A Model-driven Framework for Educational Game Design

Master Thesis

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1. Introduction

1.1. Context of Thesis

Serious games first appeared in the end of eighteenth century [Wikipedia, December 2014], probably in the form of board games. The first widely spread paper-based serious games appeared during the ‘70s, developed by Clark Abt and his colleagues, while serious video games saw their first use by the U.S. military in the 1980s [Devereux 1982].

Today, museums, businesses, large international organizations and health agencies use the so-called serious games to recruit or train staff, promote their products and educate their audience. The serious game market, consisted mainly of video games, is counting 1.5 Billion Dollars [VentureBeat, August 2013].

But what is a serious game? Abt [1970] stated: “We are concerned with serious games in the sense that these games have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement”. A statement partially supported also by Michael and Chen [2005], who defined serious games as games that do not have entertainment, enjoyment or fun as their primary purpose. While, Zyda [2005] defines a serious game as, “a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives”.

Based on Zyda’s definition, education is differentiated from training. An opinion that is also supported by Garavan [1997]. Thus, educational games can be explicitly defined as serious games focusing on a school environment, whichever this environment may be. But educate and entertain with the use of a game is also a form of edutainment. Therefore, educational games can be considered as the common ground between serious games and edutainment.

Regardless if a precise definition exists, an educational game is both designed for learning and for entertainment [*ELearning Faculty Modules, April 2015*]. Therefore, it should aim at learning, at entertain and should also be a game.

Despite the fact that serious games and specifically educational serious games

have started to draw attention the past few years due to their increasing usage both by parents and teachers [VentureBeat, August 2013] and despite all the available technology, the design process of such games has not changed and it is solely relied on tools like simple text editors [*Marfisi-Schottman et al. 2010]* and prototyping software systems [Fullerton et al. 2008] [*Gamasutra, April 2015]*.

1.2. Motivation

The lack of any significant change on the way GDDs are created [*List of Useful Game Designing Tools, April 2015]* along with the fact that these documents are read by professional with a completely different educational and/or professional background, like programmers and artists, motivated us to explore which are the potential benefits that the current technology can offer regarding the creation of a GDD.

Currently, GDDs are created by using text editors, like Microsoft Word, and in some cases by using prototyping tools [*Tools for Game Design, April 2015]* [*Kotaku, April 2015]*, like Adobe Flash or Microsoft Visio, as confirmed by the interviews we conducted, which are presented in detail in chapter 5. This unstructured way of creating a GDD can be handy in many cases, especially due to the fact that the document will be read by both programmers and artists. In other words, it will be read by individuals who on average differ a lot in their way of thinking and on how they structure and divide their workload.

Despite that, an unstructured document that its end goal is to clearly communicate all the details of a software product, like a game, can be, in many cases, vague and unclear. This statement can be backed up by Ylva Sundström's research [2012] according to which a 65% of game professionals find GDDs useful but less than 50% believe that GDDs are an effective way to communicate the design of a game. Additionally, the fact that the document will be read by both programmers and artists can cause, in some cases, miscommunication [Hart 2002] and conflicts regarding knowledge issues. For example, on the GDD of the game "Race'n'Chase" [Scribd 2014], the designer gives some specifications regarding the compression of the artwork, which is not too technical for programmers but what about artists, who have to adjust their work to fit these specifications? On the one hand, programmers need information to be presented to them in a structured and mathematically

defined way [Borgida et al. 2009]. On the other hand, artists need information to be presented to them in a more free way, in order for them to also apply their creativity and aesthetics [Callele et al. 2008].

1.3. Research Questions

This project investigates and aims at answering the following research question and subquestions.

Research Question:

How can GDDs for educational games be structured, in order to be an effective and efficient tool for game design?

Research subquestions:

1. What are the factors that affect the effectiveness and efficiency of GDD based educational game design?
2. What are the factors that inhibit the effectiveness and efficiency of GDD based educational game design?
3. Which are the elements of educational games that can be identified in the literature?
4. To what extent do existing state-of-the-art approaches support effective and efficient GDD based educational game design?
5. What is a conceptual model that supports the effective and efficient GDD based educational game development?
6. To what extent does the application of current technologies, like modern web 2.0 programming languages, help overcome problems associated with GDDs?

