INSTITUTO SUPERIOR TÉCNICO
Universidade Técnica de Lisboa

EcoLogic

Educational Digital Game for Teaching Domestic Ecology

Carolina Manso Soares Torres

Resumo da Dissertação para obtenção do Grau de Mestre em

Engenharia Informática e de Computadores

Orientador: Professor Doutor Rui Filipe Fernandes Prada

Setembro 2008

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.

INTRODUCTION

Only a few decades ago, the word ”ecological” was almost not heard. Nowadays, ecology is 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. 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 either inside and outside the classroom.

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 d*efine 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.

This paper is organized as follows. First we present the related work, where we discuss educational theories, game based learning and create guidelines that apply those principles. Afterwards, we study the subject of ecology and then we create a conceptual model that applies the guidelines and takes the ecological content into account. Finally we describe the implementation of EcoLogic, a digital educational game for teaching children ecology that follows the conceptual model.

RELATED WORK

Learning

Piaget's concept of **cognitive development stages** [1] establishes a relation between an individual's age and his cognitive abilities. It distinguishes four main stages of cognitive development – sensorimotor, preoperational, concrete operational and formal operational – and asserts that it is from around the age of 7 that we become able to distinguish our point of view from that of others. We also become capable of mental operations, i.e., internalized actions that fit into a logical system.

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. This process of learning through observation and experience is defended by many authors [2][3][4] [5] as being essential for the correct understanding of a subject.

Learning through experience and observation is complemented by another theory – the **social learning theory** [6][7][8]. 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 [8][9].

It is believed that most people prefer some particular method of interacting with, taking in, and processing information [10]. 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 [11][12]. 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. 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 theory distinguishes three main motivational systems that affect people – the head, the heart and the hands – and asserts that some people prefer cognitive (head) approaches, while others prefer affective (heart) or practical (hands) approaches in order to feel motivated.

Motivation is of particular interest to educational psychologists. Due to the fact that “learning is an active process that requires conscious and deliberate efforts” [13], motivation plays a crucial role in the learning process. It can affect the way students learn and their behavior towards subject matter, 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.

Digital Game Based Learning

Today’s educational process, consisting mainly on absorbing informal or logical lectures or readings, doing the homework and taking tests, is considered to be very inefficient nowadays [14]. 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 [15][14][16] refer and as we discussed in the previous sub-chapter, motivation is a key ingredient to learning. And today's children are not motivated. 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.

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 [16].

Digital games help people to build simulations of how information can be used in a different context [17]. Children think and solve problems in a different way than previous generations and learning from games works well for most people aged 35 and under [13]. In addition to this, our children's brains are changing to accommodate the new technologies with which they spend so much time [14]. Not only are they better at spreading their attention over a wide range of events [18] 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.

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 [2].

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 [14] briefly describes some of these interactive learning techniques: Practice and feedback, Learning by doing, Learning from mistakes, Goal-oriented learning, Discovery learning, Task-based learning, Question-based learning, Situated learning, Role Playing, Coaching, Constructivist Learning, Multisensory Learning, Learning Objects, and Intelligent Tutors.

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 [17]. Games are able to teach basic skills by introducing them as a requirement for accomplishing goals that the player really wants to achieve [2]. During gameplay the player must realize the outcome of his actions and experiences by being compelled to reflect on them by the game itself [19][17][14]. He should also be assisted and supported through knowledge imbued in the game [17].

During an educational process, feedback is most important. In the same way, in educational games it is through feedback that learning takes place. Games give information “just in time” and “on demand”. 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 [2].

Virtual worlds create a protective environment that 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.

Digital games also create opportunities to share the playing experience with other players [13].

Including scenario editors expands the longevity of the games, allowing to conclude that this way players play the game more times and, in some cases, with more interest [2][17].

Educational Games

For this research we looked for digital educational games, paying special attention to those related to ecology. We studied the EcoCasa, VGAS, Simpark, EPAL Júnior, Pond Food Web, Ecology Quiz and Food Force games.

