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EcoLogic

Educational Digital Game for Teaching Domestic Ecology

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Resumo

O mundo e o ambiente estão a sofrer alterações que resultam num grande impacto no modo de vida da sociedade actual. As gerações futuras, que irão sofrer as consequências destas mudanças, devem ser ensinadas acerca do que podem fazer para prevenir desastres futuros. Os computadores e os jogos conquistaram o seu espaço em muitos lares e os miúdos passam horas a jogar jogos de computador. Este trabalho propõe um modelo de um jogo educativo para crianças sobre comportamento ecológico. Este modelo é baseado em estudos sobre teorias de aprendizagem, em boas práticas de criação de jogos educativos e na análise de vários jogos educativos. O resultado deste estudo é um conjunto de guidelines para a criação de jogos educativos para crianças. Através da aplicação destas guidelines e da sua junção com pesquisa sobre quais os temas da ecologia que devem ser ensinados e como, resulta um modelo conceptual de um jogo educativo para ensinar comportamento ecológico a crianças. Para além disso criámos o EcoLogic, um jogo que aplica esse modelo, e uma framework para o desenvolvimento deste tipo de jogos. As conclusões mostram que muitos jogos educativos poderiam ser melhorados através da aplicação das guidelines definidas neste trabalho e que estas são um bom ponto de partida para a criação de jogos educativos, permitindo criar uma grande variedade de jogos educativos. Para além disso mostram que o modelo é fácil de ser utilizado, apresenta uma visão clara do jogo e está adaptado ao propósito educativo.

Palavras-chave: Ecologia, Aprendizagem, Jogos Educativos, Guidelines.

Abstract

The world and its environment are suffering tremendous changes which result in a large impact on the current societie's way of life. Future generations, which will suffer the consequences of these changes, should be taught about what they can do to help prevent further disaster. Computers and games conquered their space in many homes and kids spend hours playing computer games. This work proposes a model for creating a computer game to teach children ecological behavior. This model is based on learning theories and educational game development best practices. To do this we discuss the learning process, educational games, and digital educational game design and look through several educational games. This study resulted in a group of guidelines to develop digital educational games for children. From applying these guidelines and gathering them with research on what ecological subjects should be taught and how, resulted a conceptual model of an educational game for teaching children about ecological behaviors. Furthermore, we created EcoLogic, a game that applies the conceptual model, and a framework for developing this sort of games. Conclusions show that most of the educational games could be improved by following the guidelines presented in this work and that these are a good starting tool for creating educational games and allow creating a vast sort of educational games. Moreover, they show that the model is easy to be followed, presents a clear view of the game and is adapted to the educational purpose.

Keywords: Ecology, Learning, Educational Games, Guidelines.

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Chapter 1

Introduction

1.1.Motivation

Only a few decades ago, the word ”ecological” was almost not heard. The environment was still healthy. However it was already getting sick and turning into the problem we have to deal with today. Ecology is now a topic of major importance. Issues such as global warming, pollution or the exhaustion of natural resources make us think more and more about what one can do to help save the planet. Small gestures that had no meaning a few years ago, such as saving water and energy, controlling gas emissions or recycling, are now important for help saving the environment.

Today's adults did not grow up with the environmental issues kids today do, so it is harder for them to develop an environmental conscience. However, they have potentially one of the greatest environmental consciences at home – their own kids. Thus, if we primarily focus on teaching children the knowledge will flow from children to adults of today. Also, it is when we are young that we start constructing our behavior and ideals, and these become more difficult to change with time. Children are extremely receptive to new ideas and knowledge. Therefore, in order to change society, it is vital to bring them up within the correct principles. This way we are also educating adults of tomorrow.

Traditional education is not always the most effective method for teaching. Educational games are a sometimes disregarded tool for teaching but are gaining a growing importance in this area. They also have been proving to be effective for teaching both inside and outside the classroom.

1.2.Objectives

Given that ecology is a theme that needs to be taught, that children are more available to learn than adults, and that educational games are good tools for teaching, we believe that an educational game for children to learn about ecology can be a useful tool. However, there is a question that stands out:

How to create an educational game for children to learn ecology?

To answer this question we need to take into account educational and game design best practices. Furthermore, to know what subjects of ecology are more important to be taught and which are more adequate to be learned by children.

Also, knowing that easing the development process of this sort of games promotes their creation, the purpose of this work is to:

Define guidelines and a model for a digital educational game for children to learn about ecological behaviors.

Based on this model, we will create a framework to implement an educational game for children to learn about ecology.

1.3.Outline

This document is divided into eight chapters and two appendices:

Chapter 2 (Learning and Digital Games) discusses the learning process, the different learning styles and methods and game-based learning specifically, exploring why should digital game-based learning be used and which are the main guidelines for educational digital games design.

Chapter 3 (State of The Art) presents research on educational games, paying special attention to those which regard ecology.

Chapter 4 (Guidelines for Digital Educational Games) creates a group of guidelines to be followed when creating digital educational games, based on the work presented in Chapters 2 and 3.

Chapter 5 (Ecology) studies the subject of ecology and determines which educational contents should be taught in the game we proposed to create a model for.

Chapter 6 (Conceptual Model) presents the game model developed by this work, which is based in the guidelines presented in Chapter 4 and the ecological studies presented in Chapter 5.

Chapter 7 (Implementation) describes the implementation of EcoLogic, a digital educational game based in the conceptual model presented in Chapter 6.

Chapter 8 (Conclusions) presents a summary of this work, its conclusions and future work.

Appendix A completes four lists presented in Chapter 2.1 (Ecology).

Appendix B presents example files used in the implementation process.

Chapter 2

Learning and Digital Games

2.1. The Learning Process

In much of his work [Piaget 1952][Piaget 1955][Piaget et al. 1929] Piaget presents the concept of **cognitive development stages**, establishing a relation between an individual's age and his cognitive abilities. He distinguishes four main stages of cognitive development – sensorimotor, preoperational, concrete operational and formal operational [Cole & Cole 2001]. The **sensorimotor period**, which occurs from birth to around 2 years of age, is when the infants achieve their sensory perceptions and simple motor behaviors. Throughout this period, they come to realize the existence of an external world and start interacting with it. The **preoperational stage** (from 2 to around 6 years old) is characterized by the child being able to represent reality through symbols (such as mental images, words and gestures) and being able to think about objects and events without needing them to be present. However, they often fail to distinguish their point of view from that of others, are easily captured by surface appearances, and are often confused about causal relations. As they enter middle childhood (ages 6 to 12) children also enter the **concrete operational stage** where they become capable of mental operations, i.e., internalized actions that fit into a logical system. They also become able to view things from another's perspective. Finally, we have the **formal operational stage** that occurs from the beginning of puberty until adulthood (from around 12 to 19). In this stage the individuals acquire the ability to think systematically about all logical relations within a problem. They also become interested in abstract ideals and in the process of thinking itself. The ages where these stages occur may vary, however the sequence does not. They do not depend on the cultural environment, therefore they are universal, and they extend to all kinds of concepts and content knowledge. The modes of thinking differ not only quantitatively but also qualitatively between stages.

There are many **learning methods** and more would outcome if we would combine them all together. **Traditional learning** is the most commonly applied – students go to school, listen to lectures, do the homework and are evaluated according to their results on the exams. These exams are primarily theoretical with a minority of practical evaluations existing in only a few courses.

Other sorts of learning methods can be quite different from traditional learning. **Experiential learning** is a process for learning through action, or the process of making meaning through direct experience.

"Tell me and I forget. Show me and I remember. Involve me and I understand."

Chinese Proverb

In the late 19^{th} century authors such as John Dewey and Francis Parker began supporting progressive education. They defended that people would learn best when involved in real-life activities with other people. This conception later grew to produce experiential learning. The concept of experiential learning should not be confused with experiential education which is "a philosophy and methodology in which educators purposefully engage with learners in direct experience and focused reflection in order to increase knowledge, develop skills and clarify values" [AEE 2007]. Experiential education differs from experiential learning mostly due to the fact that the later focuses on the learning for the individual whilst the first concentrates on the interactive process between teachers and learners.

Learning through observation and experience is defended by many authors as being essential for the correct understanding of a subject. As [Gee 2003b] states "When language is decontextualized from perception and embodied action it is hard for humans to fully understand it. Furthermore, people can understand things more generally when they have first experienced lots of concrete examples tied to perception and action". Studies show that the mind works by keeping records of experiences and building complex patterns of connections between them [Clark 1989] [Gee 1992]. This is the reason why some believe that "humans think and understand best when they can simulate an experience" [Bransford et al. 2000]. Learning through experience and observation is complemented by another theory – the **social learning theory** – which was proposed by Miller and Dollard [Miller & Dollard 1941] and later on expanded and theorized by Albert Bandura on several occasions [Bandura 1971] [Bandura 1989]. It states that watching other people's mistakes and experiences allows us to process those experiences in our minds and take conclusions with the advantage of not having to experience it ourselves beforehand. If the occurred makes sense for us, we may try experience it afterwards and, if we succeed, we will become more confident. This theory also conjectures that learning will most likely occur if there is a close identification between the observer and the model and also if the observer has a good deal of self-efficacy, i.e., the impression that one is capable of performing in a certain manner or attaining certain goals [Bandura 1989] [Bandura 1982]. Advertising is a good example of applied social learning theory – it captures the viewer's attention, the viewer retains the information and, if the advertisement affected him, the viewer will try to experience the product. Modeling the behaviors we want others to adopt, showing how they can be successful and encouraging them to imitate us may teach general rules and strategies for dealing with different situations. Critical thinking should also be stimulated - it drives learners to consider what they have to gain from doing something.

It is believed that most people prefer some particular method of interacting with, taking in, and processing information [Changingminds 2007]. From this idea emerged the notion of "**learning styles**" as being the individual's learning method that allows him to learn best. The **Visual, Auditory and**

Kinesthetic model proposes that each person learns best through one of the referred learning channels [Felder & Silverman 1988] [Reid 1987]. Visual learning is based on observing and seeing what is being learned, auditory learning is based on listening to information and instructions, and kinesthetic learning is based on hands-on work and engaging in activities. The percentage of people who prefer each of these learning styles varies with the consulted reference. However, in average, people are nearly equally distributed amongst all three. Although rare, there are cases where the person has more than one strong learning style. Jo Claeys, an expert in animation techniques as a tool in youth work / development and in conceptualizing "informative" games and exercises, applies in his work the **Head, Heart, Hands** method. This method addresses three main motivational systems that affect people – the head, the heart and the hands. Some people prefer cognitive (head) approaches, while others prefer affective (heart) or practical (hands) approaches in order to feel motivated. According to this theory all three approaches affect us to some extent but never all with the same amount of strength. The Head, Heart, Hands theory can be applied to several areas. For example, we can apply it when creating a game but we can also apply it when lecturing – the goal is to have a motivated receiver, either he is a learner or a gamer. And, as we discussed above, having a motivated learner is essential for learning to occur

Motivation is of particular interest to educational psychologists. Due to the fact that "learning is an active process that requires conscious and deliberate efforts" [Hsiao 2007], motivation plays a crucial role in the learning process. Motivation can affect the way students learn and their behavior towards subject matter [Motivation 2007]. It can direct behavior toward particular goals, lead to increased effort and energy, increase initiation of, and persistence in, activities, enhance cognitive processing, determine what consequences are reinforcing and lead to improved performance. There are two kinds of motivation. Intrinsic motivation occurs when people are internally motivated to do something because it either brings them pleasure, they think it is important, or they feel that what they are learning is morally significant. Extrinsic motivation comes into play when a student is compelled to do something or act a certain way because of factors external to him (such money or good grades). Because students are not always internally motivated, they sometimes need situated motivation, which is found in the environmental conditions that the teacher creates.

2.2. Digital Game-Based Learning

> *"I never try to teach my students anything. I only try to create an environment in which they can learn."*
>
> *Albert Einstein*

There are many ways to teach kids, the most common one being school and home education. But what happens to subjects, such as ecology, which, many times, are not considered important enough to be taught at school or at home? By using educational games we may help solving this problem. Next we will discuss why and how to teach children using a computer game.

Today’s educational process consists mainly on absorbing informal or logical lectures or readings and doing the homework so that, later on, the ability of retaining this knowledge can be accessed by taking tests. This sort of education is considered to be very inefficient nowadays [Prensky 2006]. When receiving only verbal information students may be able to pass written tests, however they often cannot use that same information in real problem solving. This happens because they do not really understand the information – they know how to apply it in a test but they do not recognize it outside the classroom environment.

Another factor that contributes for the traditional education model to be outdated is the lack of motivation. As many authors [Denis & Jouvelot 2005] [Prensky 2006] [Bisson & Luckner 1996] refer and as we discussed in the previous sub-chapter, motivation is a key ingredient to learning. And today's children are not motivated. Some people may defend that "I was able to learn the old fashioned way, why shouldn’t they?" but today's children are exposed to a different sort of stimulus than before. The amount of different kinds of input is increasing and the expected time of response is smaller than ever before. Since children are becoming used to this, they consider school lectures to be boring and non-interesting. Hence, the need to change the learning process is not just to humor kids – it is mandatory for their learning process to be successful in today's society.

One way to solve this problem is through game-based learning. Games are fun and most people enjoy playing games. And when we are enjoying an activity and having fun, we are motivated, and therefore, more willing to learn [Bisson & Luckner 1996]. Mark Prensky goes even further and considers that “fun in the learning process is to create relaxation and motivation. Relaxation enables the learner to take things in more easily, and motivation enables them to put forth effort without resentment.” [Prensky 2006].

Digital games help people to build simulations of how information can be used in a different context [Gee 2005]. Moreover, game technology has great potential on getting people to think and learn about things. “Games reward exploration, non-linear thinking, re-thinking goals from time to time, and not always following instructions or the most obvious thing to do.” [Gee 2003b]. There are however some age/generation limitations for this type of learning. Children think and solve problems in a different way than previous generations and, according to [Hsiao 2007], learning from games will work well for most people 35 and under. It also states that “A growing body of studies has reported that as young people play digital games, they engage in learning activities that are more complex and challenging than most of their formal school tasks”. As [Affisco 1994] reinforces, educational games come as a great way of teaching kids.

Children aged around 7-12 (Piaget's concrete operational cognitive development stage) are indicated for game-based learning. Before this age they still do not have the ability to see from the other person's point of view. At this stage, children have an immense will of playing ruled games. Also, it is an age where learning is not conditioned by knowledge - beyond the age of 12, when asked to execute an experience, the person can already pre-conceive what the result will be even if he has never done the experience. This may condition the learning outcome of the experience. In addition to this, our children's brains are changing to accommodate the new technologies with which they spend so much time [Prensky 2006]. Not only are they better at spreading their attention over a wide range of events [Green 2003] but they are better as well at multitasking and parallel processing, taking in information and making decisions quickly, understanding (i.e., reading) multimedia, and collaborating over networks. Toys have evolved to regard today's society and digital games are representative of that evolution. They are a door through which children can enter the digital world [Gros 2007].

Educational games may teach many different subjects: equations, by designing graphs that intersect with points on a grid; city planning, while designing a city (SimCity is a great example on this subject); physics of motion, while controlling the movement of a spaceship and firing missiles; geometry, while solving Tangram puzzles. Studies on the students' learning show that in most cases there are benefits such as increased motivation and better understanding of the subject. "For kids today, a game is part of a whole set of activities. They play Blues Clues, watch the show, use Blues Clues books, and integrate all this into their own activities. They play Age of Mythology, look at sites on mythology, get books on mythology, write and draw about mythology. This is all great for their cognitive development." [Gee 2003b].

Learning works best when the learner is so over-involved in his goals he does not realize he is learning. This happens when playing games – many gamers do not realize they are learning. A study involving 15 and 16 year-old adolescents [Gros 2007] showed that, when asked if they considered to be learning while playing digital games, the first reaction of most players was to deny that fact and affirm the idea that "it is a game". However, in a posterior interview some of the kids started considering that possibility after one of their colleagues said that "it depends on the game, the content and what you do. For example, in Call of Duty, I learnt rather a lot about the First World War". The study concluded that "when an activity involves pleasure, fun, motivation, interest and passion, the student is capable of dedicating a great deal of time and effort to that activity".