1.4. Effectiveness and Efficiency in Serious Game Design

The answer to research questions 1 and 2 is important to be given at this point because identifying the factors that determine the effectiveness and efficiency of GDD based educational game development will allow us to analyze them later on the thesis and find ways to overcome any problem related to them.

Brown [2010] tackled the problem from the documentation perspective. He noticed that documenting everything related to the design with consistency and keep this document updated after any change is the most important factors, in order to have an effective and efficient GDD.

Bethke [2003] tackled the problem from the communication perspective. He identified three different ways of communication within a gaming company. Namely,

- Communication through an explicit GDD, which means that members of the development team are referred to the GDD for any question they have regarding the design process.
- Communication through several different digital means, which means that members of the development team communicate might communicate through Skype, e-mail, wikis etc. or through a combination of these.
- Oral Communication, which means that members of the development team communicate orally, either formally in a meeting or informally at any time.

Sundström [2012] research indicated that only a 5% of game professionals read the GDD whenever they want to understand something specific for the design, with the remaining 95% relying on instant messangers, like Skype, e-mails or on oral communication for answering their questions.

Therefore, the factors that determine the effectiveness and efficiency of GDD based educational game development are:

- Consistency of documentation, as Brown [2010] indicated, which means that the same concepts should be documented in the same way throughout the whole document.
- Frequency of updates on the documentation, as Brown [2010] indicated, which means that every change in the design of the game should be

passed on the documentation.

- Type of communication, as Bethke [2003] indicated.

Based on these factors, one can identify several problems that can occur and that can compromise the effectiveness and efficiency of a GDD. These problems can potentially be:

- Low quality of documentation. This can occur either because design is bad documented or insufficiently documented.
- Lack of consistency on the documentation. This can occur when more than one persons edit the GDD.
- Lack of information because the GDD is not updated after a change on the design. This can occur on agile project management projects, where design is constantly revised to meet the current requirements.
- Miscommunication. This can occur in game companies, where people from completely different educational and professional background communicate on a daily basis [Hart 2002].
- Lost communication. This can occur due to the many oral conversations happening within a team.
- Information overload [Gross 1964]. This can occur when the amount of information about a project is large and comes from multiple communication channels, like the GDD, Skype, e-mail etc.

