place of how the detailed information could be given to the students about these ancient animals. Firstly, it was a static image of each of these animals with information given as text underneath, but it was rather old fashioned. So, it has been changed into a 3D interface with the camera turning around the dinosaur model which gave the sense of movement and made it look more interesting (Figure 44). Many of the changes and developments of this game where given as ideas by both of supervising professors of this work. One of these ideas is given by the Figure 45 below. The idea is to give the students useful information to read while waiting between two game scenes. This information is also helpful in order the students to answer correctly the quiz questions.



Figure 45-information about dinosaurs is given for quiz game

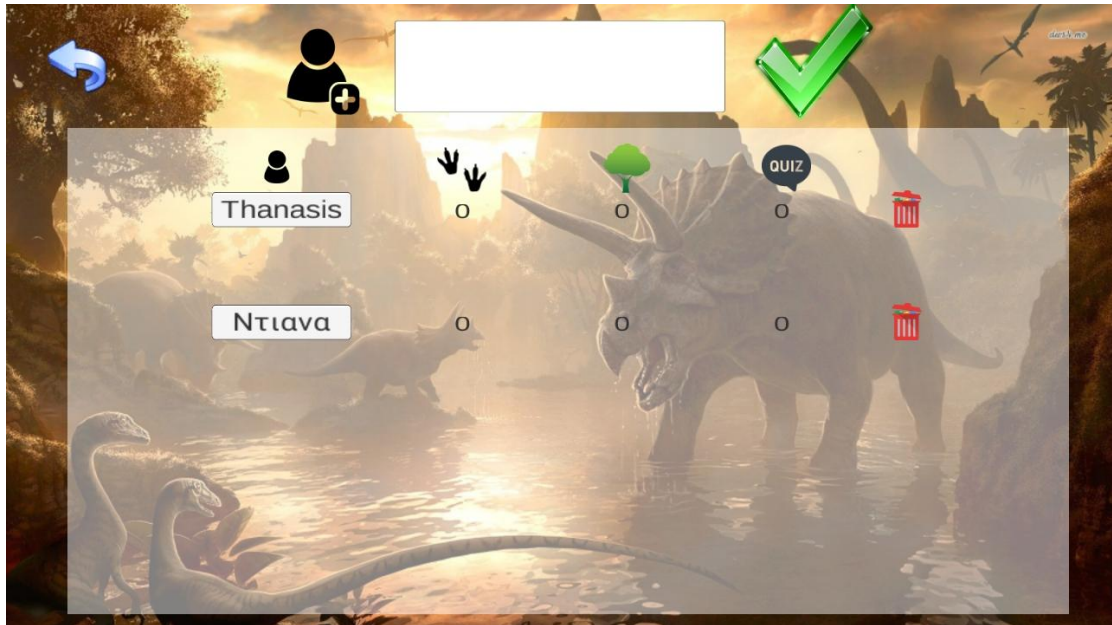


Figure 46-Score board

This scene shows the goals which had been achieved by the users.

An also interesting addition to this game is the user profile statistics. The concept of this addition is that both students and teachers are able to keep track of the in-game progress (Figure 46). So now a student can easily add his name or nickname to the add button at the top of the screen as can be seen from the image above. The feet icon shows, how many herbivores dinosaurs are eaten by the carnivore dinosaurs. The second icon (the tree) shows how many plants are eaten by herbivore dinosaurs. The third icon shows the correct answered questions from the quiz-game. Finally, through the trash icon, a gamer profile can be deleted.

#### 5.2.4 How it works.

In order the goals of this serious game to be achieved, it needed lots of lines of code programming at C#. The animals couldn't move, interact or making any noises at the beginning. The menus of the game also were created from the beginning and many other things that the game needed to be functional. The propose of this reference is not to present analytically what deployments took place during implementation of the game, but just to show the principles of the game through a small example. It may be useful to be mentioned that throughout the process the game was tested at mobile device phones (Samsung Note 2,3 and Asus Zenphone 4) and tablets (Asus Google Nexus 1, Samsung galaxy note 10.1) too. Two are the main malfunctions coming up from game's tests. The first malfunction was that the game couldn't be adjusted properly to different screen sizes. So further modifications and tests took place to correct this issue. As can be seen from the Figure 47 below there is a scenery background with a picture of dinosaurs and on it. On this scenery were



placed buttons shaped like a stone and the language buttons also. The problem was that the whole scene had a fixed size, but the elements of the scene were moved, depending on the screen resolution of the device. What needed to be done was that the elements of the scene (stones and buttons) to be at their place on the scene without having the ability of moving. Now depending on the device screen resolution, the whole scene stretches or shrinks and is functional to all the devices which was tested.

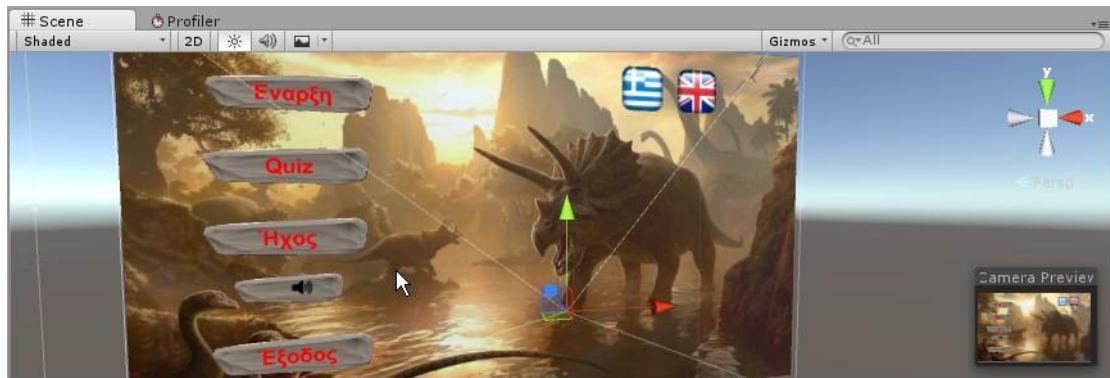


Figure 47-elements of the main scene

The main scene and the elements of it as can be seen in Unity.

The second malfunction has to do with the overloading of the devices. As there was an effort for making the environment as realistic as it could be, the game scene was enriched with plenty assets of natural materials such as water, rocks, trees and other elements which consist a natural environment. Unfortunately, that way the application became quite “heavy” and had a lot of time lugs, although both smartphone and the tablet had a satisfying processing power (Four cores, 2 gigabyte of ram). So, the scenery simplified resulting the application to run smoother. Here follows a sample of a code which has been used for making dinosaurs to react to user commands. Many modifications took place for the desirable result to be achieved.

#### Code example :

```
//Motions code

//Walking
//If the current animator state of the dinosaur is walking, the
next animator state is also walking
if (anim.GetCurrentAnimatorStateInfo (0).IsName("Comp|Walk") ||
    anim.GetNextAnimatorStateInfo (0).IsName("Comp|Walk"))
{
    //Velocity calculations: if the velocity at the z axis is
lower than 0.2, the velocity increases by 0.25 per second until it reaches 0.2.
When the velocity reaches 0.2 it starts decreasing by 0.25 per second
    if (velZ < 0.2F) velZ = velZ + (Time.deltaTime * 0.25F);
```

```

        elseif (velZ > 0.2F) velZ = velZ - (Time.deltaTime *
0.25F);
        //If the next animator state of the dinosaur is
"standing", the velocity of the model and the rotation on all axes except y
axis become equal with 0 and the rotation on y axis remains the same.
        if (anim.GetNextAnimatorStateInfo
(0).IsName("Comp|StandA")) velZ=0;

        transform.rotation *= Quaternion.AngleAxis (ang,
newVector3 (0, 1, 0));
        transform.Translate (0, 0, velZ*scale*anim.speed);
    }

    //Backward
    //If the current or the next animator state of the dinosaur is
backward walking, the velocity of the model increases by 0.25 per second until
it reaches 0.2 and decreases by 2.5 per second once it reaches 0.2
    elseif (anim.GetCurrentAnimatorStateInfo (0).IsName("Comp|Walk-"))
||
    {
        anim.GetNextAnimatorStateInfo (0).IsName("Comp|Walk-"))
        {
            if (velZ < 0.2F) velZ = velZ + (Time.deltaTime * 0.25F);
            elseif (velZ > 0.2F) velZ = velZ - (Time.deltaTime *
0.25F);

//If the next animator state of the dinosaur is "standing", the velocity of the
model and the rotation on all axes except y axis become equal with 0 and the
rotation on y axis reverses.

if (anim.GetNextAnimatorStateInfo (0).IsName("Comp|StandA")) velZ=0;

        transform.rotation *= Quaternion.AngleAxis (ang,
newVector3 (0, -1, 0));
        transform.Translate (0, 0, -velZ*scale*anim.speed);
    }

//Running
//If the next or the current animator state of the dinosaur model is "running",
"running and growling" or "attacking", the velocity of the model on the z axis
increases 0.25 per second until it reaches 0.4
    elseif (anim.GetNextAnimatorStateInfo (0).IsName("Comp|Run") ||
anim.GetCurrentAnimatorStateInfo (0).IsName("Comp|Run"))
||
    {
        anim.GetNextAnimatorStateInfo
(0).IsName("Comp|RunGrowl") ||
        anim.GetCurrentAnimatorStateInfo
(0).IsName("Comp|RunGrowl") ||
        anim.GetCurrentAnimatorStateInfo
(0).IsName("Comp|RunAttackA") ||
        anim.GetNextAnimatorStateInfo
(0).IsName("Comp|RunAttackA") ||
        anim.GetCurrentAnimatorStateInfo
(0).IsName("Comp|RunAttackB") ||
        anim.GetNextAnimatorStateInfo
(0).IsName("Comp|RunAttackB"))
    {
        if (velZ < 0.4F) velZ = velZ + (Time.deltaTime * 2.5F);

        if (anim.GetCurrentAnimatorStateInfo
(0).IsName("Comp|RunAttackA") &&