> *"When I watch children playing video games at home or in the arcades, I am impressed with the energy and enthusiasm they devote to the task... Why can't we get the same devotion to school lessons?"*
>
> *Donald Norman, CEO, Unext*

Technology has been having a growing importance and attraction power over youngsters. This is confirmed by the fact that most of the time children are at the computer is spent playing games. In fact, statistics show that the average American has now played over 10,000 hours of video games before he starts working. Repetition and time are two of the biggest keys to learning, and kids enjoy playing the same games over and over and over hundreds of times. People who spend so much time with anything cannot help but learn its messages.

With the release of the Nintendo Wii, XBox 360, and Playstation 3, the video game industry has been capturing a lot of interest lately. Either it is due to the entertainment it provides, the competitiveness, the achievement of a goal, or simply because it is something they understand very well, today's kids love video games. [Prensky 2006] determines 12 characteristics of digital games that make them so engaging for so many people:

- Games are a form of fun, giving us enjoyment and pleasure.
- Games are form of play, giving us intense and passionate involvement.
- Games have rules, giving us structure.
- Games have goals, giving us motivation.
- Games are interactive, giving us doing.
- Games are adaptive. That gives us flow.
- Games have outcomes and feedback, giving us learning.
- Games have win states, giving us ego gratification.
- Games have conflict/competition/challenge/opposition, giving us adrenaline.
- Games have problem solving, sparking our creativity.
- Games have interaction, giving us social groups.
- Games have representation and story, giving us emotion.

Carmen Sandiego is the main character of a very famous collection of successful educational games. With the first goal of teaching geography, the player had to find the character – Carmen – anywhere in the world. Later on, the game evolved into teaching also history, English, mathematics and even astronomy. Kids loved the game [CarmenSandiego 2007]. Other games, such as *Medieval Total War*, expose the player to information about history, mathematics, market negotiation and other academic contents. And when playing the game the player learns the game strategies around those concepts. This ability to think about complex systems is considered to be crucial in today's world where workplaces, communities, global institutions and the environment are all complex systems. There are many objects in these systems that interact with each other and the results of handling these objects are unforeseen. Games involving not only facts, concepts and theories but also characteristic sorts of actions, interactions, values, dilemmas and decisions, are very powerful regarding the educational purpose. Games such as Civilization III show that even children can enter a game as a complex system and learn deep conceptual principles about history and the social sciences.

"Playing and learning are two different dimensions that can be experienced during the use of a videogame"

[Gros, B. 2007]

Digital game-based learning has been using techniques that are applied in non-game forms of interactive learning. New techniques resulting from observing how the players react are also constantly being created and have demonstrated to be efficient for teaching through games. [Prensky 2006] briefly describes some of these interactive learning techniques:

<u>Practice and feedback</u> – Appropriate for teaching subjects that require much repetitive practice. Is better if combined with adaptive techniques (such as increasing difficulty or creating new goals).

<u>Learning by doing</u> – Uses techniques such as drill and practice, exploring and discovery and problem solving, allowing the learner to be an active participant, not just a mere spectator.

<u>Learning from mistakes</u> – Combines trial and error with appropriate feedback. When given through game action, feedback will seem less like a lecture but more as an amusement. This will allow the player to feel motivated to try again.

<u>Goal-oriented learning</u> – Goals are what push people to keep going after repeated failure. Therefore, they should be considered worth reaching.

<u>Discovery learning</u> – One learns best if, rather than being told, he finds out for himself. However, in problem-solving or "search for clues" games, the player should be told what the problem is / what he is looking for, otherwise he most probably will give up.

<u>Task-based learning</u> – This is a variation of learning by doing. It passes over the explanation part and proceeds directly to a series of tasks or problems to achieve a goal. These tasks may also be combined with adaptive techniques.

<u>Question-based learning</u> – Forces the player to think about information and reason to reach an answer, rather than just being told.

<u>Situated learning</u> – Students learn best if immersed in an environment that is similar to where the learning material will be applied in the future.

<u>Role Playing</u> – Is usually used for developing "soft skills" such as communication or interviewing. Extending the duration of role play during games will most likely increase learning.

<u>Coaching</u> – A virtual assistant can help make the coaching task feels as being part of the game rather than as a learning session.

<u>Constructivist Learning</u> – An extension of discovery learning. Constructivists believe that a person learns best when they can build ideas and relationships in their own minds based on experiments that they do (ex: LEGO, Sim City, The Sims, Tycoon games).

Multi-sensory Learning – Learn through multi sensory experiences (for example, learn animal names while making sounds and touching materials).

Learning Objects – Create small components of learning content data that can be connected whenever and however the teacher or the learner want it. This also allows data to be easily accessed and reused.

Intelligent Tutors – An intelligent tutor pays attention to the learner's actions and gives him specific feedback in order to help the learner.

Simulations are worlds in which variables interact through time. They are often used in science to observe or analyze results difficult to obtain in the laboratory environment. Several digital games (such as *Half-Life*, *The Sims*, *Rise of Nations* or *Civilization*) make use of simulations However these are different from the ones used in science – game simulations involve the player in a virtual world [Gee 2005] where he can contact with a much different reality. If encouraged to think about his learning the player can learn from these experiences and even transpose them into his real life [Hsiao 2007]. In simulations, the player acts and interacts with the virtual world through a character, discovers and/or forms goals, and, in order to reach these goals, the player must recognize problems and solve them. The virtual world allows the player to engage into a certain activity and observe the consequences of acting in one or other way, to think about moral issues or to learn new ways to solve problems. Video games can encourage and enact on the player a kind of attitude where he believes to actually be inside the game environment and playing the character's role. This is what Gee names as an "embodied empathy for a complex system" where a person seeks to participate in and within a system, all the while seeing and thinking of it as a system and not just local or random events. Unlike well-defined problems that have a clear initial state and goals state to deal with, games obligate players to figure out solutions either through asking one another for advice or through attempt/failure. This process of "discovery learning" (by searching for answers and clues) not only empowers the players by allowing them to take a critical distance from the subject, but it also gives them life experiences that they might not get elsewhere [Hsiao 2007]. The gaining of problem-solving skills is the most identified benefit that players can have from playing digital game. Video games are an extension of "the ways in which we all play with identities in our fantasies, reading, and media watching" [Gee 2003b]. Games have the great potential of enabling us to create and experience vastly more realistic and detailed worlds, to learn from that experience, and to transpose that knowledge to our real life.

A game is not a game if it does not have a goal. In fact, having a goal is what differentiates games from toys. An educational game must have an interesting goal – if it is not fun, the player will not feel motivated enough to play it and, consequently, will not learn from it. In some games the player is told what the goal is. In other games he must discover which are the goals and carry them out. But in open-ended games players can also make their own goals, depending on their desires, styles and backgrounds. This stimulates and motivates the player because now he is not only doing something imposed to him – his own goals and wishes become part of the game [Gee 2005].

Games do not need to be complicated in order to teach. In fact, most of the times players are learning and don not even realize it [Prensky 2003]. Teaching basic skills is one of the main goals of most educational games. One way of effectively doing this is by introducing them as a requirement for accomplishing goals that the player really wants to achieve [Gee 2003b]. Allowing the player to reflect on what he just experienced is also a key for successfully learning from the game experience – the player should not be a passive consumer, he must realize the outcome of his actions and experiences by being compelled to reckon them by the game itself [Gee 2003a] [Gee 2005] [Prensky 2006].

During gameplay, the player should be assisted and supported through knowledge imbued in the game. In an educational game this will offload some of the cognitive burden from the learner and will allow him to start acting with some degree of effectiveness without having to be totally competent in a certain area [Gee 2005]. For example, introducing virtual characters in the game can be one way of doing this – the player is assisted and supported by the knowledge imbued in the character,

During an educational process feedback is most important. In the same way, in educational games it is through feedback that learning takes place. By receiving feedback the player will be able to measure his progress and gain competence. Without it, the player might never know what happened and get stuck at a certain point. Feedback can be inputted in several ways – talking agents, written text, audio text, etc. "Games give information "just in time" – when the player actually needs it – and "on demand" – when the player feels the need for it. They also allow players to access that given information later on when they want to reflect on it or review what they have already encountered" [Gee 2003b]. This principle of explicit information in response to demand is mandatory in digital games.

During gameplay the player is immersed in a virtual world he can explore without suffering real consequences. This protective environment allows the player to feel safer and to more easily accept proposed challenges. If the game environment is close to the player's reality he will also have less difficulty transposing game concepts to real life. Therefore, allowing the player to easily identify himself with the game and its characters is a key aspect of educational games.

Digital games also create opportunities to share the playing experience with other players [Hsiao 2007]. Social participation through networked playing, game forums or other tools allows helping and getting help from others, and sharing information and experiences.

Digital games often include scenario editors, which allow the player to make changes to the game world without having to have access to the underlying technology or programming skills. This practice has proven to expand the longevity of the games, allowing to conclude that this way players play the game more times and, in some cases, with more interest [Gee 2003b] [Gee 2005]. In educational games, these editors allow a non-experienced developer (for example, a teacher) to more easily create scripts according to a given curriculum.

2.3.Summary

Learning is the process through which we take information in so that we can use it in future experiences. This process evolves along with the person's development stage. Today's children are exposed to different stimuli from previous generations and are expected to show knowledge in many different new areas more than ever before. The teaching process should be adapted to these new needs in order to motivate children to learn. Each person has its own learning style hence the learning method should address that need. Teachers should assess the learning styles of their students and adapt their classroom methods to best fit each student's learning style.

The arising of new tools for education follows the tendency for technological evolution. Digital games have proven to be an effective help to traditional learning, bringing fun and motivation into the classroom. They develop not only low-level abilities but also advanced skills that help the learner to overcome challenges in a real-world environment. Digital games are as well a natural tool for learning – they externalize the way children think in an environment that is familiar for them (games).

Teaching through entertainment is fun and enhances the pupils' motivation and will to learn. Digital games not only do that but also allow to easily adapt the learning process to a vast range of learning styles, applying most of the learning theories discussed in this chapter. This sort of educational games have been used and studied for some time now and, by increasing children’s skills such as attention and reaction spans, they have proven to be effective. Considering all this, merging educational contents with gaming seems to be a certain option.

Chapter 3

State of The Art

There are countless games, websites and computer activities relating education on several areas available for free use on the internet. For this research we paid most attention to the ones that related ecology and environment protection, and specially the ones regarding being ecological at home or with everyday practices. Nevertheless, we also present some games that, despite not regarding ecology, were considered to be good examples of educational games.

3.1. Analysis of Digital Educational Games

3.1.1. Casa Virtual da Energia (Virtual House of Energy)

Casa Virtual da Energia (CVE) [Ferreira et al. 2007] is a tool developed in Portugal and is part of a project developed by the environmental association Quercus [Quercus 2007].

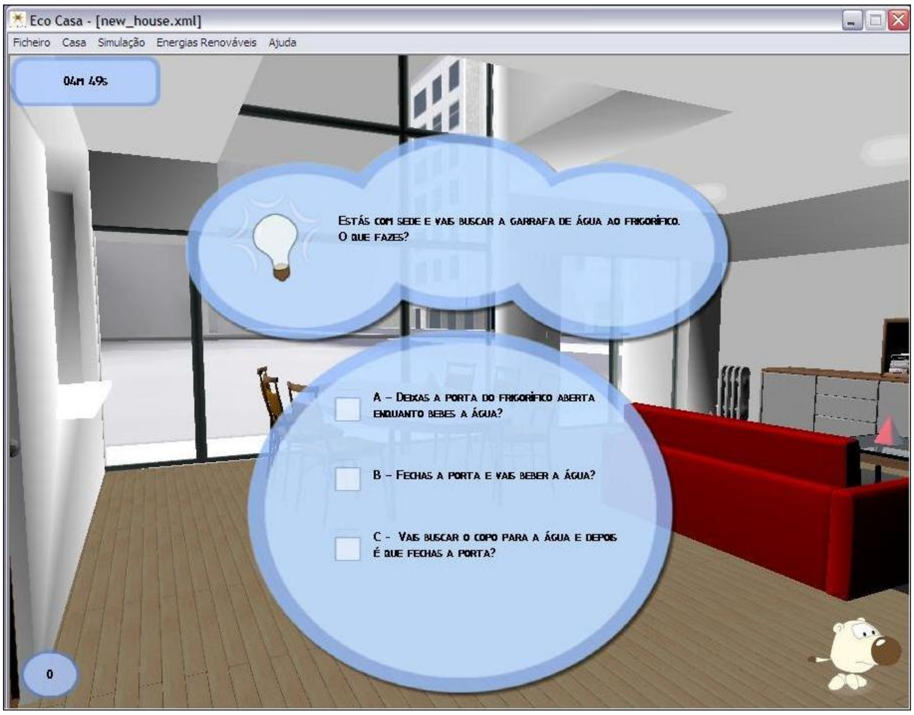

Figure 3.1 - The EcoCasa game

There is an original aspect about CVE - it separates the house simulator (energy consumption, etc.) from the game, i.e., you either simulate your house's consumption or play a game (called EcoCasa) where you can learn house ecology concepts. As we can see in Figure 3.1, the EcoCasa game takes place inside a common house. While the player walks around the house, he must answer some questions related to domestic ecology. The goal is to promote a change of habits in the energy consumption management at people's home.

CVE allows:

- Simulating energy consumptions in a house, the associated cost and resulting gas emissions of that consumption.
- Comparing two houses with different characteristics. This allows the player to make different choices on each house and analyze and compare the results of each choice.
- Simulating ecological equipment acquisition, such as solar panels.
- Playing an ecological game for children.

The simulation allows the user to have an immediate idea of the impact, on energy saving and energy consumption, of his change of habits. It lets the user experiment several kinds of equipment that would cost plenty of money and risk to try in real life. It has many details regarding the characteristics of the equipments allowing the experience to be as real as it can. Also, the game teaches useful ecological concepts and ideas.

However, it is not very intuitive. Despite having many instructions it is not easy to understand how to use neither the simulation nor the game. In addition, the amount of detail in the characteristics of the equipments may cause the person to give up experiencing the simulator.

3.1.2. V GAS

V GAS [Pedrosa et al. 2003] [ArtLab 2007] is a very interesting project. As shown in Figure 3.2, this game takes place inside a house where the player will create a virtual environment of a household and get feedback on the amount of harmful gases (which increase the greenhouse effect) that are being released to the atmosphere.

The purpose of the game is for the player to learn about the impact of gas emissions resultant from everyday life activities. The player should simulate an everyday life experience. If the house's impact on the environment is not good, the player should try to change his lifestyle in order to be more ecological.

In V GAS the player may create different scenarios and compare them to his own houses'. He can also change the appliances, lights, and many other aspects of the house. Throughout the game, the player is given some challenges in order to test his qualifications. The result of the player's actions are measured and shown in graphs.

Figure 3.2 - The V GAS game

One problem with this game is that the action unrolls very slowly resulting in the player not knowing what to do sometimes. This could be solved by creating more tasks for the player to accomplish, never leaving him with nothing to do. Another problem is that V GAS only concerns the gas emissions, leaving behind many other important ecological aspects.

One very original characteristic of V GAS is that it has its own library. This allows the player to learn more about the subject of gas emissions or even just find in the glossary some word he did not know the meaning of.

3.1.3.SimPark

SimPark [Detheroe 2007] [SimPark 2007] is a commercial game released in 1996 by Maxis. The goal is to create and manage a successful natural park. First you choose where, in northern America, you want your park to be located. This will determine its climate and what species of plants and animals you may place there. The park's layout can be chosen from several maps. Afterwards, you choose which species of animals and plants you want living in the park.

The game's goal is to manage the animals' and plants' locations so that equilibrium is achieved. The player must learn how the different species interact and how susceptible they are to a certain climate in order for them to survive.

As we can observe in Figure 3.3, SimPark has an interface very similar to other well known games, such as Sim City. Also, the playing mode is very similar to tycoon games, such as Roller Coaster Tycoon. SimPark is a typical agent-based real life simulator. The player has many variables that do not depend on his direct action such as the number of visitants the park attracts or if a certain species lives or dies.

Figure 3.3 - The SimPark Game

SimPark is somehow educational and environment related, since you learn plenty about the species. However, the lack of a short-term goal may cause the player to get uninterested. Also it does not concern domestic ecology in any way.

3.1.4.EPAL Júnior

EPAL Júnior [EPAL 2007] is a very simple online game created for kids. The purpose of the game is making children aware of the importance of saving water.