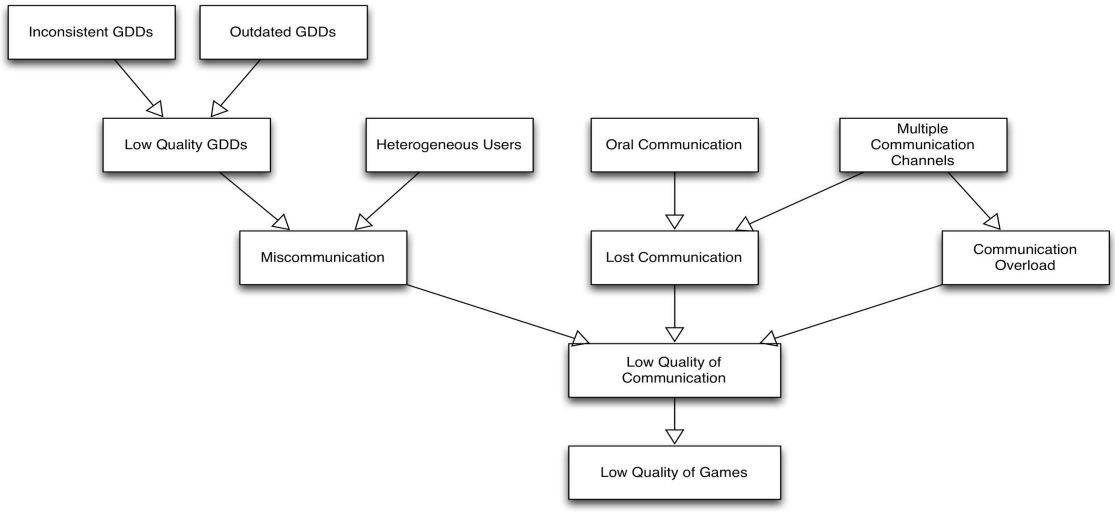


Figure 1: Factors determining the quality of a game

On Figure 1, we provide a visual representation that shows how the abovementioned factors can influence the quality of the GDD, the quality of the communication among a game development team and finally determine the quality of the game. The arrows show the causality between the factors, e.g. an incosistent GDD leads to low quality GDD. The left part of Figure 1 refers to the factors concerning the documentation, which were identified by Brown [2010]. The right part of Figure 1 refers to the factors concerning the communication, which were identified by Bethke [2003]. Finally, an additional factor is mentioned on Figure 1, which is the heterogeneous users involved in a game development team.

1.5. Research Objectives

This project aims to study the problem of designing educational serious games, and designing novel scientifically-sound techniques to support game designers in the creation of a Game Design Document (GDD) that accounts for and relates educational and entertainment game elements. Specifically, the thesis' objective is to produce as a concrete output a model-driven web-based knowledge management framework for the design of a GDD, which will enable us to answer the research questions, stated in section 1.3, and explore to what extend it can help game development teams overcome problems associated with GDDs, as shown in Figure 1. A key challenge is to balance flexibility and structure; while the prototype is structured so to ensure that all the important elements of an educational game are taken into account, flexibility has to be guaranteed to avoid restricting the designer to a rigid workflow.

The two main architectural decisions we had to make before starting the research were:

- Whether the prototype would be based on a conceptual model. We chose to develop the prototype based on a conceptual model because:
    - ◊ We believed it would better depict our research on the various fields related to serious games, meaning that a model-driven approach would allow us to implement the low-level core elements of areas such as traditional gaming, learning and entertainment, without being biased towards any of them.

- ◊ Model-driven approaches are language independent [Schmidt 2006], meaning that the conceptual model can be used independently and contribute on building an environment with any programming language.

- With which programming tools we would build it. We chose to use web technologies because:
  - ◊ They do not require any additional software from the user, apart from a modern browser.
  - ◊ Data can be accessible by any device, from anywhere in the world and by multiple users, which allows collaboration.

1.6. Outline of thesis

The thesis is divided in six chapters.

In the second chapter, we review previous work in all the fields concerning serious games. We provide the research we made on Education and Learning, on Entertainment, on Game elements, on Game Design Techniques and on Requirements for Games. In this chapter, we also address subquestions 3 and 4.

In the third chapter, we describe the conceptual model we developed based on multiple learning theories and on the current state of GDDs. In this chapter, we also address subquestion 5.

In the fourth chapter, we present the main idea behind the design environment, its main features and the software architecture we used to develop it.

In the fifth chapter, we describe the evaluation process we used and we present the results that we obtained. In this chapter, we also address subquestion 6.

In the sixth chapter, we discuss the outcome of this project, we provide suggestions about future additions and improvements and we conclude the thesis.

2. Literature Review

In this chapter, we review previous work in the field of educational games. Our research method is as follows: we first decompose educational games into their primitive components, start the research from these components and gradually research each level of abstraction until we reach the end product, the educational games.

Figure 2 below shows the different abstraction levels of educational games and on which areas of research they led us.

Although our research does not cover all the work that has been done on each of the fields analyzed, it is representative of the current state-of-the-art.