```

```

                                anim.GetCurrentAnimatorStateInfo (0).normalizedTime >
0.8) velZ =0.0F;

//If the velocity of the dinosaur model during the "running" state on the z
//axis is higher than 0.2, the velocity decreases by 2.5 per second, the rotation
//becomes 0, except the y axis, on which the rotation remains the same
                                if (anim.GetCurrentAnimatorStateInfo
(0).IsName("Comp|RunAttackB") && velZ > 0.2F)
                                    velZ = velZ - (Time.deltaTime * 2.5F);

                                transform.rotation *= Quaternion.AngleAxis (ang,
newVector3 (0, 1, 0));
                                transform.Translate (0, 0, velZ*scale*anim.speed);
                                }

```

The game does not have any elements of violence since it is referring to younger ages.

## CHAPTER 6 – Results

### 6.1 Evaluation phase

#### 6.1.1 Research identity

The game evaluation took place at the natural history museum of Crete. The sample was taken mostly at the ages between eight and eleven years old students. The questionnaire as can be seen above is consisted by seventeen questions. The purpose of these questions was retrieve some basic information about the students and their experience about this application. These questions include:

- The ages of the students.
- The familiarization with this application.
- The Duration of the game.
- The interest of the students for this application.
- The graphics and generally the in-game experience.
- The knowledge which has been gained from it.

Unfortunately, there was not enough time to spend on the application because children, their parents and school groups had little time to spend after touring the expeditions of the natural history museum. Fortunately, the user interface of the game proven to be easy at most of the children. What is not mentioned in the questionnaire is that the sample was almost equally taken by two sexes, both boys and girls. The questionnaire and the comments of the students can be seen at Annex 1.

#### 6.1.2 Results

What follows here are the results of the questioner which was given to the students to evaluate the game. The element which helped the students to understand how the game works was that all the children had previous experience with Android games and tablet devices.

##### 1.What is your age?

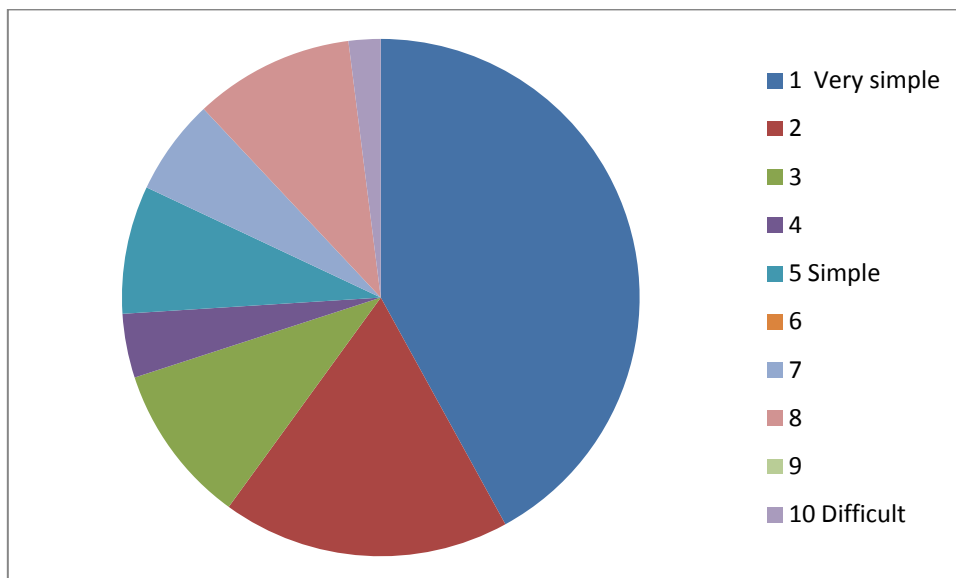
5 to 7 years old	0
------------------	---

8 to 10 years old	49
11 to 13 years old	1
13 + years old	0

The sample was taken at the ages between eight and eleven years old students.

**2. Was the game complicated to you (Difficult);**

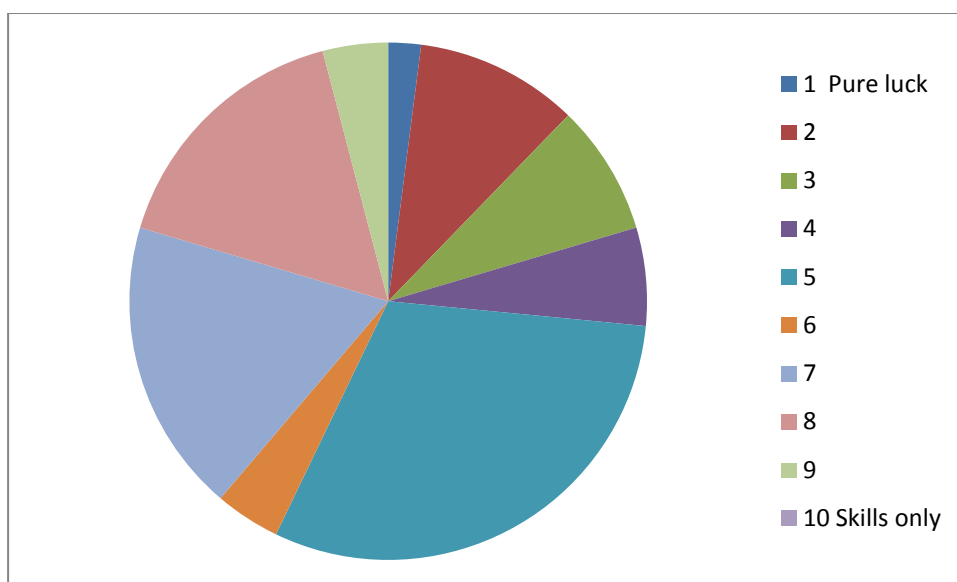
1 Very simple	21
2	9
3	5
4	2
5 Simple	4
6	
7	3
8	5
9	
10 Difficult	1



As can be seen from the specimen board above most of the students had no difficulty to understand how the game works mostly at its basic interface functions such as moving and select the dinosaurs.

### 3. This game requires luck or skills to be played;

1 Pure luck	1
2	5
3	4
4	3
5	15
6	2
7	9
8	8
9	2
10 Skills only	

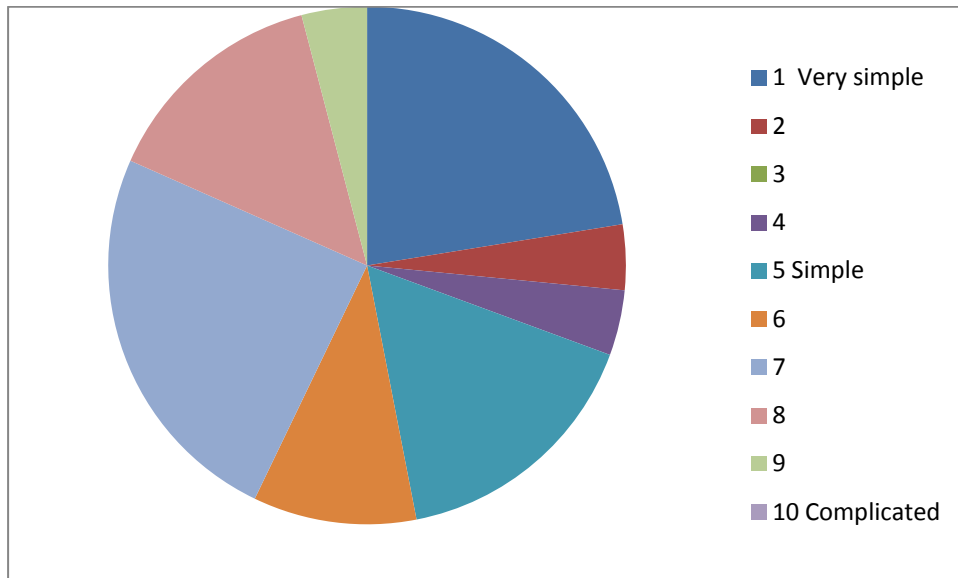


The element of luck for children to understand how the application works was equally important with the capabilities of the children to use tablet devices and play Android games.