As shown in Figure 3.4, the player controls the character of a boy carrying a bucket. In the scenery around the boy there is a lake and some water conducts. The goal is to save water by catching water drops with the bucket and pouring it into a lake. Also, whenever a water conduct gets damaged, the player should send the character to fix it.

Although it is quite fun at first the game gets boring after some time due to the repetitiveness of the task. Despite the educational purpose, the EPAL Júnior game does not illustrate a real life scenario that children may use in their everyday life.

Figure 3.4 - The EPAL Júnior Game

3.1.5.Ecology Games

Gameaquarium [Gameaquarium 2007] is a web page where there are hundreds of references to educational games. One of these references is to the Ecology Games [Ecology 2007c] website. On this website the user has access to several environment-related games. For example, "Pond Food Web" [Publishers 2007] is a drag and drop web game where the player must arrange several pictures of animals in order to create the correct food-chain of a pond (Figure 3.5).

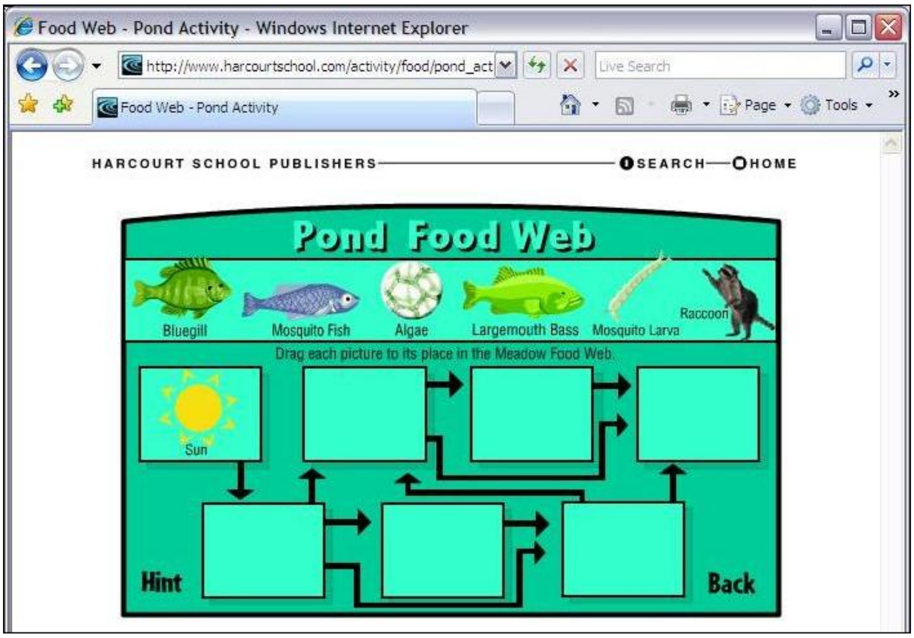

Figure 3.5 - The Pond Food Web Game

Another example is the "Principles of Ecology" [Kelleher 2007] quiz where the player must answer some questions about ecology. The questions on this quiz are very specific to Ecology as a science, so they become difficult for children to answer them. You can observe an example of one of those questions in Figure 3.6.

Both these games are quite educational and entertaining. However, each game itself does not vary much, resulting in the player getting bored after some time. Also, because they only concern the environment (ecosystems, trees, forest, biodiversity, etc), several ecology themes such as everyday life ecology are disregarded.

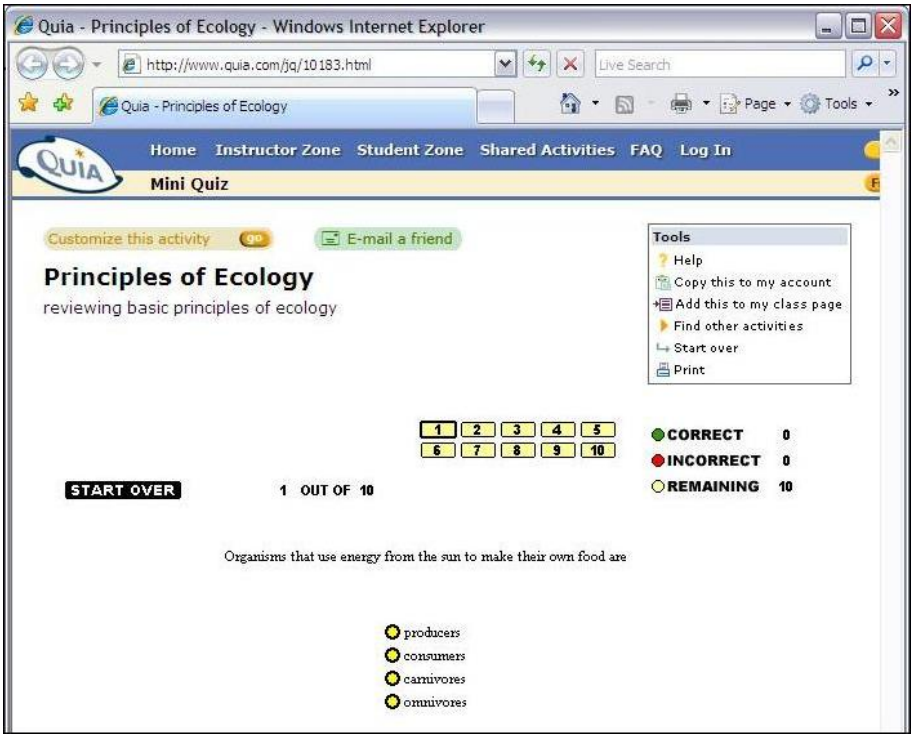

Figure 3.6 - The Ecology Quiz Game

3.1.6.Food Force

Created as a part of the United Nations' World Food Programme, Food Force [FoodForce 2007] is a game that aims to teach how to fight hunger in countries in need. The player is part of a field team in Sheylan, an imaginary country where disaster has struck and the population needs help. The team's role is to reach the population and give them health aid and food supplies not only immediately but also in a long-term perspective.

Several best-practices can be identified in this game. The player is asked to assume a role in an important mission with a clear goal. There is continuous interaction from the game's NPCs (non-playing characters), which motivates, instructs and helps the player. The game's goal is achieved by accomplishing six missions that are easy to understand, easy to perform but also difficult enough so that the player can only reach maximum performance if he trains that task. The missions are multidisciplinary and have different outcomes depending on the player's decisions. Figure 3.7 and Figure 3.8 show two of those missions.

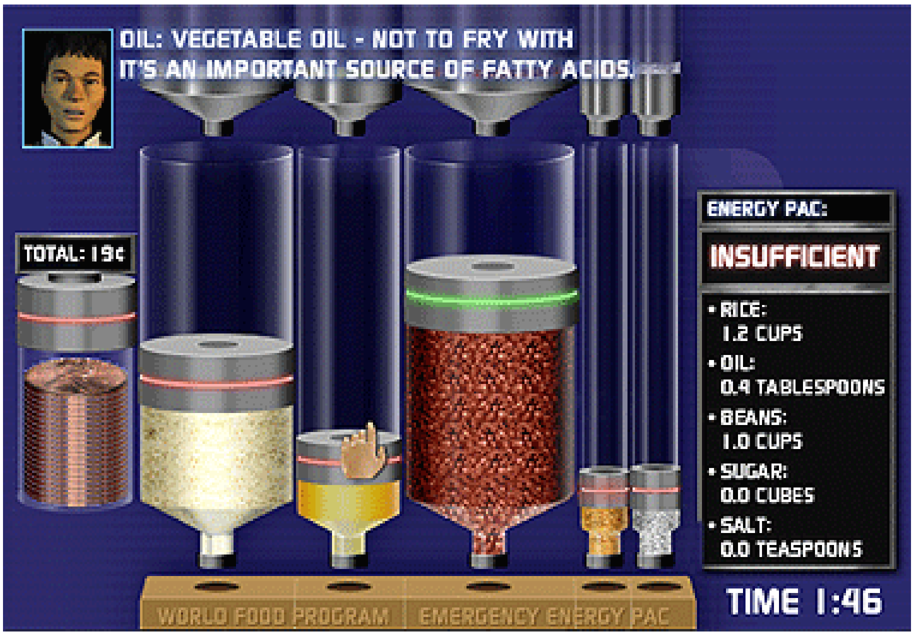

Figure 3.7 - Food Force, Mission 2

Figure 3.8 - Food Force, Mission 4

Throughout the game the player is always presented with the possible decisions and, more importantly, with the results of the decisions he made. Also, the player is continuously proposed to retry the missions in order to improve his performance to the best possible. A negative side of this game is the absence of an editing tool or something similar to allow extending the game's lifetime -

after the six missions have been accomplished the game is over. It also does not relate everyday ecology in any way. Despite this, Food Force is definitely a good model for educational games.

3.1.7.Econ 201

This is a very interesting example of a game that is actually being used as a tool for learning. Econ 201 [Econ201 2007] (Figure 3.9) was developed by the University of North Carolina (UNC) in the context of a microeconomics course. Students do not have to attend classes – they are granted real credit depending on their performance in the game. Every student starts as being an extraterrestrial that has crashed into an unknown planet and now has to apply all his microeconomics knowledge in order to survive.

Figure 3.9 - The Econ 201 Game

Econ 201 was developed by a team of around 35 people, including teachers and educational game experts. According to a press release [Econ201 2006] it applies many of the concepts mentioned above: analysis, practice, trial and error, role playing, and immersion in a contextualized environment, amongst others. Unfortunately, no information was found on whether this experience succeeded or not. Also it was not possible to try out the game because registration is limited to students enrolled in UNC.

3.2.Summary

In this chapter we presented some educational games, paying special attention to those which are related to ecology. Some of game's found aim at teaching ecological concepts while others just intend to give the user an idea of what happens if we act ecologically (or not). Surprisingly, most ecology games regarded only a very specific area of ecology. This shows how a game addressing several issues might be a breath of fresh air in the world of educational games. Also, most games were not motivating enough to make us want to play them again. Most ecology related games were so simple that after playing it once there was nothing new to achieve. Other games were so complex that demotivated the player. We do not think this directly affects if whether or not they are capable of teaching. However, if a game motivates the player and makes him want to play it more than once, the educational content will be presented more times. We also think that creating a motivating game allows reusing it to introduce new content without having to create a new game from scratch.

Chapter 4

Guidelines for Digital Educational Games

Despite the fact that they are still emerging, educational games have been studied by many authors, such as Mark Prensky or James Gee, who defend it as being a new essential way to teach. Amongst their work, they expose the importance of games in eduction, and prove its use as being effective for learning. What lacks in most of these works is a more straightforward definition of guidelines that can be easily understood by educational game designers, perhaps even by the non-professional ones, such as teachers or students themselves.

According to [Prensky 2006] “digital game based learning works because people get engaged (because it is a game) and because there is a learning process involved”. In this chapter we adapt the ideas presented in Chapter 2 and create a group of guidelines that gather both educational and digital game-based learning principles. These guidelines are to be used as a guidance by any educational game designer. Given that each educational game has its own purpose and goal, they should not be seen as rules to be followed without criteria and should be adapted to the circumstances' needs. Furthermore, we analyze the digital educational games studied in Chapter 2 according to those guidelines.

4.1. Defining the Guidelines

> *“The cutting edge is [...] building good games into good learning systems and building the good learning principles in good games”*
>
> *James Gee*

In its essence, an educational game should teach. However, it can not disregard other crucial features such as being fun and accurate. The more fun a game is the more motivated the player will feel and, therefore, the more he will learn. The accuracy of the game's content is obviously also very important. In order to assure accuracy, the contents for the game must result from meticulous research and, more importantly, from the involvement of teachers. The curriculum should be determined resulting from an interaction between the game designer and the teacher. To use games in school, teachers need to scaffold thought about the game and its contents and link it to an enhanced curriculum. However, games should not be seen as a unique solution for education. They should become part of a whole curriculum involving school teaching, internet sites, texts and discussion. As for the fun factor, most designers take advantage of the motivation existing in commercially successful games and copy the formula into educational games. Using successful formulas is considered to be one of the best ways to create successful games for education.

Following this principle of using successful formulas for creating fun games, we can also take advantage of known educational formulas for creating educational games. For instance, the Visual, Auditory and Kinesthetic learning style can be taken into account when developing a digital game with educational purposes. The stimuli corresponding to each kind of learner (such as powerful imagery, audio instructions or action-based tasks) can be equally introduced into a digital game. Each of these learning channels may be equally stimulated, allowing each learning style person to learn as any other. In fact, as [Gee 2005] corroborates, the visual, auditory and kinesthetic stimuli are implied in almost any digital game – visual stimuli trough graphics, auditory through sounds and kinesthetic through action input.

The Head, Heart and Hands learning style can also be associated with the educational game design. By creating activities that stimulate each of these sorts of learners, the game will satisfy a wider range of players. For example, in a game we can introduce an emotional plot (e.g., "Help the scientist obtain the life-saving formula"), an intellectual task (e.g., "Who invented the light bulb?") and a hands-on activity (e.g., "Kill all bacteria by clicking the mouse button").

Each of these learning style theories categorize learners into several types. The Visual, Auditory, Kinesthetic theorize distinguishes three types of learners based on the individual's preferred sensorial input method for learning. The Head, Heart, Hands theory categorizes the individual's preferred motivational method (therefore, his preferred learning style) based on the approaches that most motivate the person – mind-related, emotion-related or action related approaches.. Despite having different approaches, both these theories have a common goal – adapt to the individual's learning method that allows him to learn best. The decision of satisfying the needs of only one type of learner or trying to satisfy the needs of all types of learners should depend on the game's audience – if whether or not it has various types of learners.

Piaget's work [Piaget 1952] [Piaget 1955] [Piaget et al. 1929], states that developing and perceiving knowledge is an evolving process that differs throughout the individuals' development stages. Until entering adulthood, individuals go through four stages of cognitive development where they have different abilities. For this reason, the learning method should be adapted to the learner's development stage.

As we saw in Chapter 2, digital game based learning already applies interactive learning techniques in its principles. Nevertheless, there are other important aspects that should also be born in mind. These include using educational and gaming techniques, and appropriating the game to the player's preferences. All these aspects will allow the game to be a more effective tool for learning.

Guideline	Why to use it	How to use it
Motivate the player.	Motivation enhances learning. The player will want to play it more times.	Make the game fun. Create goals the player will want to achieve. Create goals neither too difficult nor too easy to achieve. Use formulas of successful games.
Use accurate contents.	Otherwise the game will teach wrong or inappropriate contents.	Get content from credible sources. Ask teachers for help.
Assist and support the player.	Offloads some of the cognitive burden from the learner and allows him to start acting with some degree of effectiveness without having to be totally competent in a certain area	Have a help menu. Create tutorials. Use virtual assistants. Have simple rules and expose them to the player when the game starts.
Give feedback.	Allows the player to measure his progress and gain competence. In games, feedback seems less like a lecture but more like an amusement, motivating the player to learn.	Through audio, visual or action-related information. Use intelligent tutors or talking agents.
Stimulate critical thinking and reflection.	Allows the player to realize the outcomes of his actions, therefore, to learn from the experience.	Give information “just in time” and “on demand”. Ask questions about content. Require skills for accomplishing goals.
Model behaviors that the player should adopt.	Games provide a safe environment where the player can experiment without suffering real consequences. When observing others the player can take conclusions without having to experience it himself beforehand (social learning theory)	Allow the player to make mistakes. Encourage retying after failure. Show examples of success / insuccess. Encourage imitation.

Table 4.1 - Guidelines for creating educational games (Part 1/2)

Guideline	Why to use it	How to use it
Use recognizable environments.	Learning is more likely to occur when there is a close identification between the observer and the model. The player will more easily transpose game concepts to real life.	Create a game world similar to where the content will be applied in the future. Create characters to which the player can relate to. Create realistic tasks.
Adapt the game to the player.	The player needs flow it order to keep interested. Experience and learning capabilities differ according to a person's age (Piaget's Stages of Cognitive Development) Each person has a favorite learning style.	Use adaptive techniques (increasing difficulty, creating new goals, introducing surprise elements. Adequate the game to the player's age. Identify and adapt the game to the player's learning styles.
Grant social participation.	Allows helping and getting help from others, and sharing information and experiences	Through networked playing, multi-player gaming, web forums, etc.
Allow to edit/personalize the game.	Allowing the player to personalize the game is motivating. Expands the longevity of the game.	Create editing tools (that can either allow the player to personalize the game or allow the designer to easily introduce new contents) Use learning objects (create chunks of material that can be easily reused and adapted).