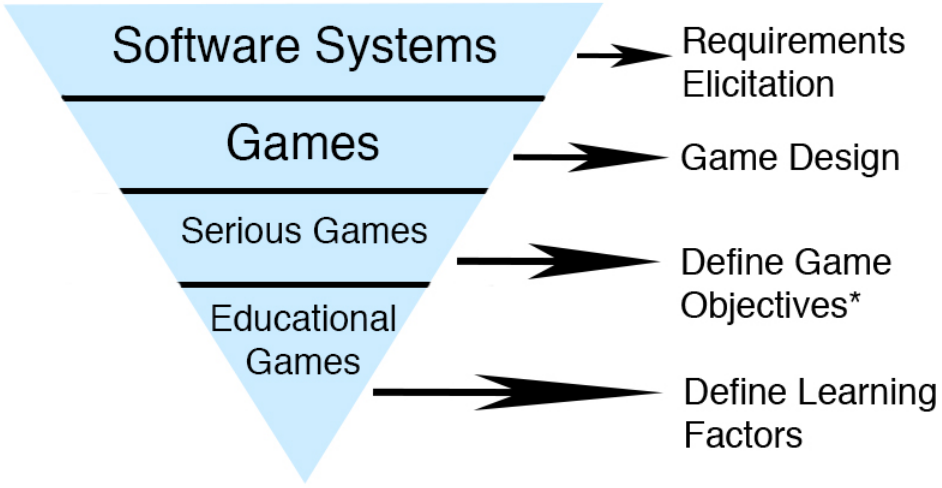


Figure 2: Abstraction levels of educational games

Educational games are a form of serious games and as such their intention is to teach children and teenagers through gaming [Betz 1995]. Therefore, educational games should not only integrate a specific curriculum but also being developed based on the factors that influence learning. Additionally, since they are games, they should be built according to certain game design guidelines, in order to incorporate important game characteristics and elements. Finally, educational games are, in a broad sense, software systems that, like any other piece of software, should be designed by taking into account specific requirements.

Based on this decomposition of educational games, we split our research in five main pillars. First, we researched theories on education and the factors that influence learning. Second, we researched theories on entertainment with the goal to identify elements that provoke fun and generally feelings of enjoyment. Third, we identified the core game elements based on the academic research on the field and we cross referenced the results with a typical Game Design Document. Fourth, we searched for techniques used in game design and more specifically for techniques that are applicable on serious and educational games. Fifth, we researched the state-of-the-art on requirements and requirements elicitation on creative fields, like games.

In order to identify the relevant literature, we first followed the “Quick and Dirty Method“ [*Erasmus University Rotterdam, April 2015]* and on the obtained results we applied the “Snowballing Method” [*Erasmus University Rotterdam, March 2015]*, also known as Reference tracking, which allowed us to track relevant papers, articles and books by looking at forward and backward references on each result. For the “Quick and Dirty Method“, for each research pillar, we used the following keywords:

- Education and Learning: factors influencing learning, learning with games.
- Entertainment Elements and Game Elements: computer games, game components
- Design Techniques: game design, serious game design, educational game design, serious game design framework

Utrecht University’s electronic library and Google Scholar were the main sources of our research.

2.1. Education and Learning

Many people perceive education as an abstract concept. They believe that education is an umbrella that includes the schools, the universities, the students, the teachers and everything else that is involved in the process of learning.

According to Dewey [1966], **education** in its general sense is a form of learning in which the knowledge, skills, and habits of a group of people are transferred from

one generation to the next through teaching, training, or research.

According to Oxford Dictionary, **learning** is the acquisition of knowledge or skills through study, experience, or being taught [Simpson et al. 1989].

2.1.1. Education

Education is one of the few concepts that have been researched through the millenniums. Many pedagogues and philosophers have tried not just to come up with a definition but also to express a framework, based on which education can be optimal.

Due to the countless theories regarding education, we will focus solely on those that, either directly or indirectly, imply that games and "play" are important aspects of education.

2.1.1.1. Plato

On Plato's *Republic* [1866], Socrates says, "Don't use force in training the children in the studies, but rather play. In that way you can better discern what each is naturally directed towards".

Socrates also says, "The best education should be more like play than work".

Finally, Plato states that children's character is formed until the age of seven mainly through playing. Therefore he believes that laws and restrictions must regulate the game and determine penalties and rewards, in order to be a good practice for the life as an adult.

2.1.1.2. Aristotle

On the same spirit as Plato, Aristotle says, "For all such amusements should prepare the way for their later pursuits; hence most children's games should be imitations of the serious occupations of later life." [1916], showing that he also strongly believed in the use of games not just for entertainment but also as an educational tool.