### 4. The instructions and the symbols of the game are easy to understand?

1 Very simple	11
2	2
3	
4	2
5 Simple	8
6	5
7	12

8	7
9	2
10 Complicated	



The instructions of the game which are given in the user interface of the game at most of the cases were not as understandable as it should. This happen because the children didn't pay more attention of what is written, instead they were focus on the dinosaur models and the background of the game. It took some time for the students to be familiarized with the symbols of the game but after a while they used to it.

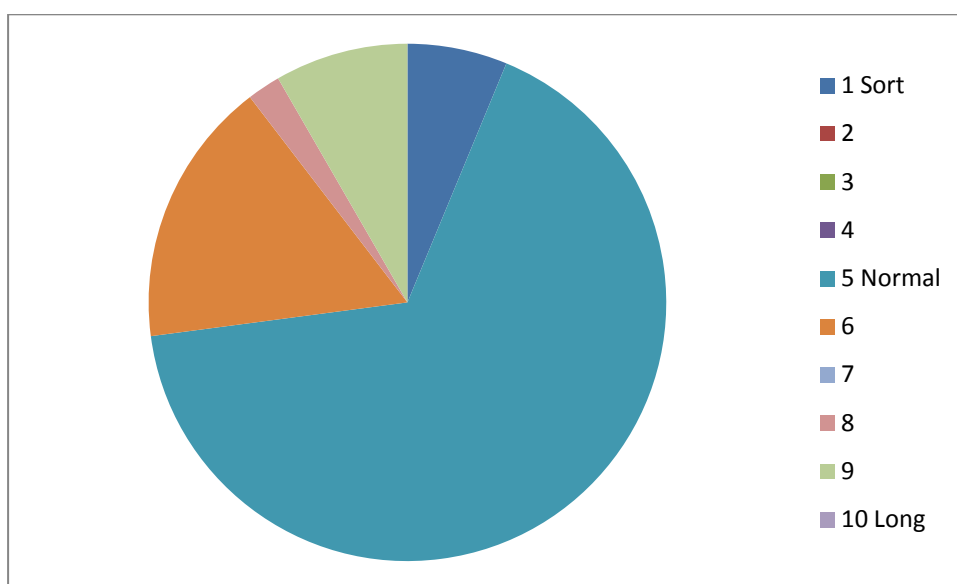
#### 4. How much time did it take you to complete the game?

Above 3 minutes	0
3 to 5 minures	0
5 to 10 minutes	42
10 to 15 minutes	7
Over 15 minutes	0

It took approximately ten minutes to the students to explore the contents of the game.

**7. This game lasted for a sort, normal or long period of time?**

1 Sort	3
2	
3	
4	
5 Normal	32
6	8
7	
8	1
9	4
10 Long	

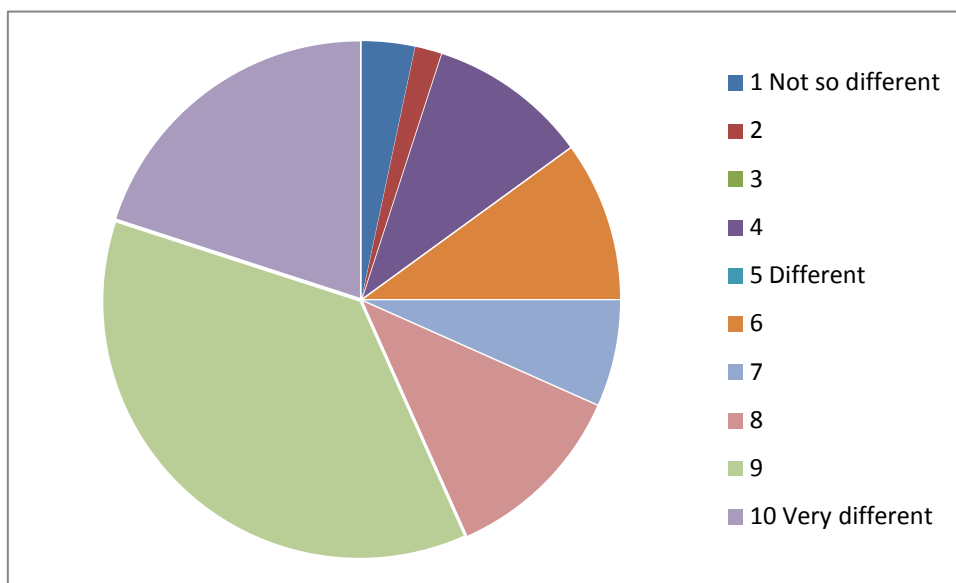


Due to limited number of tablets and time which children were able to spend for playing this application, 10 minutes time proven to be not enough time for complete evaluation of this application.

**8. Was this game different from previous similar games that you had played before?**



1 Not so different	2
2	1
3	
4	6
5 Different	
6	6
7	4
8	7
9	22
10 Very different	12

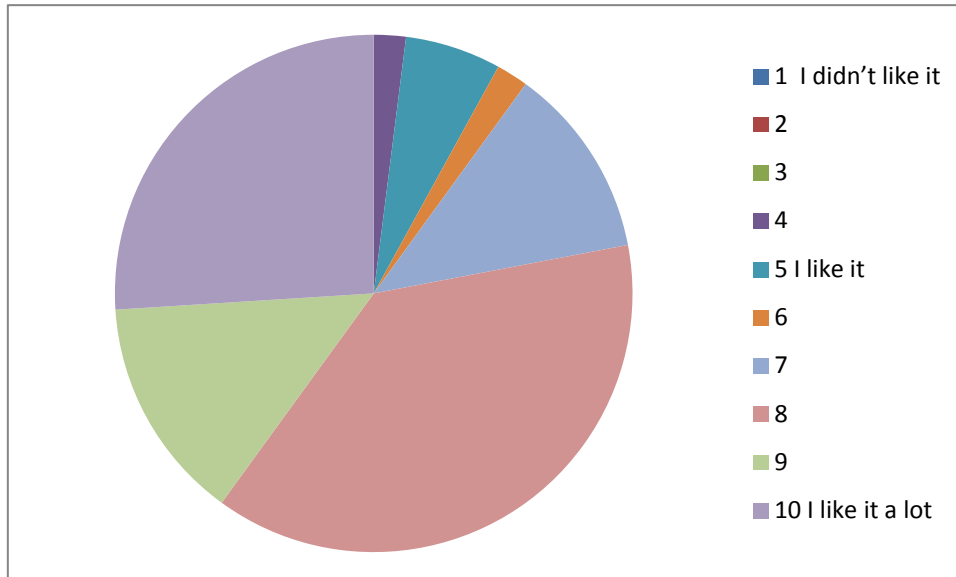


This application proven to be at most of the cases different from other games which the students used to play. That kept their interest longer and helped the students to be familiarized with this application.

### 9. Was the game interesting to you?

1 I didn't like it	
2	
3	
4	1
5 I like it	3
6	1
7	6

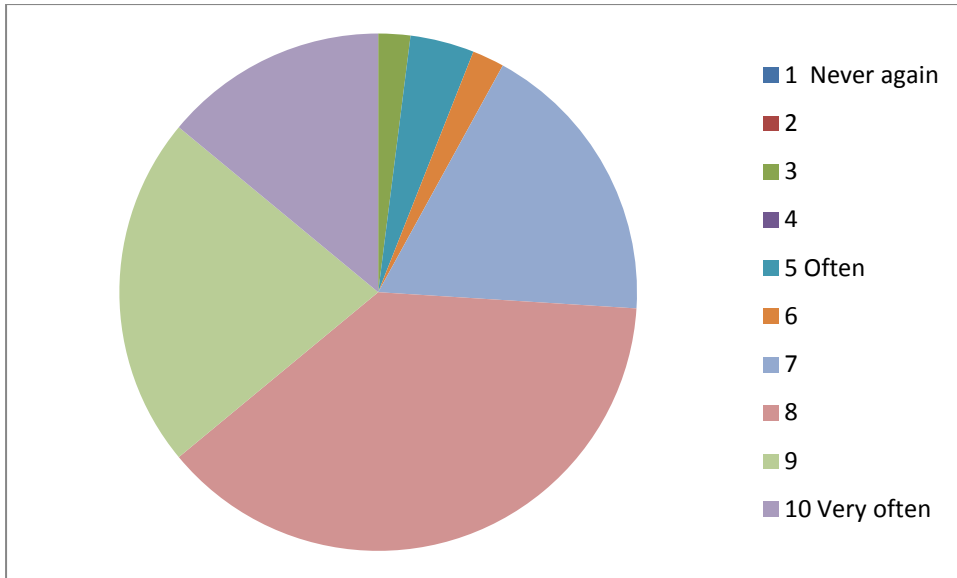
8	19
9	7
10 I like it a lot	13



The action part of the game where the carnivore dinosaurs hunt the herbivore and the herbivores eat the plants kept the students interest.