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.

GUIDELINES

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. As for the fun factor, most designers take advantage of the motivation existing in commercially successful games and copy the formula into educational games. 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, we can equally introduce the stimuli corresponding to each kind of learner (such as powerful imagery, audio instructions or action-based tasks) allowing each learning style person to learn as any other. In fact, the visual, auditory and kinesthetic stimuli are implied in almost any digital game [17]. 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.

Table 1 shows what guidelines an educational game designer should follow, why should they be followed and how they can be applied in the game. 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.

In [14] Marc Prensky exposes the “Types of Learning”, 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 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.

Game Analysis Using the Guidelines

We analyzed the games researched and 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.

EDUCATIONAL CONTENT

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. It is a vast subject and there is much to learn about it. For this reason we needed to determine what should an educational game about ecology teach.

According to the guidelines, educational game's content should be retrieved from credible sources. In order to do this we searched on specialized books [20] [21] and flyers, did some research on the Internet and 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 many families, children are the ones who introduce their parents to ecology. From this study we determined that the game should teach about ecological areas on which our actions and behaviors can have more influence and through which we can address most of the ecological problems that exist nowadays. We identified three main areas – energy, water and residues. We collected several data on these subjects from the previously mentioned resources.

CONCEPTUAL MODEL

This section presents a model for creating a digital game for teaching children ecology. The concepts of this model are based in the guidelines and in the research presented in the previous sections.

Regarding ecology, the game should show why and how children can have an ecological behavior in their everyday lives and regard the areas of ecology to which children relate more often - energy, water and residues.

By combining the guidelines we defined (see Table 1) with Prensky's “Types of Learning” 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. 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.

Figure 1 shows a diagram of the conceptual model's concepts and their relationships.

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), Guitar Hero (GH) or several of the games developed by PopCap publishers, 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 in 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 2 shows a diagram of the game cycle.

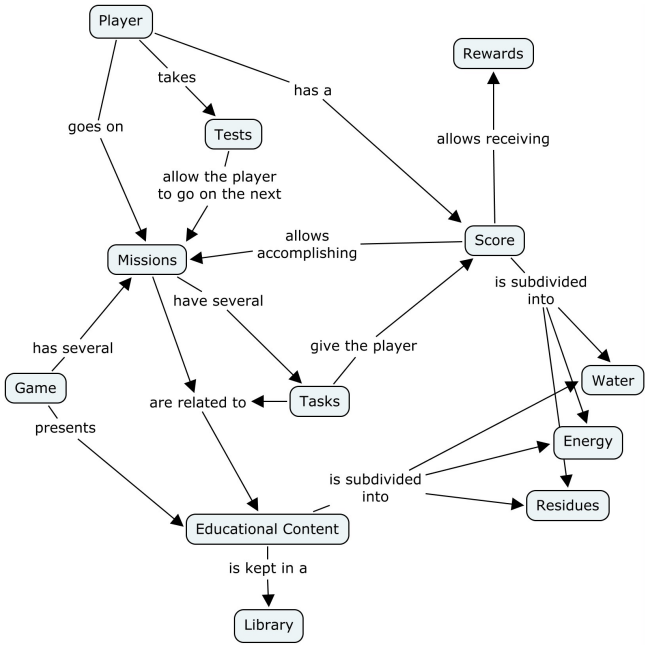

Figure 1: Model's concepts and relationships

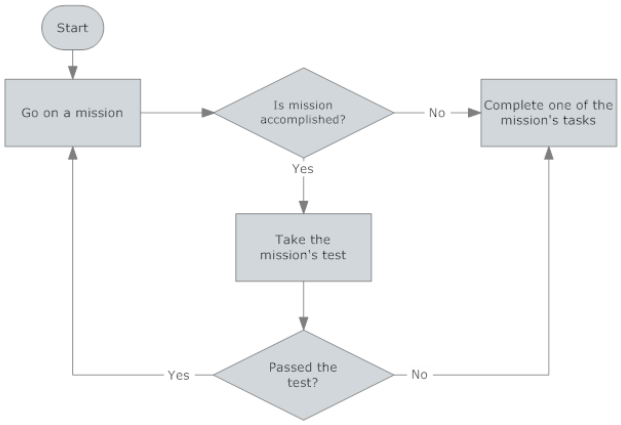

Figure 2: Game Cycle

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.