2.1.1.3. John Locke

Locke in his work *Some Thoughts Concerning Education and Of the Conduct of Understanding* [1880], recognizes the significance of games for children's mind growth, "Spare money in toys and play-games, in silk and ribbons, laces, and other useless expenses, as much as you please; but be not sparing in so necessary a part as this. It is not good husbandry to make his fortune rich, and his mind poor.".

He also said, "the chief art is to make all that they have to do, sport and play too.", indicating that making something playful will enable children to learn it faster and easier.

2.1.1.4. Jean-Jacques Rousseau

Directly influenced by Plato, Rousseau [1911] also acknowledge games as an absolute necessity for a child's life, "Plato, in his Republic, which is considered so stern, teaches the children only through festivals, games, songs, and amusements.", in order to experience childhood but also learn, "We were observing the position of the forest to the north of Montmorency when he interrupted me with the usual question, 'What is the use of that?' 'You are right,' I said. 'Let us take time to think it over, and if we find it is no use we will drop it, for we only want useful games.'".

2.1.1.5. John Dewey

Almost 200 years after and despite the many ideological differences with Rousseau's theories, Dewey agrees with Rousseau regarding the importance of games on a child's education and growth, "The intellectual harm accruing from divorce of work and play, product and process, is evidenced in the proverb, 'All work and no play makes Jack a dull boy'" [1997] and "It is the business of the school to set up an environment in which play and work shall be conducted with reference to facilitating desirable mental and moral growth" [1966].

2.1.1.6. Jean Piaget

Finally, Piaget, who is probably the most modern pedagogue with great impact, indicates that playing helps children to develop their intellectual and cognitive abilities, “It may be said conversely that play is essentially assimilation, or the primacy of assimilation over accommodation” [1952].

Another great contribution of Piaget was, what he called Genetic Epistemology, on which he managed to categorize the stages of child development, as follows [1997]:

- 0-2 years: “sensorimotor” - motor development
- 3-7 years: “pre-operation” - intuitive
- 8-11 years: “concrete operational” - logical, but non-abstract
- 12-15 years: “formal operations” - abstract thinking

This categorization provides very helpful information also for the game designers. Knowing the age of children, on which a game is targeted, designers can adjust the gameplay in respect to the children’s brain abilities.

During our research, we came up with many pedagogues and philosophers, who expressed the significance of games on children’s early life, but since this is not a pedagogic research, we decided to mention the ones we thought they had the greater influence in the history of pedagogics. This is also the reason we also chose philosophers from ancient Greece, in order to show that “playing” is not a concept adopted just the last few years, but it is something that people needed regardless of time and available technology.

2.1.2. Learning

Besides acknowledging the significance of games in children’s educations, many pedagogues have also researched the factors that influence learning. Below, we analyze some characteristics that most of the pedagogues believe that influence learning in a positive way. Each of these characteristics is influenced by several attributes. These attributes can be either contextual, which means that they cannot

be modified, or “knots”, which means that they can adjusted, in order to achieve effective learning. Identifying these attributes is important for serious game designers. Designers should take into account these attributes, when designing a game, but they should also adjust the design in such a way, in order to provoke positive changes in the modifiable attributes.

2.1.2.1. Readiness for Learning

Readiness for learning means that a person should be ready to learn something before he or she actually learns it.

Rousseau supports that we develop different abilities while we evolve. Emile is learning the “good” according to his nature, the same way Plato said [Peraki 2010]. Both Plato and Rousseau believe that the child should not be left alone to be shaped, but they guide him according to the final goal of the education, the “complete adult” [Chambliss 1979].

Readiness for learning is influenced by the following attributes:

- **Age.** According to Rousseau [1762], there are development phases on youths, during which they can learn very good certain things.

  Both Plato and Rousseau respect child’s cognitive abilities in every stage in his or her development [Chambliss 1979].

  Piaget [1997], through what he called Genetic Epistemology, identified the cognitive abilities children develop while they grow up.