**10. How often would you like to play that game?**

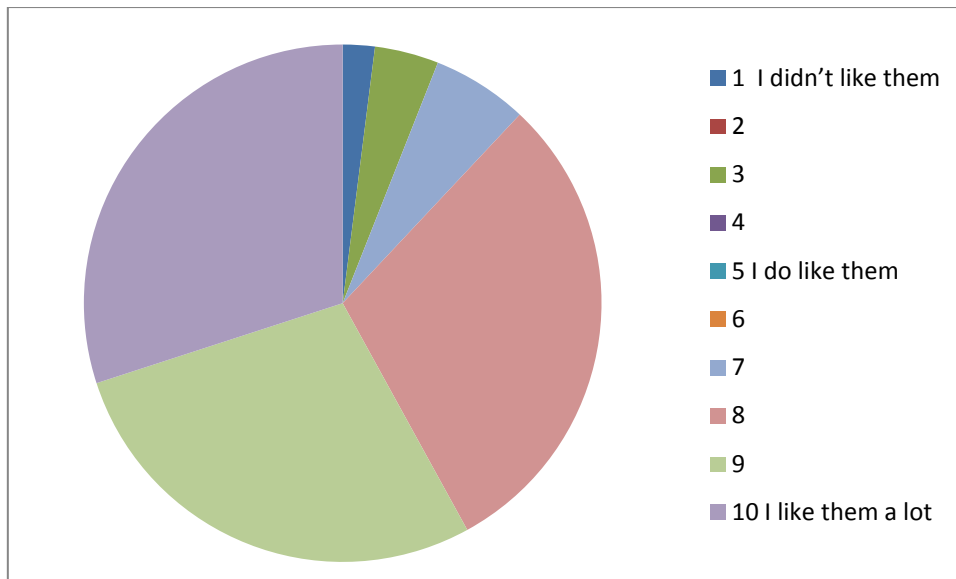
1 Never again	
2	
3	1
4	
5 Often	2
6	1
7	9
8	19
9	11
10 Very often	7



Many of the students wanted to play again with this game and many of the asked if it was available at the Google's play store.

**11. Did you like the graphics and the colors of the game?**

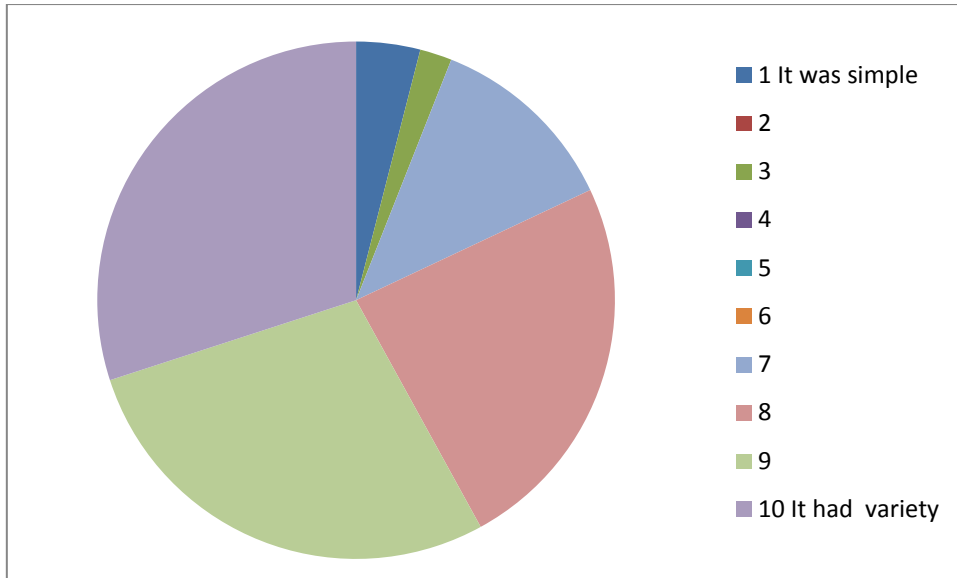
1 I didn't like them	1
2	
3	2
4	
5 I do like them	
6	
7	3
8	15
9	14
10 I like them a lot	15



The colors of the game were chosen to be lively and be easily combined with the detailed graphics of scenery. That was a very positive addition which kept the students interest.

**12. Did you like the scenery of the game?**

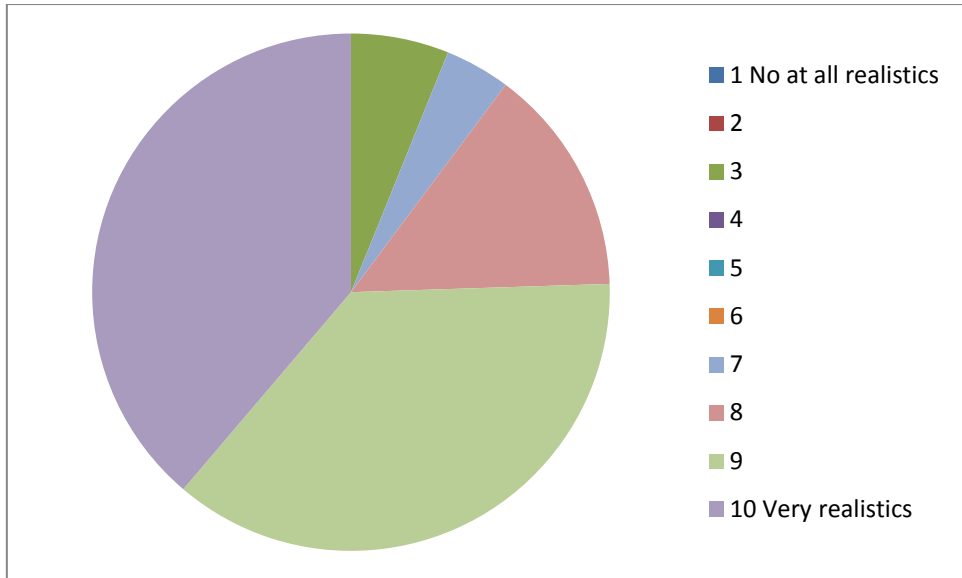
1 It was simple	2
2	
3	1
4	
5	
6	
7	6
8	12
9	14
10 It had variety	15



One more element which helped the scenery of the application to be more interesting for the students was the depth of it. Players are able to play with the dinosaur avatars without considering the scenery limits.

**13. The models of the dinosaurs are realistic to you?**

1 No at all realistics	
2	
3	3
4	
5	
6	
7	2
8	7
9	18
10 Very realistics	19



As mentioned before, one basic element which kept the students interest alive for this serious game application is the graphics of the game. The game’s landscape and especially the realistic dinosaur models proven to be the strongest characteristic of this application.

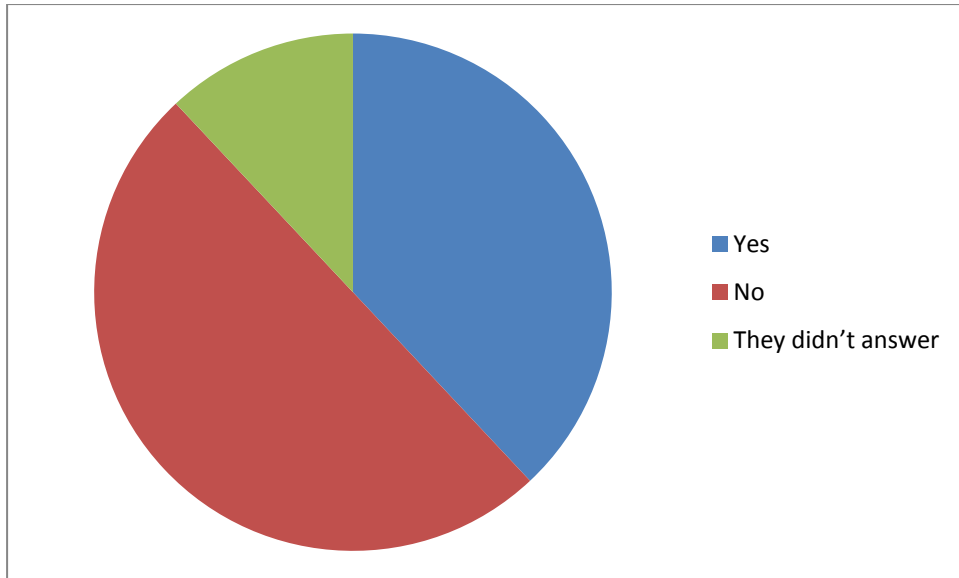
**14. Was the number of the dinosaurs satisfying?**

Yes	40
No	10

Many of the students would like the game to be enriched with bigger number of dinosaurs because of the variety which will be available for them play. The interest of how their actual appearance was, each of these ancient species and the behavior of them would be a useful addition for playing this game.