Table 4.1 - Guidelines for creating educational games (Part 2/2)

"Content"	Examples	Learning Activities	Possible Game Styles
Facts	Laws, policies, product specifications	Questions, memorization, association, drill	Game show competitions, flashcard type games, mnemonics, action, sports games
Skills	Interviewing, teaching, selling, running a machine, project management	Imitation Feedback coaching continuous practice increasing challenge	Persistent state games Role-play games Adventure games Detective games
Judgment	Management decisions, timing, ethics, hiring	Reviewing cases, asking questions, making choices, feedback, coaching	Role-play games, detective games, multi player interaction, adventure games, strategy games
Behaviors	Supervising, exercising self-control, setting examples	Imitation, feedback, coaching, practice	Role-playing games
Theories	Marketing rationales, how people learn	Logic Experimentation questioning	Open ended simulation Games. Building games Constructing games Reality testing games
Reasoning	Strategic and tactical thinking, quality analysis	problems examples	Puzzles
Process	Auditing, strategy creation	System analysis and deconstruction, Practice	Strategy games Adventure games
Procedures	Assembly, bank teller, legal	imitation practice	Timed games Reflex games
Creativity	Invention, Product design	play	Puzzles Invention games
Language	Acronyms, foreign languages, business or professional jargon	Imitation Continuous practice immersion	Role playing games Reflex games Flashcard games
Systems	Health care, markets, refineries	Understanding principles Graduated tasks Playing in micro worlds	Simulation games
Observation	Moods, morale, inefficiencies, problems	Observing Feedback	Concentration games Adventure games
Communication	Appropriate language, timing, involvement	Imitation Practice	Role playing games Reflex games

Table 4.2 - Types of Learning (from [Prensky 2006])

In this chapter we present all this variety of knowledge assembled into a number of general guidelines that can be easily followed by any educational game designer. This will allow the designer not only to follow experienced game based learning techniques but also to take into account all the important aspects that surround them. Table 4.1 shows **what** guidelines an educational game designer should follow, **why** should they be followed and **how** they can be applied in the game.

In [Prensky 2006] Marc Prensky exposes the “Types of Learning” (presented in Table 4.2), a relation between the content one wants to teach and the learning activities and possible game styles that are able to teach that content. We suggest cross-referencing the guidelines in Table 4.1 with the possible game styles Prensky presents in this work. This will ease the educational game designer's task not only in determining which game aspects are important but also in defining which game style he may apply.

4.2. Game Analysis Using the Guidelines

In Chapter 3 we researched for digital educational games, paying special attention to the ones that relate everyday life ecology. We will now analyze those games regarding the previously defined digital educational game design guidelines. Table 4.3 indicates, for each game, if whether or not it uses the presented guidelines.

All of the researched games motivate the player in some way. Most of them do this by having goals that are neither too difficult nor to easy to achieve. CVE, VGAS and Simpark also make use of a successful formula – they are based in simulations.

CVE, VGAS and Food Force were the only games of which we could find references for the content's sources. CVE is part of a project with recognized Portuguese partners, such as ADENE, EDP, Instituto Superior Técnico and Oeinerge. VGAS is part of a study on environmental effects of gas emissions and Food Force was published by the United Nations World Food Program.

All games assist and support the player and give him feedback. Assistance is usually done by exposing the rules in the beginning of the game. CVE, VGAS, SimPark and Food Force extend their offer with a help menu. Food Force also uses a talking agent not only to guide the player throughout the game but also to give him feedback on his actions. Most of the other games restrict the feedback to visual information but some also make use of sounds and game actions.

Almost all games stimulate critical thinking and reflection. Only EPAL Júnior did not do this in any way (the player was neither stimulated to think about why he should save water nor to reflect on the consequences of collecting water with a bucket). The other games gave the player information on the subject that was under discussion (this varied with the game) and VGAS, SimPark, Pond Food Web and Food Force require the player to think about the subject in order to accomplish goals. CVE and Ecology Quiz make use of questionnaires.

What?	CVE	V GAS	Sim Park	EPAL Júnior	Pond Food Web	Ecology Quiz	Food Force
Motivate the player.	✓	✓	✓	✓	✓	✓	✓
Use accurate contents.	✓	✓	([1])	([1])	([1])	([1])	✓
Assist and support the player.	✓	✓	✓	✓	✓	✓	✓
Give feedback.	✓	✓	✓	✓	✓	✓	✓
Stimulate critical thinking and reflection.	✓	✓	✓		✓	✓	✓
Model behaviors that players should adopt.	✓	✓	✓	✓	✓	✓	✓
Use recognizable environments.	✓	✓	✓				✓
Adapt the game to the player.	✓		✓	✓			✓
Grant social participation.	✓						✓
Allow to edit/personalize the game.	✓	✓					

Table 4.3 - Guideline application in the researched games

By allowing the player to make mistakes and encouraging retrying after failure, all games model behaviors they want players to adopt. Some of them, such as CVE, VGAS, and Food Force also encourage imitation. Food force is the only game that shows examples of success/insuccess.

As for recognizable environments, CVE, VGAS, SimPark and FoodForce use realistic scenarios that allow the player to more easily immerse in the action. Some of these games also require the player to accomplish realistic tasks, i.e., tasks that are related to the content in the real world. In VGAS the player must manage gas emissions in a common house, in Simpark he must manage a natural

[1] - It was not possible to verify this guideline due to lack of information.

park and the species that live in it and in food force he must help the habitants of a country that is in war and needs food supplies.

CVE and EPAL Junior adapt their tasks and difficulty level to the target player's age (simple and easy tasks for children). Simpark and Food Force use adaptive techniques – increasing difficulty and creating new goals, respectively.

Only CVE and Food Force grant social participation, both of them through websites and forums on the game's subject. Curiously, none of the games was multi player.

As for personalizing the game experience, only CVE and VGAS allowed the player to do this – in both cases the player was able to change the house and appliances characteristics. None of the games had an editing tool to allow expanding the game or its contents.

4.3. Summary

Developing digital games for education is a multidisciplinary task. In this chapter we presented a group of guidelines for creating digital educational games. These guidelines concur resulted from joining educational game design best-practices and learning theories.

In summary a digital educational game should motivate the player, use accurate contents, assist and support the player, give feedback, stimulate critical thinking and reflection, model behaviors that players should adopt, use recognizable environments, adapt itself to the player's needs, grant social participation and be editable/customizable. These guidelines were created in order to be easily used by any educational game developer. We also suggest that, in order to ease the development task even further, the designer should reference Mark Prensky's “Types of Learning”, an easy to use guide to cross-referencing educational game contents, learning activities and possible game styles.

We analyzed the games researched in Chapter 2 regarding the guidelines created in this chapter. We observed that in general the guidelines are present in most of the games. Where these games failed the most was in granting social participation and allowing to edit/personalize the game, allowing us to conclude that these are areas in educational games that should be more explored. The only games that adopted the last guideline, followed it by allowing the player to change scenarios, and they were both simulations, meaning that this guideline should be more explored by non-simulation games. None of the games could be edited in order to introduce new contents in the game.

Chapter 5

Ecology

What is ecology? According to [Ecology 2007a] [Ecology 2007b], ecology is the scientific study of the distribution and abundance of living organisms and of how these are affected by interactions between the organisms and their environment. The word is derived from the Greek "oikos" (household) and "logos" (study). Therefore "ecology" means the "study of the household [of nature]". The word "ecology" is often used as a synonym for the natural environment or environmentalism and "ecologic" or "ecological" is often taken in the sense of environmentally friendly. Ecology is a vast subject and there is much to learn about it.

As mentioned before, the purpose of this work is to teach children about ecology. However, what should we teach them exactly? Also, according to the guidelines in Chapter 4, educational game's content should be retrieved from credible sources. In order to solve these matters we searched on specialized books [Group 1990] [Group 1991] and flyers, did some research on the Internet. We also asked for help to the students and teachers of a local primary school (the IDEIA ATL at Tires, Portugal). Their support was very important. Teachers told us that children are very interested in the subject of ecology and that many concepts, such as recycling and saving water and energy, are nowadays taught at most schools and children understand them very well. The teachers also told us that, from around the age of 7, the children are taught basic ecologic behaviors, such as recycling and saving water and energy. By interacting with the students, we asserted that, in spite of showing they know what should and should not be done, some of the younger children did not know why. Usually they said it was because their teacher/parent said so. We concluded that younger children learn a lot from examples and telling. However, older children (closer to 12 years old) were already capable of giving an explanation. This shows that, by giving examples but also explanations, the game model proposed in the previous chapter adapts to all these childrens' needs. One very interesting fact is that in many families, children are the ones who introduce their parents to ecology, and the fact is that adults learn from their children and change their behavior to a more ecological one. Perhaps teaching children ecology is a good way to teach adults too.

The collected data was organized as follows – first we expose the most important environmental issues and some environmental curiosities and afterwards we reveal what we (and children) can do on a daily basis to help save the environment. The vocabulary is simplified so that it can be easily understood by children.

5.1.Environmental Issues

Although children may know that there is something wrong with the environment, what is it exactly? Next, we present some information about some of the most problematic environmental issues: air and water pollution, excessive waste, the greenhouse effect and the ozone hole. We also add some curiosities that intend to help children realize the impact of some actions on the environment.

5.1.1. Air Pollution

Uptil a few years ago, the air was clean and unpolluted. With the growth of industry, more and more factories have been constructed and more and more cars exist, releasing many polluting gases to the atmosphere. Also, because of the cutting down of trees and lack of green spaces in the cities that obstructs the air renovation all the pollution stays there.

Polluted air provokes diseases on humans, animals and plants. Some gases that pollute the air also contribute to the greenhouse effect and to the creation of ozone holes.

5.1.2. Water Pollution

Despite the fact that most of our planet is covered with water, this is not a never-ending source. The water has become polluted due to the fact that industry residues, petroleum, pesticides or even common garbage have been dumped to the rivers and oceans for years.

The water we consume comes mostly from rivers, because it is not salted. But due to water pollution and also because most of the water is naturally salted, the water now has to be treated in order to be consumed. This treatment demands the use of much energy and resources.

5.1.3. Excessive Waste

What happens when we throw something away? After putting the garbage in the trash can, a truck will collect all the garbage and take it to a landfill or garbage dump. The garbage will be buried there and we will never see it again. But trash takes time to decompose and these days we create more trash than the one nature can handle. Lack of space is a problem. Also, not all materials decompose in the same way. Plastic takes more time to disintegrate than food and glass might never disappear. So what we can do to prevent this is to reduce (pre-cycle), reuse and recycle. We can reduce the amount of garbage we create by avoiding to buy things that cannot be reused (like plastic wrapping and other packages). Reusing is to use something more than once. For example, you can use the plastic bag from the supermarket to wrap the trash can. You should also use both sides of the paper sheet. Recycling is the destiny to give to materials that can no longer be used, like old newspapers and magazines, glass bottles, plastic and other packages.

5.1.4. Greenhouse Effect

The Earth is surrounded by a blanket of invisible gases that keep the heat coming from the sun from getting out. Without this blanket, we would not be able to live on Earth because it would be too cold. However, the amount of these gases is growing due to smokes released by factories and cars and also by the cut down of trees. This causes the Earth to heat too much carrying several consequences such as the overheating of places where the temperature used to be comfortable for living, the land becoming too dry to cultivate and the melting of the poles that is causing the sea level to rise and invade the coasts of many countries.

5.1.5. Ozone Hole

The ozone layer is a gas layer that surrounds the Earth. It protects us from strong solar rays, called ultraviolet rays, that may harm our skin. But the ozone layer is being damaged by gases we create everyday. These gases, called CFCs, are used by appliances (such as refrigerators and air conditioners) and plastic foam, amongst other things. When these gases reach the ozone layer it creates holes on it, allowing the rays to more easily attack us.

To help protect the ozone layer we should buy only environment-friendly appliances and also avoid using materials composed with CFCs. For example, buy only energy efficient appliances (in Europe most appliances and also cars have an EU Efficiency Label graded from A to G - A being the most efficient and G the less efficient) and, when isolating a house, use mineral wool instead of plastic foam.

5.1.6. Excessive Use of Energy

We are more and more dependent on the use of energy on our everyday lives. We use it to have light, to heat or cool our houses and to feed all our appliances – refrigerator, washing machines, TV, computer, telephone. But creating this energy demands burning fossil fuels, that are becoming rarer, and this causes the release of many gases with greenhouse effect. Some countries already produce energy from renewable sources, such as the wind, the sun or the energy of tides, but yet in very small amounts.

Much of the energy produced is wasted on appliances that are on when they could be off, such as TVs or light bulbs on empty rooms, or on appliances that do not use energy efficiently, such as incandescent light bulbs. To help prevent the excessive use of energy we must use reduce the amount of energy we spend to the lowest possible and use energy from renewable sources.

5.2. Educational Content

5.2.1. Environmental Curiosities

Next, we present some interesting curiosities that should help kids achieve a better understanding of the problems previously mentioned and of the importance of changing some habits. The complete list can be consulted in Appendix A.1.

- Glass is recycled in factories where they break the bottles, melt the pieces and mix them with new glass.

- Recycling glass saves energy for making new glass. The energy saved from recycling one glass bottle will light a 100W light bulb for hours.
- In order to recycle aluminum, the cans and other aluminum products are ground into little chips and melted. Then, they are turned into aluminum sheets which are used to do new cans. This process can be done over and over again.
- The energy saved by recycling one aluminum package may keep a TV running for hours.
- Foam, the material used at fast food restaurants to serve hamburgers and for packaging things inside boxes, is permanent garbage. This means it will never become part of the Earth again.
- In one year, a leaking toilet can waste over 80.000 liters of water.
- About 20% of all toilets are leaking right now...
- Trees absorb carbon dioxide, a gas produced by cars and factories. This helps absorb air pollution.
- If everyone in the USA recycled their newspapers, 500.000 trees would be saved every week.
- Fumes exhausted by cars are one of the biggest causes of pollution. They contain invisible gases that increase the greenhouse effect, acid rain and smog. So, if it is not far, do not take the car.

5.2.2. What Can We Do on a Daily Basis

Most people believe that the problems mentioned above can only be solved by major changes in our societies. However, there are small habits we can introduce to our everyday life that can bring a huge impact on saving the planet. If more people do it, the bigger the impact will be.

Next are some advices for what one can do at his house to help saving the environment. They are categorized into three themes – energy, water and residues – which are the main areas of action in a household.

5.2.2.1. Energy

Since the discovery of electric current we have created countless devices that depend on it. Lamps, TV and refrigerator are some of the things we just can not image living without. Nevertheless, energy sources such as fossil fuel are disappearing at an alarming rate. Also, alternatives such as nuclear energy are very dangerous and criticized these days. Alternative energy sources such as solar, water or wind power are one solution to the problem. However these sources do not provide energy in such a large scale as we are used to, thus, we must learn how to save energy.

Avoid keeping lights or equipment on when not necessary, avoid opening the refrigerator door too many times, switch incandescent light bulbs for economy ones or use air conditioning and heating appliances as few as possible are some of the things one can do to decrease the energy consumption at home. A more complete list can be looked up in Appendix A.2.

5.2.2.2. Water

Our planet is almost two-thirds water. Because of that we sometimes believe it is a never ending source. Sadly, that is not true. Scarcity of usable water and water pollution are current problems. In order to keep having usable water we must deal with these problems rapidly. Regarding water, one should, for example, make sure the water taps do not drip, verify if the toilet leaks and, if it does, repair it as soon as possible and to close the water tap while brushing their teeth or soaping in the shower. A more complete list can be looked up in Appendix A.3.

5.2.2.3. Residues

The excessive amount of waste is a severe problem on current society. We are creating more trash than the one Nature is capable to deal with. In order to reduce that problem we must also reduce the amount of trash we generate. This can be done by changing habits such as buying unpacked products instead of packed ones, using rechargeable batteries, bringing bags from home when going to the supermarket or using ecological detergents. A more complete list can be looked up in Appendix A.4.

5.3. Summary

Problems such as sea level rise, lack of potable water or diminishing of fossil fuels have been concluded to be related with ecological issues such as holes in the ozone layer, excessive amounts of pollution. Research allowed us to understand what contents the kids are already familiar with, what contents they are able to understand (and what contents they can not) and what methods allow them to learn best. Not surprisingly, the methods teachers suggested were similar to the learning methods discussed in Chapter 2.