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.

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.

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.

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.

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.

IMPLEMENTATION

In this section we describe the implementation of EcoLogic – a digital educational game for teaching children aged 7-12 ecological concepts and behaviors. During implementation we followed the proposed model, 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.

Architecture

As shown in Figure 3, the application's architecture is divided into three main layers: Presentation, Logic and Data.

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).

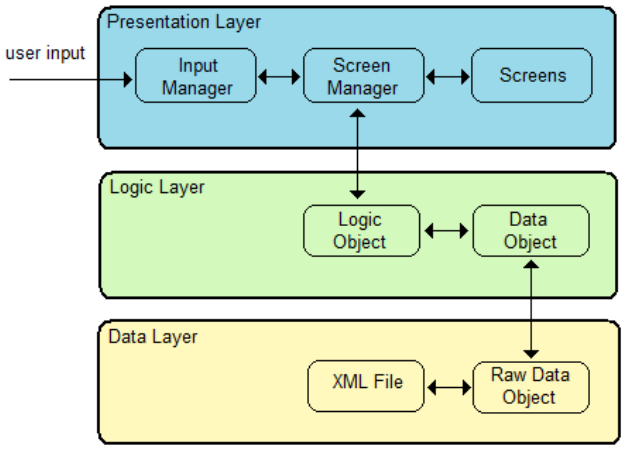

Figure3: Game Architecture

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 4 shows a diagram with the game's screens.

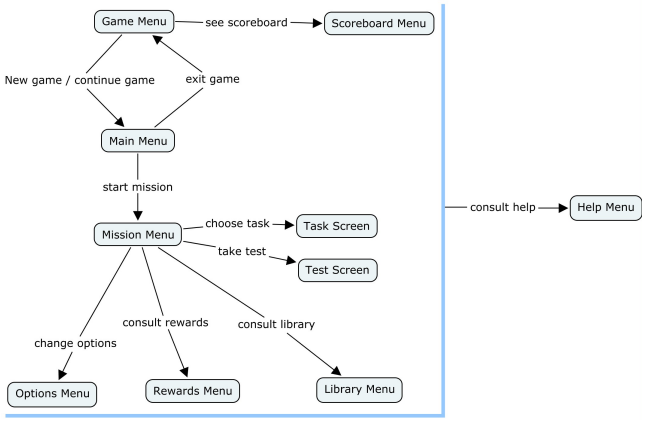

Figure 4: Game Screens

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.

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. 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.

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.

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

The game data file contains the definitions for the game's name, the relative path of the directory where the players data should be kept, and the relative path of the directory where the definition files of the mission's tasks are. Also in this file is the general definition of each of the missions.

The task's data file 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. The task's general data includes the task's rules, the path of a picture containing a snapshot of the task, and the maximum score that can be achieved in that task is kept. Each score should be divided into three components – energy, water and residues. The general data must also contain the textual educational contents related to that task and all questions relating the task. The task's specific data will vary from task to task. It has only one constant element which is the path where the XML file needed for the Torque engine to run the task is. All other elements are task-specific.

The player's data file containing the player's personal data (name, age, avatar) and game data (scores). There is one of these files for each player.

Implementation Examples

To test the model we created a mission where the player has to prevent landfills from getting overflowed.

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. 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. As determined by the model, in the beginning of a task the player is be presented with textual educational content.

We also created this mission's test. It has multiple-choice questions based on the mission's content. 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.

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.

Extending The Game

During the implementation process we paid much attention to the fact that the game should be extensible. Therefore, EcoLogic allows adding new missions, tasks and educational content.