**15. Did you learn things for the dinosaurs that you didn’t know before?**

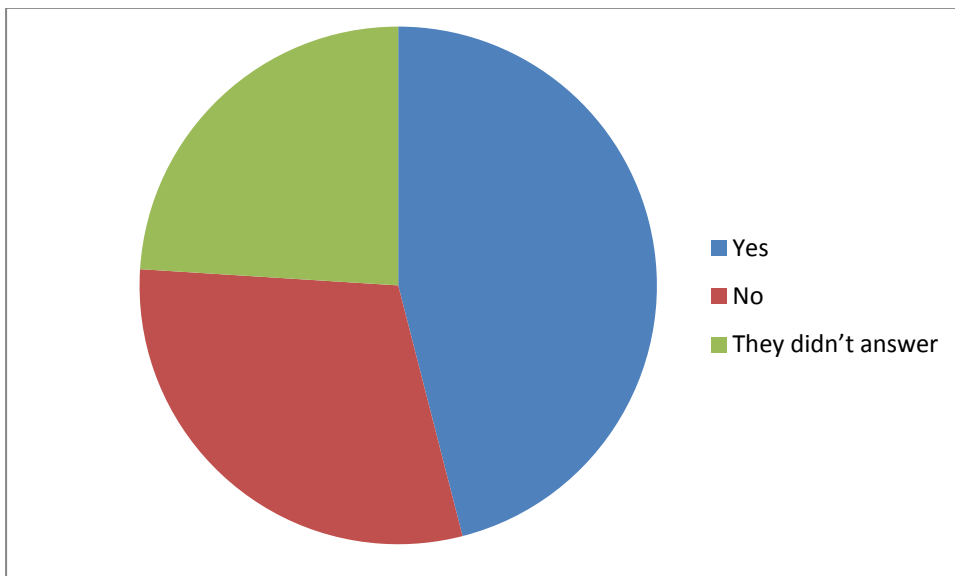
Yes	19
No	25
They didn’t answer	6



Most of the students were focused mostly at the hunting part of this serious game and paid less attention to the quiz part of the game or the information about dinosaurs and the comparison between them.

**16. Did you found interesting the knowledges that you have learned for the dinosaurs?**

Yes	23
No	15
They didn't answer	12



Unfortunately, most of the students did not have the luxury of time to explore this application as it should be. As mentioned before most of their time was spend at the action part of the game.

**17. Did this application intrigued your interest of learning more about these ancient animals?**

Yes	50
No	0

The names and the shapes of the dinosaurs helped the students to recognize them easier than before. The dinosaur’s exhibit of the museum of the natural history also helped for the positive feedback of this question. These are the reasons why all the children applied positive to the question sixteen about if students interest was grown about learning more about dinosaurs.

**Comments of the Students:**

- These are the comments of the students which were written at the questionnaire for the evaluation of the application:
- Sometimes the application lags during gameplay.
- The game’s touch-screen should be more sensitive.
- The game is nice, but the movement of the dinosaurs should be smoother for example when a dinosaur turns right or left is difficult to stop moving.
- The application should have also flying dinosaurs
- The game should support on line gaming so as the players could play and interact together.
- The game should be enriched with more effects.



## CHAPTER 7

### 7.1 Discussions

Most of the students have access to smartphones and tablet computers, which is surprising as these technologies were only gained significant market share in early 2011. Students are also using their mobile devices to support increasingly sophisticated learning activities previously only possible with computers (Murphy, 2014). During the evaluation of the game, the younger ages between three to six years old were not easily able to play with this application or to understand the information for the dinosaurs which was given through this application since their skills haven't fully developed yet. The students which were twelve years old or older seemed to pay also less attention than younger ages for this application.

Unfortunately, there was not enough time to spend on the application because children, their parents and school groups had little time to spend after touring the expeditions of the natural history museum. Fortunately, the user interface of the game proven to be easy at most of the children. The element which helped the students to understand how the game works was that all the children had previous experience with Android games and tablet devices (Murphy, 2014).

The element of lack for children to understand how the application works was equally important with the capabilities of the children to use tablet devices and play Android games. The instructions of the game which are given in the user interface of the game at most of the cases were not as understandable as it should. This happened because the children didn't pay more attention of what is written, instead they were focus on the dinosaur models and the background of the game.

It took some time for the students to be familiarized with the symbols of the game but after a while they got used to it. What needs to be mentioned here is that most of the students were focus mostly at the part of the game where the dinosaur hunting takes place. At most of the cases it had to be given extra instructions for understanding how the hunting game works. For example, that the carnivore dinosaurs hunt the herbivore dinosaurs and the herbivore dinosaurs eat the plants or the trees. Moreover, it had to be explained that the "targets" of the dinosaurs are spotted within the red bubbles. That applies to Nielsen's usability heuristic about help and documentation. Due to limited number of tablets and time which children could spend for playing this application, 10 minutes time proven to be not enough time for complete evaluation of this application. As mentioned before students were focus mostly at the hunting part of this serious game and paid less attention to the

quiz part of the game or the information about dinosaurs and the comparison between the dinosaurs. In other words, they mostly liked action. As has been mentioned in section 1.3 of this work, the action part of the game was the motivation for the students to play this serious game (Wouters, 2013). That explains why many of the children wanted a bigger number of dinosaurs to play with them but most of them didn't learn anything new for these ancient animals. On the other hand, the names and the shapes of the dinosaurs helped the students to recognize them easier than before and that can be seen from the question fifteen of the questionnaire, that applies to learning theory which has been written above about the short-term (working) memory and the long-term memory (storage, retrieval). What was surprisingly interesting was that all the children applied positive to the question fifteen about grown their interest to learn more about dinosaurs. In a way this application achieved its purpose to propel the children to learn more about these ancient animals.

As for the gaming part, this application proven to be at most of the cases different from other games which the students used to play. That kept their interest longer and helped the students to be familiarized with this application. Many of the students wanted to play again with this game and many of the asked if it was available at the Google's play store (Google Play, 2017). One basic element which kept the students interest alive for this serious game application is the graphics of the game. The game's landscape and especially the realistic dinosaur models proven to be the strongest element of this application as can be seen from the diagrams of results section. That is why from all our senses, vision is the most dominating one. It is estimated that it contributes up to 70% of the information humans perceive. To process this information, we rely on diverse visual cues which all are essential for our orientation and perception (Masuch, 2004).

## **7.2 Related work**

By started developing the present serious game, a web search took place in (Google Play, 2017) market application about similar or related games with the current one. Plenty of them were found and separated in two categories. The first category has the element of an action game and the second one is educational. The game has elements from both categories. What follows are two examples from the web search which helped to improve this project.

### **7.2.1 Action dinosaur games:**

**Game description:** ([Jurassic dino island, 2017](#)) , (Figure 48). The player tries to survive on a mysterious island inhabited by various dinosaurs. Player get resources and fight against pangolins. The player should demonstrate survival skills in extreme situations

in this Android game and explore of various locations of the island. The player also uses the found resources to craft weapons, tools, furniture and build a house. Hunting various dinosaurs, and avoid huge predators is also one of the games characteristics.



*Figure 48-Dino island game*

The front cover of the game

What was found quite useful about this game was the usability engineering about the controls of this game and the colors which have been used for this propose. As can be easily seen from the Figures 49 and 50 the main controls of the game with which the player directs his avatar are placed at the left and the right of the user interface scene. Both movement button and action button are larger than the other buttons for helping the gamer to control the avatar character much easier. What was noticed to be also helpful is that the movement button is a circle within a circle and by moving to any direction the circle within makes the character moving without lifting the users' finger from the screen. When the player needs to make a certain action, option buttons automatically appear to help the user to complete the task (Figure 50). The present project has a few similarities about the game controls with the game which has just been described and was a good example for someone who wants to design his own game.



Figure 49-Dino island game screenshot 1



Figure 50-Dino island game screenshot 2

**Game title: Dinosaur Planet**

**Game description:** (Baby Bus, 2017) Dinosaur Planet presents brand new dinosaurs. This game content gives you concise facts about each dinosaur. Learn about them while you feed them and play with them.

Fun features:

1. Brooding relies on the heat created by rotten leaves.
2. Herbivores or carnivores? Feed them and find out!

3. Play games with dinosaurs and be friends with them.
4. Learn about 6 types of dinosaurs in an audio museum.



*Figure 51-front page of the game*

This game is produced from a company which is called (BabyBus, 2017). This company product refers to elementary ages as can be seen from the Figures 51 and 52. The purpose of this game is the students to learn about these ancient animals with a very easy and educational way. For example, when the game starts the player has the options of digging and finding dinosaur bones which are used to reconstruct the dinosaur. Once the dinosaur is reconstructed it becomes alive and the gamer has the option to hear the dinosaur to introduce itself. Among other options which a player have is that offers the option to feed the dinosaur with the proper food. Younger ages by playing this game can easily learn the differences between carnivorous and herbivores dinosaurs. This project also has the element of knowledge which is given in a different way as described previously above. Audio content has also been placed to this project along with the choice of feeding the dinosaurs just by playing the game.