There is a main environmental area on which our actions and behaviors have more influence and through which we can address most of the ecological problems that exist nowadays – resources. Human beings are using too much natural resources and are also transforming them into new forms that are not easily absorbed by the environment. We can divide this area into three components – energy, water and residues. By using large amounts of energy and water and by producing much residues in our everyday lives we are hurting the environment. However, this is a problem that can be addressed through changing our behavior and actions regarding those three components.

Chapter 6

Conceptual Model

This chapter presents a model of a digital game for teaching children ecology. The concepts of this model are based in the guidelines presented in Chapter 4 and in the research made in Chapter 5.

6.1. Overview

There are many sorts of educational games. They can be more or less complex, apply different educational techniques and have different teaching goals. The model described in the following sections is to be used for creating a digital educational game to teach ecology to children aged 7-12. Thus, we will cover 3 distinct domains – ecology, education and game.

Regarding ecology, in Chapter 5 we concluded that the most important ecological content to be taught is that on which children can have an influence. Therefore the game should show why and how children can have an ecological behavior in their everyday lives. We also identified energy, water and residues as being the areas of ecology to which children relate more often.

Regarding the education domain, we must take into account that the game is to be played by children aged 7-12. As we saw in Chapter 2, by this age children are already capable of seeing the world through the other person's perspective, which means that they are now able to understand problems that may not influence them directly. This is very important, given that some ecological problems cannot be directly observed. However, they can still only solve concrete problems, i.e., problems related to actual objects and events and not abstract concepts or hypothetical tasks. Given this, this model only applies concepts that children can interiorize.

In Chapter 4 we suggest combining the guidelines we defined (Table 4.1) with Prensky's "Types of Learning" exposed in Table 4.2. Given that this game aims at teaching facts, skills, judgment and behaviors, from that table we concluded that we could base our game model in several learning activities such as questions, memorization, association, drill, imitation, feedback, coaching, continuous practice, increasing challenge, reviewing cases, and making choices. As we will demonstrate throughout the following sections, most of these activities are present in the game model. We also concluded that we could base the game on several game styles: game show competitions, flashcard type games, mnemonics, action and sports games, persistent state games, role-play games, adventure games, detective games, multi player interaction, and strategy games. Creating a game model based on all these styles seemed excessive, therefore we opted to choose some of them. The teachers of the IDEA ATL told us that children enjoy playing games where they are the main characters. This idea concurs with the concept of a role-playing game. Following this idea we give the player the role of a hero who has to go through several missions in order to save the Earth. This also captures the concepts of detective and adventure games.

6.2. Game Model

In this section we present the game model and its concepts. Figure 6.1 shows a diagram of those concepts and their relationships.

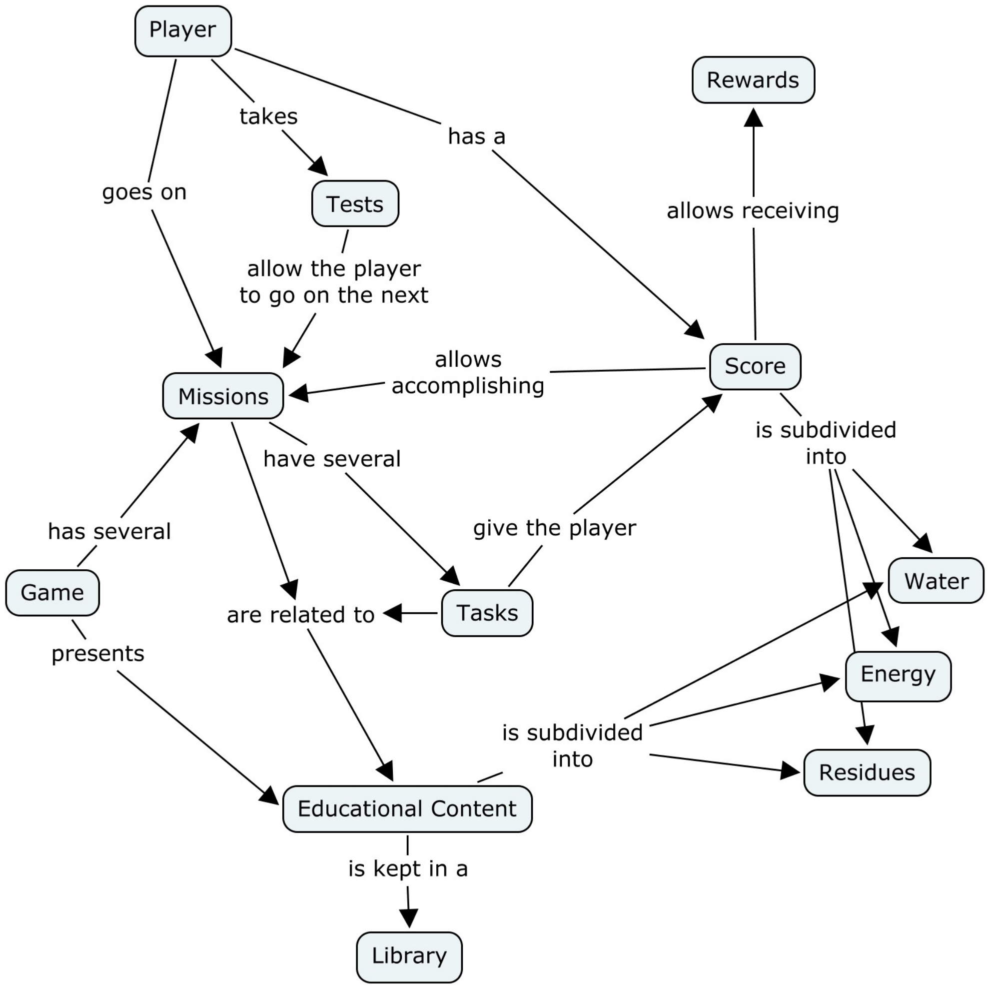

Figure 6.1 - Game Model Concepts and Relationships

6.2.1. Game cycle

The game cycle is divided into several stages, named **missions**. This idea was based in the game cycle of successful games such as Super Mario Bros (SMB) [SuperMarioBros], Guitar Hero (GH) [GuitarHero] or several of the games developed by PopCap publishers [PopCapGames], such as Peggle. All these are games that make the player want to go further and further. Missions in this model correspond to SMBs' eight worlds or to GH's four difficulty levels (Easy, Medium, Hard, Expert).

Mission's are accomplished within an order, which means that completing one mission unlocks another. The number of missions may vary, depending on the implementation. The level of difficulty of each mission may also vary. This gives the game some flow, which is needed to keep the player motivated. On each mission, the player has to complete some **tasks** that allow the player to achieve the mission's goal. After completing a mission the player must answer questions a **test** in order to be able to go on to the next mission. After completing all missions the player wins the game. Nevertheless, he may continue playing – missions and tasks can be repeated. This allows the player to improve his scores, motivating him to achieve better results and to keep playing the game. Furthermore, it extends the lifetime of the game and also exposes the player to the presented knowledge more times, thus it is more likely that he will learn. Figure 6.2 shows a diagram of the game cycle.

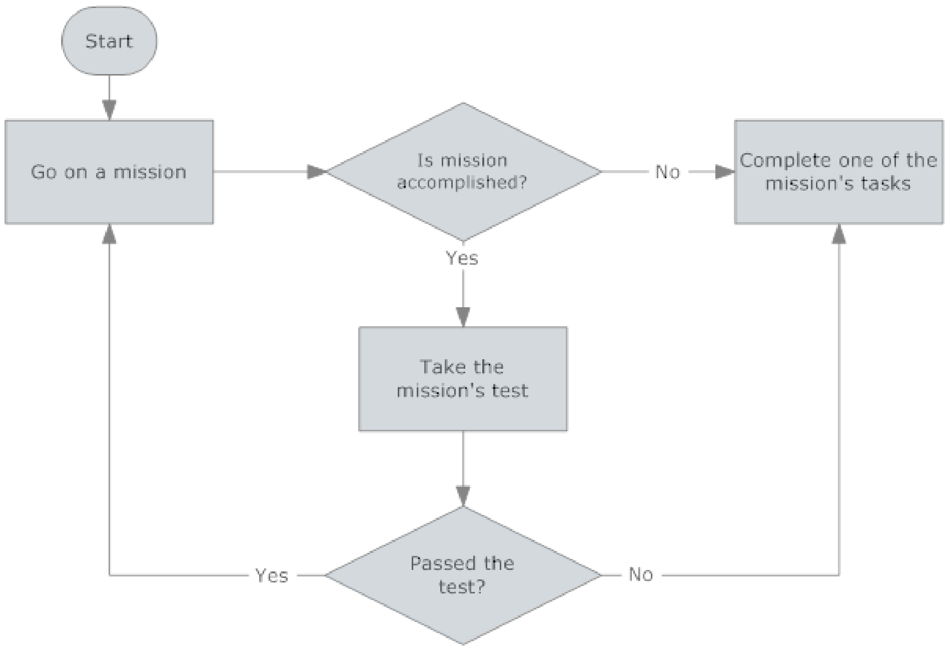

Figure 6.2 - Game Cycle

6.2.2. Score and Rewards

The game's score is divided into three parts – energy, water and residues. Each mission has a minimum score that needs to be achieved in order to accomplish that mission. Each task gives the player points that allow him to achieve the mission's goal. When all tasks' points add up to the minimum score demanded by the mission, the mission is accomplished. Given that missions and tasks can be repeated when the player wants to, the recorded score for each mission and for each task is the best score he ever achieved. The game has a scoreboard where players can see their score results and compare them to the other players'.

Having the score divided into the three ecologic areas allows the player to more easily reflect on the impact his actions have on each of these components individually. Having a scoreboard satisfies competitive players at the same time that avoids direct competition, which could be frustrating for other players. Keeping the best score and not the last score motivates the player to redo missions not only in case he fails but also if he just wants to achieve a better score.

Missions require only a minimum score for the player to continue the game and tasks do not require a minimum score at all. However, if the player achieves a certain amount of score he is rewarded. In missions, he receives a bronze, silver or gold medal, depending on his score (50% of the maximum score gives the player a bronze medal, 75% a silver medal and 100% a gold medal). In tasks, if the player achieves the maximum score, he is rewarded with a game he can print and play with his friends (e.g., cross-words, puzzles, etc) or with a challenge he is proposed to accomplish in the real world (e.g., teaching his parents how to recycle). Rewards are a surprise element in the game – the player will not know about these prizes until he receives one.

Introducing surprise elements and rewards is an adaptive technique that creates game flow and keeps the player interested and motivated. The reward challenges and printable games create an opportunity for the player to interact socially and discuss the subject with other people.

6.2.3. Missions and Tasks

The player is given the role of the earth's savior and his goal is to help save the Earth. In order to do this, he has to go through several missions and accomplish them. On each mission the player has a goal to achieve. This goal is related to an environmental issue and is achieved by reaching a certain score. For example, one of the mission's goals could be “In this mission you have to help reduce the amount of residues being thrown to landfills. Reach 100 residue points and accomplish this mission”.

The game's goals are neither too simple nor too easy to achieve and, therefore, stimulate the player. Requiring for a minimum score in order to successfully complete the mission avoids the game from becoming too easy to complete. Having a goal that asks the player to be sympathetic with the environment helps fulfilling the needs of “Heart” learning type players. Having a different goal on each mission gives the game flow and motivates the player.

On each mission the player has several tasks to perform. By completing these tasks the player collects points that give him the score he needs to complete the mission's goal. These tasks are individual mini-games that represent as much as possible ecological behaviors that children can transpose to their own lives (e.g. separating trash for recycling). Still, the tasks must be fun to accomplish. For example, a mission's tasks could include separating trash to put in recycling containers and reusing materials before throwing them out.

As with the number of missions, the number of tasks can vary and they can be repeated as many times as the player wants to. However, the player can perform these tasks by any order he wishes to. Each task has an impact on the environment that can either be on the energy, on the water or on the residues level. This impact will reflect on the task's score, i.e., tasks only give the player score on the environmental components they have an impact on. For example, if a task only has an impact on residues, by performing that task the player will only achieve residue points. In order to successfully complete a task, the player must achieve a minimum score.

As mentioned before, the score achieved in tasks contributes for the mission's score. Imagine a mission where the player has to achieve a minimum of 100 residue points. Consider that this mission has 3 tasks. One task gives the player a maximum of 0 Energy, 0 Water and 40 Residue points. Other gives him 50 Energy, 0 Water and 50 Residue points. Finally, other gives him 0 Energy, 0 Water and

50 Residues points. The player can achieve the mission's goal in several ways – by achieving the maximum score in the last two tasks, or by achieving a part of each task's score as long as the residues score adds up to 100.

Mission's and tasks can have different difficulty levels throughout the game. For instance, the first mission can have a goal score of 100 Residues and another mission can have a goal score of 100 Energy, 100 Water and 100 Residues. Also, a task can require the player to only pay attention to saving water while another task can require for him to pay attention to saving both water and energy. Tasks can also increase their difficulty level by increasing the difficulty level of the task's action itself – for example, in the same task of separating trash to recycle, the player can be given 20 objects to separate in 1 minute, but he could also be given 50 objects to separate in the same amount of time.

By performing tasks that they can easily transpose into their real lives, it is more likely that the players will use that knowledge outside the game environment. Creating individual mini-games inside the game (learning objects) allows the designer to easily adapt the game to new contents and also to reuse others already made, expanding the lifetime of the game. Requiring for each task to have an impact on the environment and reflecting that impact on the score models behaviors the player should adopt and stimulates critical thinking. Adapting the game's level of difficulty throughout the game gives the game flow and motivates the player.

6.2.4. Tests

When the player completes all tasks within a mission, he is presented with a test he must pass in order to be able to go on to the next mission. There is only one test per mission and it consists on several multiple-choice questions that evaluate the ecological content presented to the player throughout that mission. The player must answer correctly to at least half of the questions in order for it to be successfully completed. Like the missions and tasks, the player can repeat the tests any amount of times, allowing him to achieve better scores.

Giving the player a different obstacle to overcome motivates him. Also, asking the player questions stimulates critical thinking and helps fulfill the needs of players who are “Head”-style learners.

6.2.5. Educational Content

Educational content is present throughout the entire game. This content can be perceived through the missions' goals, the tasks' actions, the scoring values, and also through textual/audio content. For example, in a task that requires the player to select trash to be recycled and put it in the right trash can, he is able to learn which trash belongs to which trash can by watching the outcome of putting a sort of trash in a sort of trash can. If the player's action is correct/incorrect, he sees his score change accordingly and gets visual/audio feedback. In addition to this, in the beginning of each task the player is presented with written educational messages. These can contain some environmental curiosities. All educational information is kept in a game library that the user can consult whenever he wishes to.

Educational content should result from retrieving it from credible sources and also by asking teachers/educators for support. Audio and visual information not only give the player feedback on his actions but also adapt the game to learners who prefer Visual and Auditory stimuli. Giving the player information in the beginning of each task gives the player information just-in-time. Keeping that information in a game library gives the player information on-demand. This stimulates critical thinking and reflection.

6.2.6. Help and Assistance

In addition, the game must have a help menu accessible at any time containing textual aid for the player. Also, a tutorial explaining how to play the game and the menus' functions should be shown the first time the game is started. The player must be able to access this tutorial later on through a menu option.

Having a help menu, a tutorial and the rules explained in the beginning of the game provides the player assistance and support.

6.2.7. Adding Content and Personalized Data

The game must have a way to add new content. It should be possible not only to insert new textual educational content but also new missions and new tasks. The player should also be able to insert his personal data in the game, such as his name, age and an avatar image. Allowing teachers to introduce new content is a way to assure the accuracy of that content. Also, having new goals and action content (the tasks' mini-games), motivates the player to keep playing the game, thus potentially learning more.

6.3. Summary

In this chapter we created a game model for creating digital educational games for children aged 7-12 to learn about why and how they can have an ecological behavior in their lives. This model was based on the guidelines and on Prensky's “Types of Learning” presented in Chapter 4.

The game cycle is based on the player going through several missions in order to save the planet. To accomplish those missions the player has to complete tasks within the missions. After accomplishing a mission the player must pass a question-based test in order to be able to go on to the next mission. Every mission and task must relate to the environment – energy, water and/or residues. The score is also divided into those three components. The player can repeat the missions, tasks and tests as many times as he wishes to. If the player reaches a certain score in a mission, he is given a medal according to his score (bronze, silver or gold). If he reaches the maximum score in a task he receives a reward – a challenge to accomplish in the real world or a printable game he can share with his friends or family.