Creating a Mission

Missions are defined in the GameData.xml file. To create a new mission we need to edit that file and 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. Missions' objects (such as the logic and data object) are automatically created by the application, thus there is no coding required.

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, for tasks there is the need to code several objects. Each task presents the player its own torque game, so for each task we need to create that game. Each task also needs the following elements to be defined: an XML file, a raw data object, a data object, a logic object and a screen.

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 there.

DISCUSSION AND CONCLUSION

The work presented in this paper intends to create expand ecology educational game development.

First we created guidelines to be followed when creating educational games. These were based on education, learning and digital game based learning principles.

After studying the subject of ecology and following those guidelines we developed a model for creating educational games for children to learn about ecology. This model intends to determine accurate and simple concepts based in learning and educational game development best practices.

When creating the model for this work, we found that the presented guidelines 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.

Future Work

As for future work we would like to evaluate if the game created through using the model has an impact on what children know about ecology. We would also like 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 assert 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.

ACKNOWLEDGMENTS

We would like to thank the teachers and students of the IDEA school in Tires, Portugal, for their support during the development of this work.

REFERENCES

[1] Cole, M., Cole, S. (2001): The Development of Children, Worth Publishers, New York.

[2] Gee, J. (2003): (online at http://chronicle.com/colloquylive/2003/08/video/) Last accessed on Oct/8/2007

[3] Clark, A. (1989): "Microcognition: Philosophy, cognitive science, and parallel distributed processing", Cambrige, Mass, MIT Press.

[4] Gee, J. (1992): The social mind: Language, ideology, and social practice, New York, Bergin & Garvey.

[5] Bransford, J., Brown, A. L., and Cocking, R. R. (2000): "How people learn: Brain, mind, experience, and school: Expanded Edition", Washington, DC, National Academy Press.

[6] Miller, N. E., Dollard, J. (1941): Social Learning and Imitation. New Haven: Yale University Press.

[7] Bandura, A. (1971): "Social learning theory". New York: General Learning Press.

[8] Bandura, A. (1989): Human Agency in Social Cognitive Theory. American Psychologist, 44, 1175-1184.

[9] Bandura, A. (1982): Self-efficacy mechanism in human agency. American Psychologist, 37, 122-147.

[10] Changingminds: Learn in your own style (online at http://changingminds.org/articles/articles/learning_style.htm) Last accessed on Oct/8/2007

[11] Felder, R., Silverman, L. (1988): Learning and Teaching Styles In Engineering Education, Engr. Education, 78(7), 674–681.

[12] Reid, J. (1987): The Learning Style Preferences of ESL Students, Tesol Quarterly, 21(1) pp 88-112.

[13] Hsiao, H.-C. (2007): A Brief Review of Digital Games and Learning. DIGITEL 2007: 124-129

[14] Prensky, M. (2006): Digital Game-Based Learning. Paragon House Publishers

[15] Denis, G., Jouvelot, P. (2005): Motivation - driven educational game design: Applying best practices to music education. In: Proceedings of the 2005 ACM SIGCHI International Conference on Advances in computer entertainment technology ACE'05.

[16] Bisson, C., Luckner, J. (1996): Fun in learning: The pedagogical role of fun in adventure education. Journal of Experimental Education

[17] Gee, J. (2005): Why are video games good for learning? (online at http://www.academiccolab.org/initiatives/papers.html) Last accessed on Oct/8/2007

[18] Green, C.S., Bavelier, D. (2003): Action video game modifies visual selective attention. Nature

[19] Gee, J. (2003): What video games have to teach us about learning and literacy, New York, Palgrave.

[20] Group, T.E. (1990): 50 Simple Things Kids Can Do To Save The Earth. The EarthWorks Group

[21] Group, T.E. (1991): 50 Simple Things You Can Do To Save The Earth. The EarthWorks Group

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.
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 1: Guidelines for Creating an Educational Game