Figure 52-Dinosaur planet quiz

This is where the player learns the differences between carnivorous and herbivorous dinosaurs.

Similar educational contents can easily be found on the internet. These games cover a variety of contents which a student can learn by playing these serious games. It could be described as a visual encyclopedia with elements of gaming. What follows is two screenshots which show, how the contents of these kinds of sites are built.

A first good example of these kind of sites can be found at this web address (Kiddsdinos, 2017). As can be seen from the Figure 53, there are three main categories to start with multiple options inside.

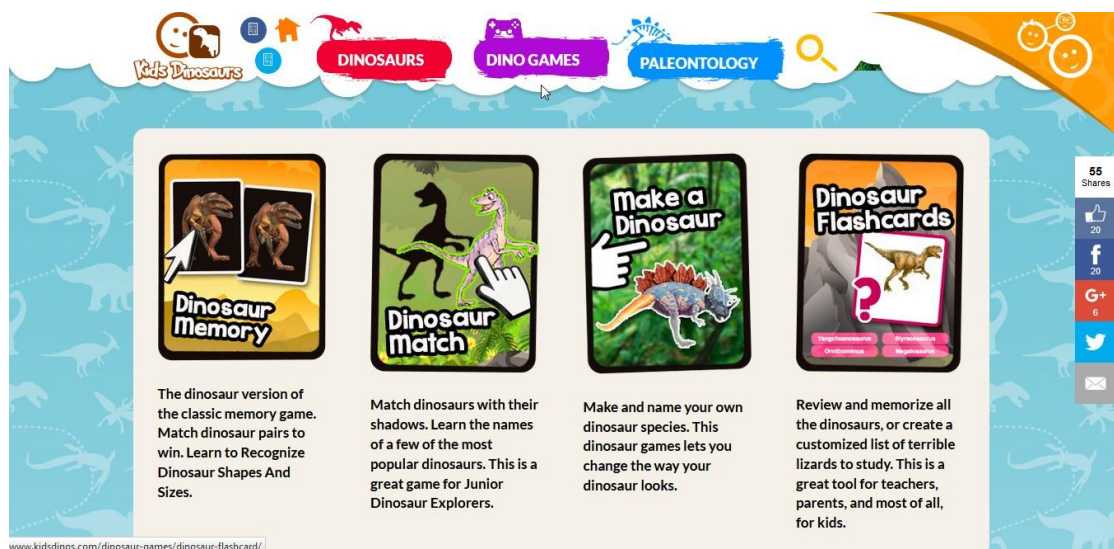


Figure 53-user interface option menu

The user interface option menu of the game

By choosing the Paleontology button (Figure 54) students can be informed about this interesting science.



Figure 54-Kids Dinosaurs game

The Information is given by the combination of text and images.

The dinosaur button (Figure 55) shows a variety of dinosaur species which are categorized by their biology similarities. A second personal conclusion would be that great ideas with the proper use of usability engineering could produce great results (Nielsen's: flexibility and efficiency of use). To be more specific this game and the menu of it are colorized with lively and bright colors. Moreover, the home button and rest of the control buttons of this game (depending of the options menu) are placed at the top left or right of the screen as can be seen also at Figure 56. These comply to Nielsen's about "aesthetic and minimalistic design and help and documentation" heuristics. The whole structure of this game is designed to be played by young students.

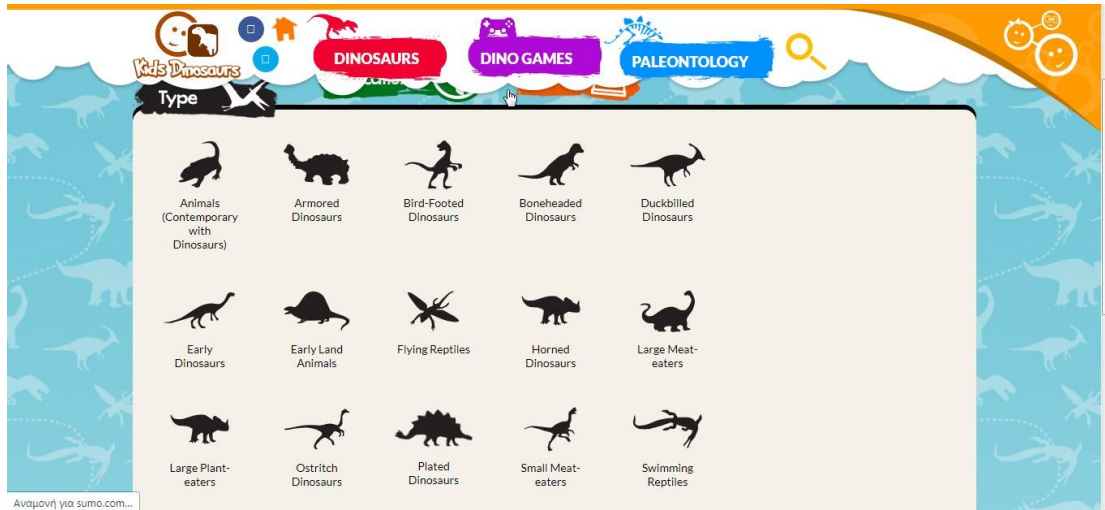


Figure 55-Kids Dinosaurs user interface

Once again, the images accompanied by text help the student to be familiarized with the menu easily.

Choosing the desired category of the dinosaurs, a new option menu appears as can be seen from the Figure 57 below.

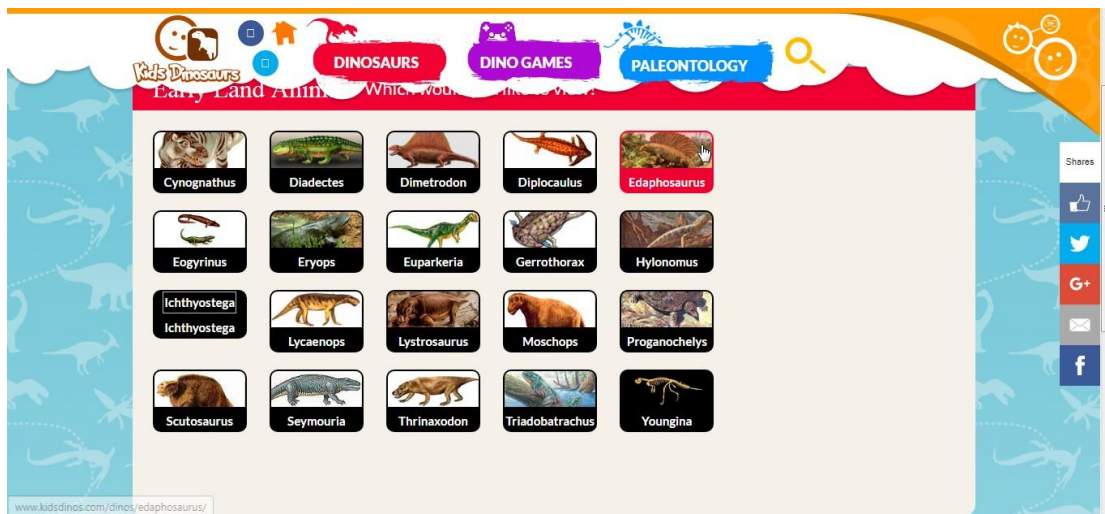


Figure 56-Kids Dinosaurs user interface

Information is given by the combination of text and images.

Speaking for usability engineering the site offers with a very easy way the option to the students to choose the dinosaur of their choice and learn any information is given about them (Figure 58).





Figure 57-Kids Dinosaurs user interface

With simple graphical timelines and questions given, the student understands better the meaning of time and the animal's biology.

Finally, the gaming part of this site includes some of classic board games such as hangman or find the match are now modified as dinosaur subject educational games (Figure 59).

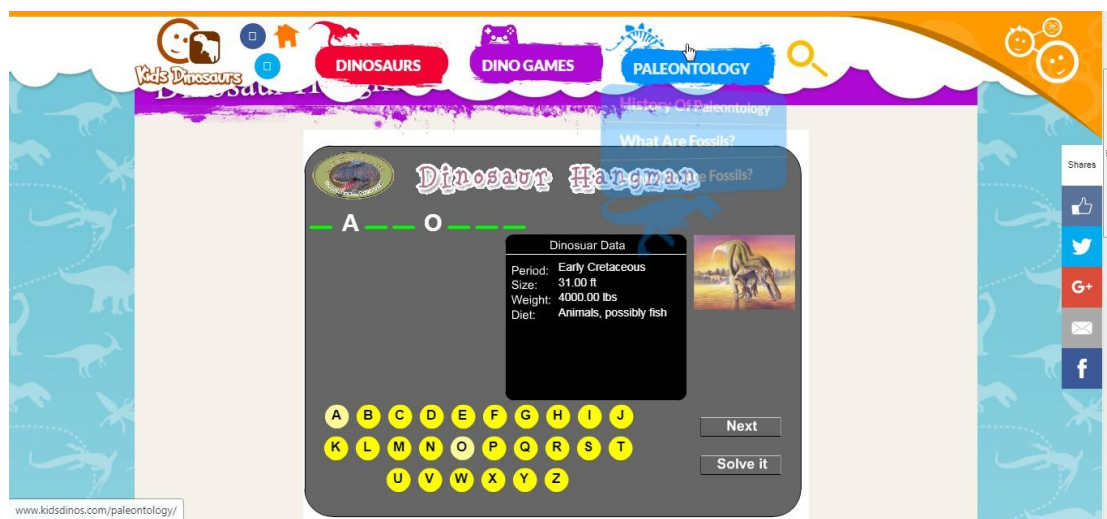


Figure 58-Kids Dinosaurs user interface

Classical games are still used for educational proposes.