The educational content is passed throughout the entire game – through the missions' goals, the tasks' actions and the textual content. Help and assistance is given to the player through a help menu and a tutorial. Finally, the game must have a way to introduce new contents – missions, tasks and goals – and some data about the player – name, age, avatar picture.

Table 6.1 presents a summary on how the guidelines are applied in the game model.

Guideline	How the Model Applies the Guideline
Motivate the player.	Game cycle with missions and tasks within the missions, following successful formulas. Change difficulty level of missions and tasks throughout the game. Allow the player to repeat tasks and missions and to keep playing the game after it has ended. The game's goals neither too simple nor too easy to achieve. Have a different goal on each mission. Require a minimum score to successfully complete the mission. Introduce surprise elements: give the player medals and rewards when he achieves certain scores.
Use accurate contents.	Educational content retrieved from credible sources and also by asking teachers/educators for support. Allow teachers to introduce new contents.
Assist and support the player.	Have a help menu, a tutorial and the rules explained in the beginning of the game.
Give feedback.	Use audio and visual information to give the player feedback on his actions. Have rewards and score indicating the player's progress.
Stimulate critical thinking and reflection.	Each tasks has an environmental impact that affects the score. Have tests (questionnaires). Divide the score into the three ecologic areas (energy, water and residues). Give the player educational content in the beginning of each task (just-in-time) and keep that content in a game library (on-demand).
Model behaviors that the player should adopt.	Allow the player to repeat tasks and missions. Have tasks representing ecological behaviors players can easily adapt to their own lives. Tasks have an impact on the environment. The recorded score is always the best score achieved.
Use recognizable environments.	Give the player the role of the main character. Create tasks that relate with children's everyday life.
Adapt the game to the player.	Have a goal that asks the player to be sympathetic with the environment (“Heart” learners). Have tests/questionnaires (“Head” learners). Have a scoreboard (competitive players). Use audio and visual information (Visual and Auditory learners)
Grant social participation.	Have a scoreboard. Give challenges and printable games for the player to do in the real world that he can share with other people (friends/family).
Allow to edit/personalize the game.	Create individual mini-games inside the game (tasks). Have a way to add content to the game. Allow the player to insert personal data in the game.

Table 6.1 - Summary of how the guidelines are applied in the game model

Chapter 7

Implementation

This chapter describes the implementation of EcoLogic – a digital educational game for teaching children aged 7-12 ecological concepts and behaviors – using the model presented in Chapter 6.

7.1. Overview

The next sections describe implementation details. During implementation we followed the model defined in Chapter 6, but also very importantly, we aimed at creating a game that could be easily extended with new tasks and content. Ecologic runs locally on a personal computer and is meant to be played by one player at a time. Each player has its personal data saved in the game, allowing the player to save/load the game at any time. EcoLogic was developed using the XNA 2.0 framework and the Torque X game engine. The XNA framework was used to implement the game logic (menus, GUIs, game management, etc.) while Torque X was used to create the game tasks.

7.2.Torque

To create the tasks in EcoLogic we used Torque X and the Torque X Builder (TXB) tool. This allowed creating each task independently from the game's implementation. In order to allow a better understanding of the task implementation the following sections describe some torque elements involved.

7.2.1.Scenes

Scenes are created using the TXB and can contain objects (graphics, animations, etc). We can also associate torque components (see the next section) to the objects in a scene. Each scene is kept in a file in XML format (with a *.txscene* file extension). These files are automatically created by the TXB. Having a different scene for each task allows us to easily create a new task independently from other tasks and from the game implementation.

7.2.2.Components

The objects in the TxScene can have components applied to them. These components are used for applying an action or a property to an object. The same component can be applied to different objects, reducing the amount of duplicated code. However, torque components are completely independent from the Torque objects on which they are used.

For instance, imagine we have a *MovementComponent* that moves the object it is associated with to the left when the left arrow key is pressed and moves it to the right when the right arrow key is pressed. When we associate that component to a torque object in the scene, that object will move to the left/right when the left/right arrow key is pressed. But we can also apply the *MovementComponent* to other objects in the scene. If we associate the *MovementComponent* to al objects in the scene, then all objects will move to the left/right at the keystroke.

Components can also have properties. Properties allow us to give the same component on different objects different values, without having to create a different component for each object. For example, if we define a *distance* property for the *MovementComponent*, we can define that one object will move 20 *distance* spaces at the keystroke, and that another object will only move 10. This will allow the objects to move at different speeds in spite of using the same *MovementComponent*.

In spite of having some components already defined, Torque allows defining new components. If the task has the same action repeated in several objects, then a component reproducing this action should be created and applied to all objects that need it. For instance, the task of recycling the trash by putting it into the correct containers uses an *OpenCloseContainer* component that is applied to every container object in the scene. By having this component applied to it, the container opens when a trash object is near and closes when the trash is inside or out of range.

7.3. Architecture

As shown in Figure 7.1, the application's architecture is divided into three main layers: **Presentation**, **Logic** and **Data**.

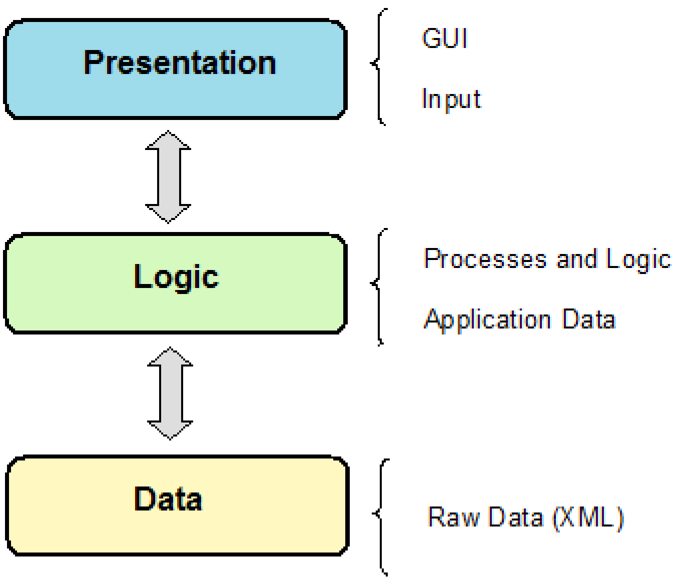

Figure 7.1 - Game's Architecture

Each layer communicates only with the adjacent layers. The data layer contains the raw data retrieved from the game's XML definition files and shares it with the logic layer. The logic layer manages all game processes and makes logical decisions. It transforms the raw data into application data objects and shares them with the presentation layer. It also contains the Torque components needed for the tasks. The presentation layer manages the graphical user interface (GUI) and all input from the player (mouse and keyboard).

7.3.1. Presentation Layer

The presentation layer has two major purposes – dealing with the game screens and user input. EcoLogic receives user input either through the mouse or through the keyboard. Menu navigation is done using only the mouse. The keyboard is used for text input and in some task actions.

Game screens can be of three types: menus, task screens or test screens. Figure 7.2 shows a diagram with the game's screens.

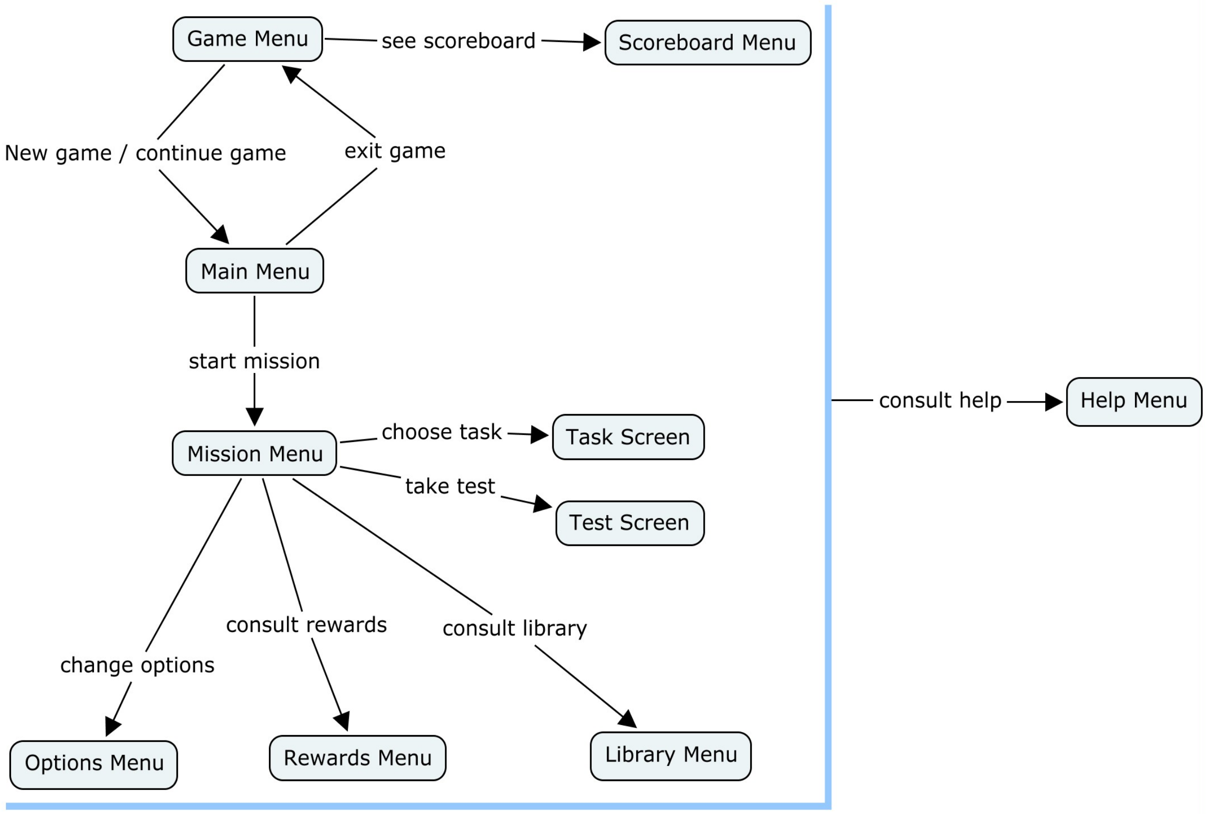

Figure 7.2 - Game Screens

This layer has an input manager that deals with user input and communicates it to the screen manager. The screen manager communicates with all screens and with the logic layer. Figure 7.3 depicts the presentation layer in more detail.

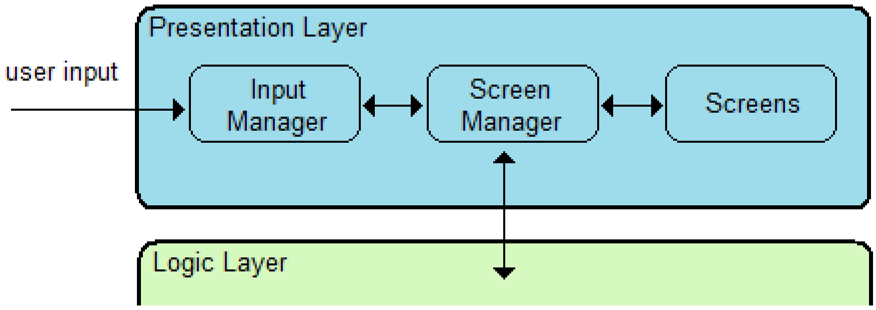

Figure 7.3 - Presentation Layer

7.3.2. Logic Layer

This layer takes care of all logical decisions needed for the game. It is also where the application data is kept. This data differs from the data kept in the data layer – the data in the data layer is raw, while application data is the raw data transformed into a format that can be used by the logic and presentation layers. This means that if the raw data format is changed, presentation and logic procedures do not need to be altered. Only the method that transforms raw data into application data needs to be updated.

Some of this layer's chores include knowing if the player can or cannot go onto a certain mission, recognizing when a mission was accomplished, updating and keeping scores and interchanging data to/from the data layer.

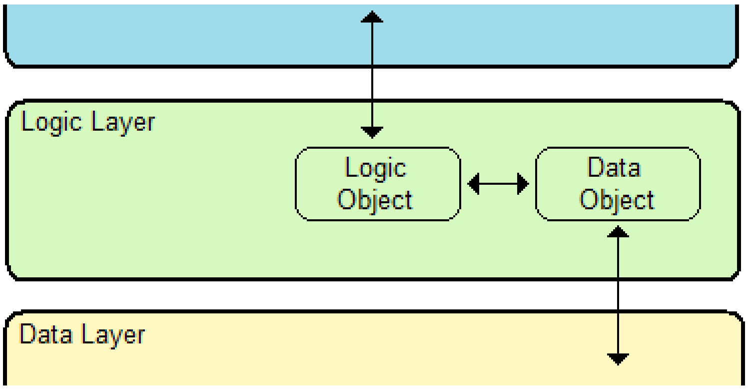

Figure 7.4 - Logic Layer

As shown in Figure 7.4, the logic layer contains logic objects and data objects. Each game element, such as missions, tasks, tests, and players, has an instance of each of these objects, i.e., the logic layer contains a mission logic object, a mission data object, a task logic object, a task data object, etc. The logic object communicates with the screen manager (in the presentation layer) and with the element's data object. By its turn, the data object communicates with the data layer.

7.3.3. Data Layer

The game needs information such as the missions' goals and tasks, the resources the tasks relate to or information about the players and their scores. This data is defined in XML files. In order to retrieve the data from the files, each of the data elements defined in the logic layer needs to communicate with a raw data object defined in the data layer. This raw data object is a bridge between the XML file and the data object in the logic layer. Figure 7.5 shows the data layer's objects and their communications.

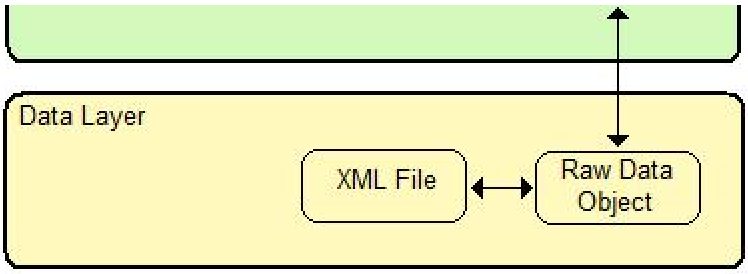

Figure 7.5 - Data Layer

There are 3 types of XML files for this game: the game data file, the task data files and the player data files.

7.3.3.1. Game Data File

The game's general data is kept in a single file named "*GameData.xml*" which has the root element tag <*Game*>. An example of this file is presented in Appendix B.1.

The game data file contains the definitions for the game's name, <*Name*>, the relative path of the directory where the players data should be kept, <*PlayersDataDirectory*>, and the relative path of the directory where the definition files of the mission's tasks are, <*MissionsDataDirectory*>.

Inside the <*Missions*> tag is the general definition of each of the missions. According to the model the number of missions can vary, which means each game has its own amount. For each mission there must be a <*Mission*> tag group defining it. This group contains the mission's name (*name* attribute of the <*Mission*> tag) and the number of questions that mission's test will have (*numQuestions* attribute of the <*Mission*> tag). For each task on that mission there must be a <F*ileName*> tag with the task's definition file inside the tag <*TasksFiles*>.

7.3.3.2. Task Data File

In EcoLogic, each task is a Torque X game. We decided to use this tool but it could have been any other compatible with the XNA framework. Each task implementation is independent from all other tasks and from the game itself. If we decided to create tasks using another tool, all that needed to be changed was the logic object in the logic layer. This approach eases the process of extending or adapting the game.

Each task's data is divided into two parts – general data and specific data. This division results from the need of having certain informations from all tasks given to the general game but also having specific information of that task to give to the Torque engine. This way, when the game starts, it can access only all task's general data, such as its name or its rules, and does not need to load their specific data, which is only needed by the torque game. An example of a task file can be seen in Appendix B.2.

Given that tasks belong to missions, the tasks' definition files are all kept in the directory defined in the <*MissionsDataDirectory*> of the "*GameData.xml"* file. There must be one of these files for each of the game's tasks. For example, if the game has 3 missions and each mission has 2 tasks, there must be 2 x 3 = 6 task definition files.