A second example of a site which has educational content is also shown at the Figures 60 and 61 below (weebly , 2017).



Figure 59-interactive sites for education user interface

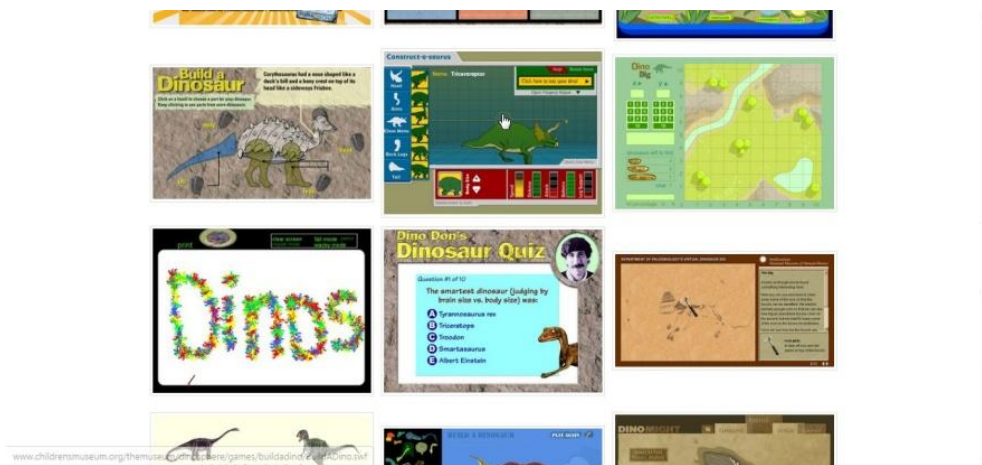


Figure 60-interactive sites for education user interface

Both figures show the user interface list of the games at this site.

This site gives a variety of games with educational contents. One of the games given includes a quiz differently given but similar to the quiz of the present work. The answers are multiple choices answered with elements of humor which is one of the basics elements for making a serious game to include entertainment as well. According to Nielsen (Nielsen, 2003) the purpose of this site is well given and helps the students find what they need.

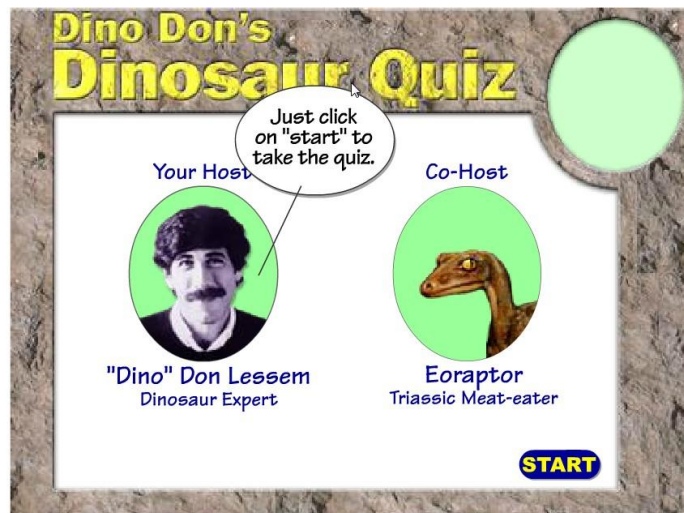


Figure 61-Dino Don's Quiz screenshot 1

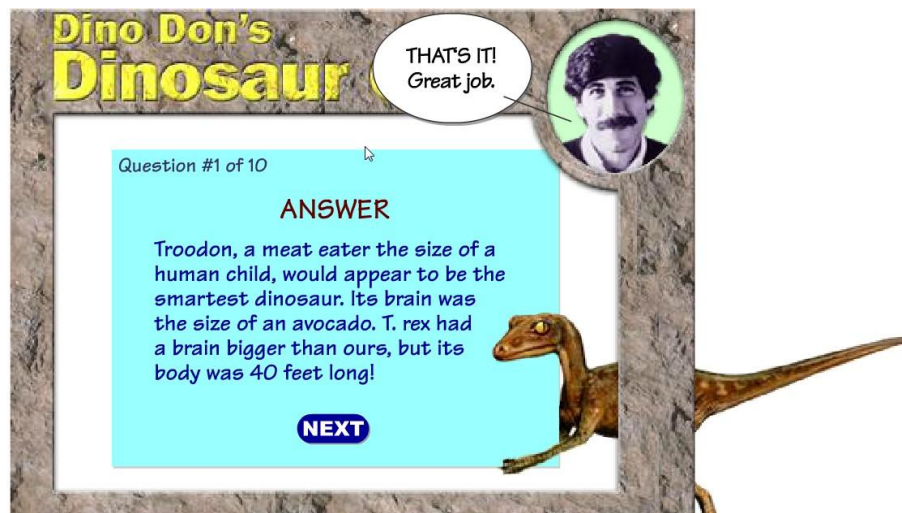


Figure 62-Dino Don's Quiz screenshot 2

A simple question and answer game with elements of humor “draws” the attention of the students

A general notice about these kinds of games is that any educational information is given not only at the beginning or the end of the game but also during playing the game with hints or questions given as can be seen at Figures 62 and 63 as the game moving forward to the next level.

### 7.2.2 Disadvantages of the game.

As it mentioned before this game needs improvements for keeping the interest of the students longer. Since this work is a software development in educational context, there is only one stage for the student to play in the game. A multiple stage

scene where students could gradually pass stages after winning bonuses would much more attractive. Another problem of the dinosaur models is the collisions between them, when a dinosaur model touches another, it just passes through it, fortunately it has partly fixed. This serious game application demands a good at technical characteristics mobile device (at least four-core with 2 gigabytes of ram) to run properly. Finally, the quiz game could have been enriched with more questions. That could keep the students interests longer. Unfortunately, since this is a demo game, can't support the ability of inserting more questions for it.

### **7.2.3 Advantages of the game**

Despite the «flaws» which had been previously described, the game meets the requirements of a serious game. To begin with, the models of the dinosaurs are as realistic as it can be and the movement of them also. That is probably the main feature which should draw the students' attention because students would be interested to play with the models of the dinosaurs. The controls of the dinosaurs are easily recognizable and easy to be learned from the young students. Any information which is given at the game for these animals has been retrieved from approved web sources like "Wikipedia" (Wikipedia, 2017), "Google scholar" (Google, 2017) , "National Geographic" (National Geographic, 2017) and many more as can be seen from the references. Students not only are able to play both games, (race against time and quiz game), but also learn about paleontology and keep track of their progress through the profile of the user interface. This game is a first step for games of this kind and opens the way for further future developments.

## CHAPTER 8

### 8.1 Conclusions

#### 8.1.1 Achievements from this game development

A serious game for providing knowledge about dinosaurs is developed. The purpose of this game is, hopefully, to motivate the students to learn more about this ancient period of our planet. For the creation of the game Unity engine have been used and Nielsen's usability heuristics were applied. The game does not include all the species of dinosaur, nevertheless the game should be interesting with just twelve species as there much for the students to learn. Bringing back even virtually these animals which ceased to exist sixty-five million years ago is quite fascinating by itself.

By elaborating this work, we had the opportunity to get a lot of knowledge about serious and their development issues. A serious game demands a research depending on the content and the elements it consists from. The elements or in other words the knowledge that should be planted in at this kind of games should be scientifically and academically correct to characterize a game as "serious". The time which was given for evolving this game, by adding features and correcting flaws had a positive impact on the knowledge it was gained during this process. This knowledge was not only at the field of programming and testing the functionality of the game but also at the field of education and the science of paleontology. As conclusion to the question if this serious game has achieved its purpose would be that despite the "flaws" which are mentioned before, considers being harmonized with the purpose of what was developed for. There is also a thought, after improving the application, to upload the game on the Google play store in order the students to have an easier access to it.