The task definition file must contain the <*Task*> root element tag. Inside this tag is defined the task's name (*name* element of the <*Task*> tag), and the general, <*GeneralData*>, and specific data, <Specific*Data*>, of the task.

The elements inside the <*GeneralData*> element are the same for all tasks. The values inside these elements are individual for each task. There is the <*Info*> tag group, containing the task's rules, <*Rules*> and the path of a picture containing a snapshot of the task, <*PicturePath*>. There's also the <*MaxScore*> element where the maximum score that can be achieved in that task is kept. Each score should be divided into three components – <*Energy*>, <*Water*> and <*Residues*>. If a task, for example, only relates energy and water, then all residue score values should be set to 0 (zero).

The general data must also contain the textual educational contents related to that task. These should be inserted in the <*Contents*> tag. Each task can have as many contents as wanted, but each content should be defined using the <*Content*> tag, indicating the resource it relates to ("energy", "water", "residues" or "other", in case the information does not fit directly into one of the resources).

Still in the general data group, we have the <*Questions*> group element. Here should be put all questions relating the task. Each task can have as many questions as needed. However, not all questions will appear in the test – the number of questions to appear is defined in the *numQuestions* attribute of the <*Mission*> tag in the GameData.xml file. The questions that appear on the test are chosen randomly from all questions in all of the mission's tasks. Each question should be defined using the <*Question*> tag and must contain a query, <*Query*>, which is the question to be asked and an <*Answers*> element group. This group should contain at least three <*Answer*> tags, as this is the number of possible answers presented to the user. Each <*Answer*> has an *isCorrect* attribute (that can either be true or false) that indicates if that is the correct answer or not, and the answer's text, <*Text*>. There can be as many answers as wished but there must be exactly one correct answer. From all possible answers, two false answers will be chosen randomly. The third answer presented to the user is, obviously, the correct answer.

The contents of the <*SpecificData*> tag group will vary from task to task. It has only one constant element – <TXScene> – which represents the path where the XML file needed for the Torque engine to run the task is. All other tags are task-specific.

7.3.3.3. Player Data File

Each of the game's players has a definition file containing the player's personal data (name, age, avatar) and game data (scores). An example of this file is shown in Appendix B.3.

The player's name is kept in the <*Name*> element and his age and avatar in the <*Age*> and <*Avatar*> elements, respectively.

The player's scores are kept in the <*Scores*> element group. For each mission, defined with the <*Mission*> tag, we have the mission's name, <*Name*>, and, given that according to the conceptual model the player could only access the next mission if he finishes the previous one, if whether or not that mission has been unlocked, in the <*IsUnlocked*> tag. For each of the missions tasks, there is a <*TaskScore*> element identifying the task's name, in the *taskName* attribute of the <*TaskScore*> element, and the <*Energy*>, <*Water*> and <*Residue*> scores in that task. Finally, we have the <*Test*> element containing the score in that mission's test, <*TestScore*>.

7.4. Implementation Examples

In order to test the model we created a mission, "*Mission Residues*". The XML files shown in Appendices B.1, B.2 and B.3 contain the data for this mission When the player starts that mission he is presented the following text:

"*Every day tons of trash arrive to landfills at a higher rate than Nature can absorb. Landfills are crowded and there is no more space where to put all this trash. Your mission is to reduce the amount of trash that is being sent to landfills. Reach at least 50 residue points and complete this mission. This message will self destruct in 5 seconds. Good luck!*"

Inside the mission's menu, the player can visualize the score on that mission on the upper-left corner. He can also see information about each of the mission's tasks. He can see to which themes the task is related to and the best score achieved on that task, a small description of what the task consists in and a snapshot image of the task. Figure 7.6 presents an image of a mission menu.

Figure 7.6 - Mission Menu

One of this mission's tasks is "*Trash Hero*", a mini-game where the player has to sort trash that appears into the correct recycling containers (Figure 7.7). The idea for this task came from the Guitar Hero game, where the player has to strike the correct musical notes as they appear on the screen. Trash Hero follows the same principle with the difference that instead of musical notes we have trash and instead of pushing a button the player needs to choose the correct container. The idea of creating a task such as this one was supported by the teachers of IDEIA, an ATL school in Tires, Portugal. Teachers said that recycling is a task children this age are already capable of understanding and learning about, and is also a task to which they have access in their everyday lives.

The "*Trash Hero*" task has an impact on the residues ecology theme, therefore by carrying it out the player will win residues score. These informations are shown to the player through the mission's menu. As determined by the model, in the beginning of a task the player must be presented with textual educational content. In "*Trash Hero*" two examples of content that can appear in the beginning of this task are:

"Did you know that nature cannot absorb glass? This means that a glass bottle put in the trash will end up in a landfill forever."

"If you put a glass bottle in the recycling container, it will be melted and converted into new glass. This glass can then be used to create new bottles."

Figure 7.7 - Trash Hero Task

We also created this mission's test. It has multiple-choice questions based on the mission's content. As mentioned in the previous sections, the questions for the test must be defined in each of the mission's task's XML file. Also, the number of questions to appear in the test must be defined in the *GameData.xml* file, in the *numQuestions* attribute of the <*Mission*> element tag. The questions in the test are randomly chosen from all of the mission's tasks questions. Having the possibility of showing different questions each time the player takes the test increases the amount of knowledge the player might have to learn. A possible question related to the previous task is:

"*How many years does it take to decompose a glass bottle?*

a) 100

b) 5000

c) It never decomposes"

If the player answered correctly to at least half the questions in that test, we was able to go on to the next mission.

As determined by the game model, all educational content was kept in a menu named "*Notebook*". This menu was introduced to the player as being his detective notebook, where he took note of all things as he goes on the missions. Of course, he did not have to take the notes himself, they appeared in the menu as he went on in the mission. This way, he always had access to the educational content given throughout the missions. Also as determined by the model, the player is given medals according to his scores in the mission and rewards if he achieves the maximum score in a task. He is able to insert his personal data when he starts the game. Furthermore, he is shown a tutorial and the game rules the first time he starts the game and has a help menu available throughout the entire game.

7.5. Extending The Game

During the implementation process we paid much attention to the fact that the game should be extensible. This means that it should be possible to add new missions, tasks and educational content. This was reflected in the game's architecture and elements.

The following sections describe how to insert new missions, tasks and educational content into the EcoLogic game.

7.5.1. Creating a Mission

Missions are defined in the *GameData.xml* file. To create a new mission we need to edit that file and create a new <*Mission*> element inside the <*Missions*> element group. We must give the mission a name and define the number of questions that mission's test will have. We must also define a textual goal (the score goal is automatically calculated according the mission's tasks maximum scores) and insert the names of the files where the mission's tasks are defined. These files must be put inside the directory defined in the <*TasksDataDirectory*> element of the *GameData.xml* file. Missions' objects (such as the logic and data object) are automatically created by the application, thus there is no coding required.

7.5.2. Creating a Task

Tasks are inserted in a different way than missions and educational content. In the later, we just need to edit XML files. However, and in spite of also needing their own XML data files, tasks have a more complex creation process. Each task presents the player its own torque game, so for each task we need to create that game. As a consequence, each task also has its own logic, so we need to code its logic object. As mentioned above, each task has its own XML file, thus we need to code its raw data object and its data object. Finally, we need to code that task's screen in order to show the task to the player.

In summary, each task in EcoLogic needs the following elements to be defined: an XML file, a raw data object, a data object, a logic object and a screen. Figure 7.8 shows the relationships between the task's elements and their placement in the application's architecture.

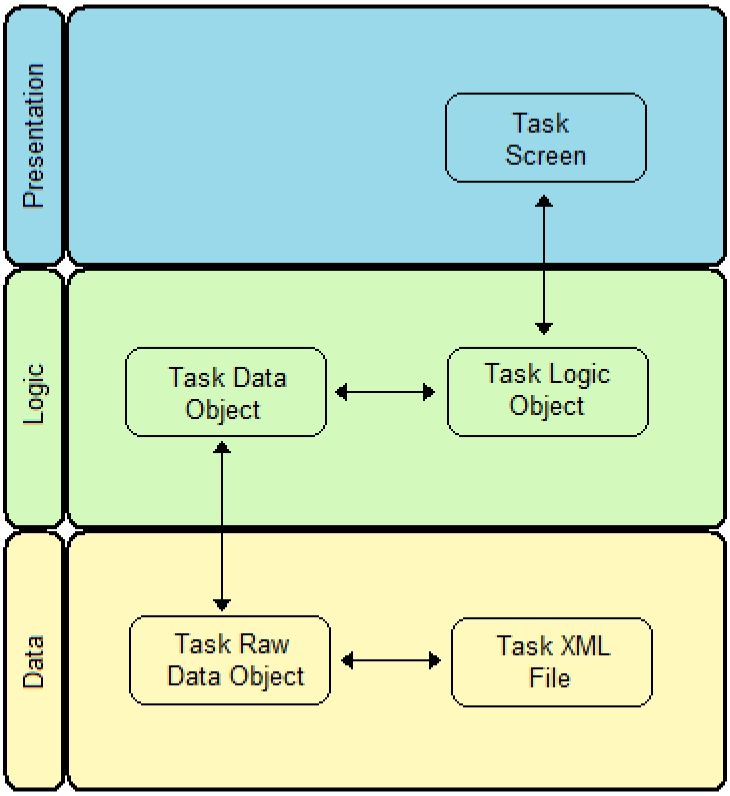

Figure 7.8 - Task Elements

7.5.2.1. XML File

The XML file will contain the task's general data and the task's specific data and should obey the format described in section 7.3.3.2. The task's specific data (the data only that task needs to know) should be defined inside the <*SpecificData*> element of that file. The task data file presented in Appendix B.2 shows the data of the task of recycling the trash presented in section 7.4. That task needs to have access to certain information such as: what kind of trashes will appear, <*TrashTypes*>, how many trashes will appear before the task ends <*NumTrashToFinish*> and the velocity at which they appear, <*TrashFallRate*>. These variables could have been directly inserted in the task's class, however that would not allow to easily change them without having to manage code. Keeping these variables in a file allows to alter them directly only by editing the XML file. This also allows using the same class to create another task similar to this one but with a different level of difficulty – for example, by increasing the number of trash types, the velocity at which they appear or the total amount of trash.

The XML file must be saved inside the directory defined in the <*TasksDataDirectory*> element of the *GameData.xml* file.

7.5.2.2. Raw Data Object

The game has a general raw data object that is able to read any task's XML file (*TaskRawData*), however it only loads the task's general data. Appendix B.4 shows an example of this object. This object was created in order to avoid repeating code in all raw data objects – the structure of the general data is equal in all tasks' XML files. However, each task has its own specific data element structure, thus the structure of the specific data must be read by the task's raw data object. Appendix B.5 shows an example of one of these objects.

7.5.2.3. Data Object

The task's data object loads the information obtained by the raw data object and keeps it in a format that is used by the game. This allows separating the way data is kept from the way it is used. For example, if we decide to use an SQL database instead of XML files to keep the game's data, we need only to redevelop the data object's loading method – the game logic and presentation will not have to be changed, given that they only have access to the data object which contain the data already transformed. Appendix B.6 shows an example of a task's data object.

7.5.2.4. Task Object

The task object is what actually puts the task running. It contains all of the task's game logic. Given that we are using Torque to produce the tasks, this object loads the task's TXScene and accesses all Torque components needed to run that scene. A torque component that all tasks need to have is a data component. This component accesses the task's data object and gives the other components access to that data. Without the data component each component would have to individually load the task's data allowing each component to change that data individually without taking into account that other components could be also changing it. Therefore, the resulting data would be worthless. By having a data component we have a central element where to keep the task's data (the task's XML file) and make sure it is modified and kept correctly.

7.5.2.5. Task Screen

The task screen is the element that gives the player the visual output of the task. It contains all the GUIs needed by the task and relies on the task logic object to update those GUIs. For example, the task screen contains a GUI that shows the score to the player. This score is visually represented by text and is updated by the task logic object when the player scores. At the same time, the logic object sends this score to be kept in the task data object.

7.5.3. Inserting Textual Educational Content

Textual educational content can be added to the game by editing the tasks' XML files. To insert new textual educational content we must first decide to which task that content is more related to. Then, we edit that task's XML file and insert the content in the <*Contents*> element by creating a new <*Content*> element. In this element we indicate the resources that contents relates to – energy, water, residues, or other (in case it relates more than one resource or none of them) – and the textual content itself.

7.6.Summary

In this chapter we described the EcoLogic game – an implementation of the conceptual model described in Chapter 6. This game uses the Torque X game engine to create the game's tasks. For this reason, each task must have an associated torque scene and the needed torque components. The implementation's architecture is divided into 3 layers – Presentation, Logic and Data. The presentation layer manages the game's screens (such as the main menu, the mission menu, the help menu, the task's screens, etc) and user input (from keyboard and mouse). This layer communicates only with the logic layer, which manages the game's logic and data objects. Only the logic layer communicates with the data layer. The data layer contains the XML files that have the information needed by the game (such as information about the missions, tasks and players) and raw data objects that are able to load that info from the XML files. Raw data objects communicate with the logic layer's data objects that keep the raw data in a format that is used by the game. This allows changing the way data is kept without having to change the game's objects.

To test the model we created a mission where the player has to prevent landfills from getting overflowed. One of that mission's tasks is to separate trash into the corresponding recycling containers. We also implemented other concepts determined by the model, such as the mission's test, tutorial and help menu, rewards and medals, amongst other.

To insert new missions and textual educational content in the game we just need to edit XML files. To create new tasks we need to create an XML file, a raw data object, a data object, a logic object and a screen specifically for that task.

Chapter 8

Conclusions

Having an ecological behavior is an important issue in today's society. This subject needs to be learned, however, it also needs to evolve from theory to practice. Children are more receptive to learning new things than adults and their behaviors are easier to shape. For this reason, ecology, like other behavior-shaping matters, should be taught from an early age. Children love games, and educational games have been proving to be an effective way of putting theory into practice.

After researching about education, learning and educational games, creating an educational game for teaching children about ecology stood as a good option. However, one question remained – How should this be done? For this reason, the purpose of this work was to create guidelines and a model for developing educational games for children to learn about ecological behaviors. This model intended to determine accurate and simple concepts based in learning and educational game development best practices. We also created a framework for developing this sort of games.

To create the model we started by studying the process of learning. Here we saw that learning can be conditioned by many factors. Cognitive abilities evolve through the person's stages of development. It is from around the age of 7 that we become capable of comprehending causal relations and also of perceiving things from a perspective other than ours. There are different methods through which we can learn – we can go to lectures and absorb information (traditional learning), but we can also learn from trying things out ourselves (experiential learning) and from our social experience (social learning). The learning methods can be adapted to an individual's learning style, i.e., the person's favorite way for dealing with or taking in information. This style can relate to the way the information is given – through visual, audio or kinesthetic stimuli – but it can also concern the individual's motivational system – if whether he prefers head (cognitive), heart (emotional) or hand (practical) approaches. A common requirement for learning to take place is motivation. The learner must feel motivated in order to improve his learning performance. Despite not being able to control the learner's internal motivation, we can control his external motivation by creating an environment suited for learning.

Digital game based learning is one way of creating such an environment. By creating an environment where it is safe to try new things , games allow people to meet concepts that can be difficult to experience in their real lives. Also, games are engaging for most people. Children love to play videogames. If we bring together the advantages of games as a learning environment and the learning techniques, we are able to create a powerful tool for learning.

With the purpose of knowing what has been done in the field of digital educational games, we analyzed some games, paying special attention to those which were related to ecology. From this analysis we realized that, despite the abundance of educational games, most of them were only related to a specific ecological theme. Also, most of them did not motivate us enough to want to play them more than once.

From studying the learning process and digital game based learning and from analyzing some current educational games we created a group of guidelines to be followed when creating a digital game for teaching children about ecology. These are: motivate the player, use accurate contents, assist and support the player, give feedback, stimulate critical thinking and reflection, model behaviors that the player should adopt, use recognizable environments, adapt the game to the player, grant social participation and allow to edit/personalize the game.

After analyzing the researched educational games according to the previously mentioned guidelines we asserted that they followed most of the guidelines. Where these games failed the most was in granting social participation and allowing to edit/personalize the game, allowing us to conclude that these are areas in educational games that should be more explored.

In order to know which subjects of ecology were important to be taught in such a game, we explored this subject. After discussing the most problematic environmental issues we concluded that the most useful themes to teach were the ones regarding which we can do something about. Energy, water and residues are subjects on which our actions and behaviors cause great impact, therefore, we decided to divide the game's educational content throughout these three matters. We also reasoned that inserting ecological curiosities could introduce motivation into the the game.

Using the defined guidelines and based on the studied ecological information we created a conceptual model of a digital game to teach children about ecology. This model defines how each of the guidelines is specifically applied in the game. The game's score is divided into three components – energy, water and residues. The game cycle is divided into several missions each of which has a goal that reflects the need of saving energy, water and/or residues. The mission is accomplished through completing several tasks inside that mission. Each task has an impact on at least one of the score's components and requires for the player to have an ecological behavior. During a task, the player is presented with educational content, not only through direct information (text) but also through the task's action itself. He is also immediately shown the impact of his actions (whether it is good or bad). When a mission is completed, the player must take a test in order to pass on to the next mission. Throughout the game, the player can receive surprise rewards, in case he achieves good scores. The game has a scoreboard, where the player can see his and other player's score, and an educational content repository, where all educational data that was passed throughout the game is kept.

Finally, we implemented this model in a game named EcoLogic. This implementation was built in a three-layered architecture – Presentation, Logic and Data. The bottom-most layer, the Data layer, contains the raw data (XML files) needed by the game and the necessary objects to read/write that data into/from the game. The Data layer communicates only with the Logic layer. The Logic layer manages the game's procedures and the data objects containing the raw data transformed into data the game can use. Finally, the Presentation layer, which communicates only with the Logic layer, takes care of the graphical user interface and user input. Having the implementation objects separated into several layers and restricting each layer to communicate only with the adjacent one(s) allowed creating a game that can be easily extendable. This way, new missions, tasks and textual educational content can easily be introduced into the game.

In order to test the model we created a mission, "*Mission Residues*", where the player has to help reduce the amount of trash being sent to landfills by achieving a minimum score of 100 Residue points. A task in this mission is "*Trash Hero*", a mini-game where the player has to sort trash into the correct recycling containers. We also created a multiple-choice test the player had to pass in order to go on to the next mission and other concepts determined by the model.

When creating the model for this work, we found that the guidelines presented in Chapter 4 are a good starting point for any educational game for children. The guidelines were easy to follow at the same time that they explained the reason why they should be followed. We also realized that, in spite of being detailed enough to be easily understood, they were general enough to allow creating a vast sort of educational games.

Through gathering the referred guidelines with the subject of ecology, we achieved the purpose of this work – creating a model of a game that teaches children about ecology. The model applies the guidelines, gathers the educational content and creates concepts to be followed when creating a game for teaching children ecology.

During implementation, we found that having this model, instead of only having the general guidelines, made the development process easier. The model presents a clear view of the type of game, its cycle and components. It is adapted to the educational purpose – teaching children about ecology – at the same time that allows new contents within the subject to be introduced.

8.1. Future Work

In future work we would like to evaluate if the game created through using the model has an impact on what children know about ecological behavior. It would also be interesting to assess if the player transposes this knowledge to the world outside the game and adopts the behaviors the game encourages. Furthermore, we believe it would be interesting to assess if this knowledge and behavior would extend to their family, i.e., if through the children the family would also learn and change their behavior.

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Appendix A

A.1 Environmental Curiosities (Complete List)

- Batteries need to be eliminated in a special way and if they end up at a landfill they will contaminate the soil.
- We throw out 28 billion glass bottles and jars every year.
- Glass is recycled in factories where they break the bottles, melt the pieces and mix them with new glass.
- Recycling glass saves energy for making new glass. The energy saved from recycling one glass bottle will light a 100W light bulb for hours.
- Over 80 billion aluminum soda cans are used every year.
- In order to recycle aluminum, the cans and other aluminum products are ground into little chips and melted. Then, they are turned into aluminum sheets which are used to do new cans. This process can be done over and over again.
- The energy saved by recycling one aluminum package may keep a TV running for hours.
- Each American throws away about 30 Kg of plastic packaging every year.
- Americans use 2.5 million plastic bottles every hour, and most of them get thrown away.
- About 1/3 of the garbage at garbage dumps is from plastic packages.
- Foam (the material used at fast food restaurants to serve hamburgers and for packaging things inside boxes) is permanent garbage. This means it will never become part of the Earth again.
- A small leak fills up a coffee cup in 10 minutes. This means a waste of more than 11.000 liters of water in a year.
- In one year, a leaking toilet can waste over 80.000 liters of water.
- About 20% of all toilets are leaking right now...
- You can save up to 76.000 liters of water a year by not letting the water run while you are brushing your teeth or soaping in the shower.
- If you put a bottle filled with water inside your toilet tank you will save that exact amount of water every time you flush.
- When you shower you use 20 liters of water every minute.
- Taking a bath takes about twice as much water than a short shower. A bath can easily take 190 liters of water.
- 2/3 of the Earth is covered with salted water. This means most of the water in the world is not drinkable.

- 4 liters of paint or motor oil can pollute almost 3.000.000 liters of drinking water. And 4 liters of gasoline can pollute 8.000.000 liters of water.
- Because of lawn watering, we use about 1/3 more water during summer.
- Trees absorb carbon dioxide, a gas produced by cars and factories. This helps absorb air pollution.
- Americans use 85 million tons of paper every year, which gives about 300 Kg for each person.
- If everyone in the USA recycled their newspapers, they would save 500.000 trees every week.
- Compact fluorescent light bulbs (also know as economical lamps) use 1/4 of the energy of a regular bulb and last 10 times longer.
- Almost half the energy you use in your home is spent on heating it.
- Half of the energy spent on heating our houses is wasted due to cracks around windows and doors.
- If all Americans turned their heat down 3ºC in the winter, they would save 500.000 barrels of oil each day. By using less oil, you also reduce the probability of having an oil spill at sea.
- Every year, heating USA homes puts over a billion tons of greenhouse gases into the air. So, by turning down the heater you are also fighting the greenhouse effect.
- Fumes exhausted by cars are one of the biggest causes of pollution. So, if it is not far, do not take the car.
- Fumes exhausted by cars contain invisible gases that increase the greenhouse effect, acid rain and smog.
- When you open the refrigerator door you let cold air go out and hot air go inside. This means the refrigerator has to use lots of extra electricity to cool back down. We open our refrigerators around 22 times a day.
- Every time you open the oven door 14ºC to 30ºC go flying out the door.
- A covered pot of water boils faster than an uncovered pot, so it uses less energy to reach boiling point.
- You can use up to 14ºC less heat if you bake with glass or ceramic pans. They keep in more heat than other pans.

A.2 List of Energy-Related Actions

- Avoid keeping lights or equipment on when not necessary.
- Turn equipments (TV, computer screens, etc) off using the power button instead of only using the remote. This annuls any energy consumption and CO2 emissions.
- Avoid opening the refrigerator door too many times. When you do open the door try to take as few time as possible. Every time you open the door the temperature inside the refrigerator rises and it spends more energy to return to low temperatures.
- Buy appliances with energy category A. These are the ones that spend less energy.
- Switch incandescent light bulbs for economy ones (fluorescent). These lights use 80% less energy and last 8 times more.
- Use natural light as much as possible, avoiding turning lights on during the day.
- Turn on clothes and dish washers only when they are full. Wash at low temperatures and use the energy saving program. This way you save energy, water and detergent.
- Choose gas stoves instead of electric ones.
- Use air conditioning and heating appliances as few as possible.
- Avoid acclimatizing uninhabited areas of the house.
- Open window shields during winter and close them during summer. This will keep the house with a pleasant temperature without needing to use acclimatization appliances.
- A well constructed house (south oriented, with good window and door isolations, etc) may not need climate control appliances to cool or warm the environment, thus saving a lot more energy.
- Painting the walls with light colors, which reflect light better, will reduce the need to use artificial lighting and save energy.
- Installing double windows will save 10% of the energy and reduce the amount of noise coming from the outside.

A.3 List of Water-Related Actions

- Make sure the water taps do not drip.
- Reduce the water taps' pressure.
- Put filled water bottles inside the toilet flusher recipient in order to reduce the amount of water used on each discharge.
- Verify if your toilet leaks and if it does repair the leak as soon as possible.
- Close the water tap while brushing the teeth or soaping in the shower.
- When using the clothes/dishwasher, use it at full capacity. This way you will wash more using the same amount of water.
- When buying a clothes/dishwasher choose one that has an economy program. It will use less water and energy.

A.4 List of Residue-Related Actions

- Buy unpacked products instead of packed ones.
- When buying packed products, make sure the package can be recycled.
- Avoid using plastics and cans/aluminum because these are more difficult to recycle.
- Use rechargeable batteries. They last longer and you produce less garbage.
- When going to the supermarket, bring your own bag from home. Choose one made of cloth - they are more resistant and less polluting.
- If you bring plastic bags from the supermarket, reuse them. For example, you can use them to wrap the trash can instead of buying bags especially for that purpose.
- Separate and recycle your trash - paper, plastic and glass.
- Use ecological detergents.
- Isolate the walls using environment friendly materials such as mineral wool.
- Return your old appliance to the vendor or deliver it at a recycling center in order for it to be recycled.

Appendix B

B.1 Game Data File


```xml
<Game>
  <Name>EcoLogic</Name>
  <PlayersDataDirectory>_Data/XML/Files/Players/</PlayersDataDirectory>
  <TasksDataDirectory>_Data/XML/Files/MiniGames/</TasksDataDirectory>
  <Missions>
        <Mission name="Mission Residues" numQuestions="10">
              <Goal>Every day tons of trash arrive to landfills at a higher rate than Nature can absorb. Landfills are crowded and there is no more space where to put all this trash. Your mission is to reduce the amount of trash that is being sent to landfills.</Goal>
              <TasksFiles>
                    <FileName>TrashHeroTask.xml</FileName>
                    <Filename>...</Filename>
                    <FileName>SavePackagesTask.xml</FileName>
              </TasksFiles>
        </Mission>
        ...
        <Mission name="World Wide Mission" numQuestions="30">
              ...
        </Mission>
  </Missions>
</Game>
```

B.2 Task Data File

```xml
<Task name="Trash Hero">
 <GeneralData>
    <Info>
        <Rules>In this task you must catch the trash in the correct recycling container.
            Use the arrow keys to move the truck to the left and to the right.</Rules>
        <PicturePath>data/images/TrashHeroTask</PicturePath>
    </Info>
    <MaxScore>
        <Energy>0</Energy>
        <Water>0</Water>
        <Residues>20</Residues>
    </MaxScore>
    <Contents>
        <Content resource="residues">
            <Text>Did you know that nature can not absorb glass? This means that a glass bottle put in the trash will end up in a landfill forever.</Text>
        </Content>
        <Content>
            ...
        </Content>
        <Content resource="residues">
            <Text>If you put a glass bottle in the recycling container, it will be melted and converted into new glass. This glass can then be used to create new bottles.</Text>
        </Content>
    </Contents>
    <Questions>
        <Question>
            <Query>
                How many years does it take to decompose a glass bottle?
            </Query>
            <Answers>
                <Answer isCorrect="true">
                    <Text>It never decomposes</Text>
                </Answer>
                <Answer isCorrect="false">
                    <Text>1</Text>
                </Answer>
                <Answer isCorrect="false">
                    <Text>100</Text>
                </Answer>
                <Answer isCorrect="false">
                    <Text>500</Text>
                </Answer>
                <Answer isCorrect="false">
                    <Text>5000.</Text>
                </Answer>
            </Answers>
        </Question>
        <Question>
            ...
        </Question>
        <Question>
            <Query>
                In which container should we put the paper?
            </Query>
            <Answers>
```

```xml
						<Answer isCorrect="true">
							<Text>The blue</Text>
						</Answer>
						<Answer isCorrect="false">
							<Text>The yellow</Text>
						</Answer>
						<Answer isCorrect="false">
							<Text>The red</Text>
						</Answer>
						<Answer isCorrect="false">
							<Text>The green</Text>
						</Answer>
						<Answer isCorrect="false">
							<Text>The brown</Text>
						</Answer>
					</Answers>
				</Question>
			</Questions>
	</GeneralData>
	<SpecificData>
		<TXScene>@"data\levels\TrashHeroTask.txscene"</TXScene>
		<NumTrashCans>3</NumTrashCans>
		<TrashFallRate>1</TrashFallRate>
		<NumTrashToFinish>20</NumTrashToFinish>
		<TrashTypes>
			<string>paper</string>
			<string>packages</string>
			<string>glass</string>
		</TrashTypes>
	</SpecificData>
</Task>
```

B.3 Player Data File


```xml
<Player>
  <Name>Helena</Name>
  <Age>11</Age>
  <Avatar>8</Avatar>
  <Scores>
            <Mission>
              <Name>Mission Residues</Name>
              <IsUnlocked>true</IsUnlocked>
              <Tasks>
                        <TaskScore taskName="Trash Hero">
                                  <Energy>0</Energy>
                                  <Water>0</Water>
                                  <Residues>15</Residues>
                        </TaskScore>
                        ...
                        <TaskScore>...</TaskScore>
              </Tasks>
              <Test>
                        <TestScore>7</TestScore>
              </Test>
    </Mission>
    ...
    <Mission>...</Mission>
  </Scores>
</Player>
```

B.4 General Raw Data Object

```
[XMLRootElement("Task")]
public class TaskRawData
{
   [XmlAttribute("name")]
   public string Name;

   public GeneralData GeneralGameData;

   public TaskRawData()
   {
      GeneralGameData = new GeneralData();
   }

   public static TaskRawData Load(string filePath)
   {
      Stream stream = File.OpenRead(filePath);
      XmlSerializer serializer = new XmlSerializer(typeof(TaskRawData));
      return (TaskRawData)serializer.Deserialize(stream);
   }

   public class GeneralData
   {
      public Info TaskInfo;
      public MaxScore MaximumMaxScore;
      public List<Content> Contents;
      public List<Question> Questions;

      public GeneralData()
      {
         TaskInfo = new Info();
         MaximumMaxScore = new MaxScore();
         Contents = new List<Content>();
         Questions = new List<Question>();
      }

      public struct Info
      {
         public string Title;
         public string Rules;
         public string PicturePath;
      }

      public struct MaxScore
      {
         public Score Minimum;
         public Score Maximum;

         public struct Score
         {
            public int Energy;
            public int Water;
            public int Residues;
         }
      }

      public struct Content
      {
         [XmlAttribute("resource")]
```

```
            public string Resource;
            public string Text;
        }

        public struct Question
        {
            public string Query;
            public List<Answer> Answers;
        }

        public struct Answer
        {
            [XmlAttribute("isCorrect")]
            public bool IsCorrect;
            public string Text;
        }
    }
}
```

B.5 Task Raw Data Object

```
[XmlRoot("Task")]
public class TrashHeroTaskRawData : TaskRawData
{
   [XmlElement("SpecificData")]
   public SpecificData SpecificGameData;

   public TrashHeroTaskRawData()
   {
      SpecificGameData = new SpecificData();
   }

   public static new TrashHeroTaskRawData Load(string filePath)
   {
      Stream stream = File.OpenRead(filePath);
      XmlSerializer serializer = new XmlSerializer(typeof(TrashHeroTaskRawData));
      return (TrashHeroTaskRawData)serializer.Deserialize(stream);
   }

   public class SpecificData
   {
      public int NumTrashCans;
      public float TrashFallRate;
      public int NumTrashToFinish;
      public List<string> TrashTypes;

      public SpecificData()
      {
         NumTrashCans = -1;
         TrashFallRate = -1;
         NumTrashToFinish = -1;
         TrashTypes = new List<string>();
      }
   }
}
```

B.6 Task Data Object

```
public class DTrashHeroTask
{
    public int NumTrashCans;
    public int NumTrashToFinish;
    public float TrashFallRate;
    public List<string> TrashTypes;

    public void Load(string filePath)
    {
        TrashHeroTaskRawData rawData = TrashHeroTaskRawData.Load(filePath);

        NumTrashCans = rawData.SpecificGameData.NumTrashCans;
        NumTrashToFinish = rawData.SpecificGameData.NumTrashToFinish;
        TrashFallRate = rawData.SpecificGameData.TrashFallRate;
        TrashTypes = rawData.SpecificGameData.TrashTypes;
    }}
```