#### 8.1.2 Future developments of the game.

So far it has been analyzed of how this game was created and developed. This section is focusing of how this game could be developed in the future to be more educational efficient and harmonized with the modern aspects of teaching practice. For this reason, the terms data and meta-data will be shortly introduced for being more understandable the developments which could take place on the continuation of the project. According to Wikipedia Data is measured, collected, analyzed and reported whereupon it can be visualized using graphs, images or other analysis tools. Data as a general concept refers to the fact that some existing information or knowledge is presented or coded in some form for better usage or processing. In our case that is happening with the results of each gamer profile statistics. These statistics show the progress of the user within game. A future improvement could be

students' progress to send to database as data or metadata. To the question what metadata means the answer is simple. Metadata is described as data about data. It means metadata contains the informative and relevant description about the original data. Figure 64 helps to understand better the connection between data and metadata. The metadata also helps a user to know the nature of the data and helps the user to take the decision whether he requires that data or not.

**Comparison Chart**

BASIS FOR COMPARISON	DATA	METADATA
Basic	Data is a set of facts and statistics can that be operated, referred or analyzed.	Metadata describes relevant information about the data.
Information	Data can or can not be informative.	Metadata is always informative.
Processing	Data may or may not have been processed.	Metadata is always a processed data.

*Figure 63-data-metadata comparison chart*

(Privacypies, 2017)

This board makes a comparison about data and metadata.

A second thing which could be developed is the ability of the game to be transformed from single player to multiplayer, not only locally but via internet as well. This upgrade could make the game be more interesting and competitive among the students. At the comments part of the questionnaire students wrote that the game would be more interesting if it could be connected via internet and one player could hunt another's player dinosaur. So, the element of the challenge between players is considered important. Once more the data and the metadata of the students' progress would be enriched because a larger number of students would be able to learn and play.

Enriching the content is a continual need as well. For example, teachers should be able to add their own question to quiz or modify the playing period of time. Moreover, this game could be also enriched with the addition of new dinosaur species. New dinosaur models would sorely make this game more interesting, increase educational soundness of the game. That should keep the students interest longer. According to the questionnaire which was given to the students, this was a demand for many of the students. Students would like to control more dinosaur

species which live on land and dinosaurs which could fly as well. Moreover, the motion of some dinosaur species needs to be smoother facilitating that way students' control on the models. Speaking of controls, the direction arrows which are used in this application, proven to be easy for the students to operate but not efficient enough. Sometimes students tend to miss the direction arrow of the dinosaurs and that makes navigation more difficult. At «Warrobots» (Warrobots, 2017) game in Figure 64 a more efficient control system is shown, where the player doesn't need to choose a specific arrow to move the game avatar. Instead the only thing a player must do is to point with his finger. According to comments received from the questionnaire one characteristic which could be enriched is the effects of the game. For example, the dinosaurs could bleed if they were bitten or the fight between the dinosaurs to be more realistic. On the other hand, that extra effects wouldn't improve the educational purpose of this application, and the element of violence wouldn't serve any educational purpose. According to Möller.I (Möller, 2009) an exposure to violent games can increase the accessibility of hostile cognitions, aggressive affect, physiological arousal, and aggressive behavioral tendencies. What also needs to be improved is the way the instructions are given (as information to the students). Maybe this could be solved by giving the instructions at full screen mode and before starting the game.

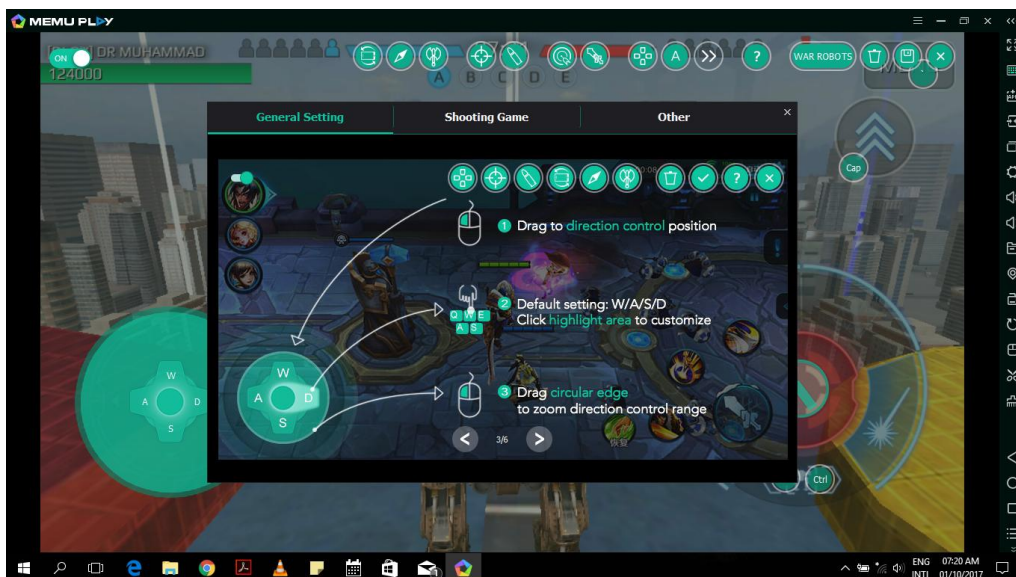


Figure 64-warrobots user interface

(Warrobots, 2017)

At this figure can be easily seen at the left corner of the screen the navigation control system a cycle within a bigger cycle.

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## Annex 1

The application was given to students for evaluation. For this propose, students were be given a questionnaire as can be seen right below.

## Αξιολόγηση παιχνιδιού

Σημάδεψε την απάντηση που σε αντιπροσωπεύει καλύτερα

1. Ποια είναι η ηλικία σας;  5 με 7  8 με 10  11 με 13  13 και πάνω

2. Το παιχνίδι φάνηκε πολύπλοκο (δύσκολο);

1	2	3	4	5	6	7	8	9	10
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πολύ απλό πολύπλοκο

3. Το παιχνίδι κατά την γνώμη σου απαιτεί πιο πολύ τύχη ή επιδεξιότητα;

1	2	3	4	5	6	7	8	9	10
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Καθαρά τύχη μόνο επιδεξιότητα

4. Οι οδηγίες του παιχνιδιού και τα σύμβολα του είναι κατανοητά;

1	2	3	4	5	6	7	8	9	10
---	---	---	---	---	---	---	---	---	----

πολύ απλές πολύπλοκες

5. Πόσα λεπτά χρειάστηκαν για να τελειώσετε το παιχνίδι;

κάτω από 3  3-5  5-10  10-15  πάνω από 15 λεπτά.

6. Το παιχνίδι φάνηκε σύντομο, κανονικό ή είχε μεγάλη διάρκεια;

1	2	3	4	5	6	7	8	9	10
---	---	---	---	---	---	---	---	---	----

Σύντομο Είχε μεγάλη διάρκεια

7. Πόσο διαφορετικό είναι το παιχνίδι αυτό από άλλα παρόμοια παιχνίδια που έχετε παίξει;

1	2	3	4	5	6	7	8	9	10
---	---	---	---	---	---	---	---	---	----

Όχι τόσο διαφορετικό Πολύ διαφορετικό

8. Το παιχνίδι σου φάνηκε ενδιαφέρον;

1	2	3	4	5	6	7	8	9	10
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Δεν μου άρεσε Μου άρεσε πολύ

9. Πόσο συχνά θα ήθελες να παίζεις αυτό το παιχνίδι;

1	2	3	4	5	6	7	8	9	10
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Ποτέ ξανά Αρκετά συχνά

10. Σου άρεσαν τα γραφικά και τα χρώματα;

1	2	3	4	5	6	7	8	9	10
---	---	---	---	---	---	---	---	---	----

Δεν μου άρεσαν Μου άρεσαν πολύ

10. Σου άρεσαν τα γραφικά και τα χρώματα;

1	2	3	4	5	6	7	8	9	10
---	---	---	---	---	---	---	---	---	----

Δεν μου άρεσαν Μου άρεσαν πολύ

11. Το τοπίο του παιχνιδιού σου φάνηκε ενδιαφέρον;

1	2	3	4	5	6	7	8	9	10
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Ήταν απλό Ήταν πλούσιο

12. Τα μοντέλα των δεινοσαύρων σου φάνηκαν ρεαλιστικά; (σαν πραγματικά)

1	2	3	4	5	6	7	8	9	10
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Καθόλου Πολύ

13. Ήταν ικανοποιητικός ο αριθμός των δεινοσαύρων;

Ναι  Όχι

14. Έμαθες για τους δεινόσαυρους πράγματα που δεν γνώριζες πριν ;

Ναι  Όχι

15. Βρήκες ενδιαφέρουσες τις γνώσεις για τους δεινόσαυρους που έμαθες από το παιχνίδι;

Ναι  Όχι

16. Σου κίνησε το ενδιαφέρον να μάθεις περισσότερα για αυτά τα προϊστορικά ζώα;

Ναι  Όχι

*Μουσείο Φυσικής Ιστορίας Πανεπιστημίου Κρήτης*

## Αξιολόγηση παιχνιδιού

17. Γράψε αναλυτικά τις παρατηρήσεις –σχόλια – προτάσεις σου σχετικά με την εμπειρία του παιχνιδιού για την περαιτέρω βελτίωσή του.