- **Prior Knowledge.** According to Vygotsky [1997], and generally to the school of Constructivism, prior knowledge impacts the learning process. Although it’s not always the case, most of the times new knowledge requires some pre-existing knowledge, e.g. a child cannot learn how to solve an equation if he or she doesn’t know basic arithmetic.

- **Talent.** Talent is an important factor regarding how ready is a child to absorb knowledge, but it’s not just limited to the brain functions. A child can be talented in math, in physics or even in a sport. A child that is talented in a field will be more willing to explore that specific field instead of another field, thus making him or her more ready to master this field compared to

another child.

Csikszentmihalyi et al. [1997] listed six experiences that are linked to talent:

◊ Losing track of time

◊ The personal need to do the activity well

◊ The sense of skillfulness

◊ High personal interest

◊ High challenge

◊ Sense that the activity offers opportunities for self-expression

And proposed that teachers should adjust the learning process, in order to include activities that provoke in a positive way the abovementioned experiences.

- **Willingness.** Willingness is the desire to accomplish something. In this case, the desire to learn something new and it's vital for a child to feel this way, if he or she wants to obtain knowledge. In many cases, willingness can be interpreted as motivation, which we analyze, in more detail, below.

2.1.2.2. Motivation

It is very important for teachers and parents to motivate children, at least to the point where they will be able to be self-motivated.

The effectiveness of motivation is influenced by the following attributes:

- **Usefulness.** According to Rousseau [1762], the greatest motivation for learning is interest. Children are interested only for things that they consider useful and needs to satisfy their interest now. Thus, learning should correspond to the children's needs.

  Johnson also said "Motives derive from needs" [1973] and that every child, either consciously or unconsciously, creates a hierarchical set of needs. Maslow [1943] theorized that set of needs, which are common

among humans, as follows:

- ◊ Psychological needs
- ◊ Safety needs
- ◊ Love and belonging needs
- ◊ Esteem or achievement needs

Maslow noticed that needs higher in the list should be satisfied first, by children, if they want to focus on another need. E.g. children would first seek to satisfy their hunger or their thirst before focusing on learning a new subject at school.

- **Environment.** The different environments, on which children live, influence significantly their ability to acquire knowledge. These environments and their definitions are:
  - ◊ **Family.** We define the family environment as the overall background (academic, cultural etc.) and the day-to-day attitude of a child's parents and siblings.

    Whitaker et al. [2012] noticed a positive correlation between a well-functioning family environment and motivated children.
  - ◊ **School.** We define the school environment as the overall background (academic, cultural etc.) and the day-to-day attitude of a child's teachers and the overall infrastructure of the school.

    It's upon teachers to decide on the learning process of a specific curriculum, thus they play a significant role on motivating children.
  - ◊ **Society.** We define the society environment as the cultural, political and economic situation of the society the child lives in.

    Whitaker et al. noticed a positive correlation between wealthy societies and motivated children.
- **Type.** A child can exhibit a motivation that is [Ormrod 2010]:
  - ◊ **Extrinsic.** In that case, children are motivated by factors external to themselves and unrelated to the task they are performing. These fac-

tors can be high grades, recognition by the teachers and/or the fellow students or other type of reward. And/or,

- ◊ **Intrinsic.** In that case, children are motivated by factors within themselves and inherent in the task they are performing. These children may engage in an activity because it gives them pleasure, helps them develop a skill they think is important, or seems to be the ethically and morally right thing to do. Some learners with high levels of intrinsic motivation become so focused on and absorbed in an activity that they lose track of time and completely ignore other tasks. The latter phenomenon is known as flow, which was described by Csikszentmihalyi [1991].

- **Time.** A motivation can be:
  - ◊ **Short-term.** In that case, the child would feel that learning something would reward him or her almost instantly.
  - ◊ **Long-term.** In that case, the child would feel that learning something will eventually be helpful, but not in the near future.

2.1.2.3. Repetition

Although repetition is considered crucial for learning, as stated clearly on the quote “Repetitio est mater studiorum”, Piaget [1964], along with many pedagogues, believes that repetition should be exercised in a practical way and with slight modifications.

The repetition of reactions to stimuli is called exercise. Learning rarely can be accomplished by the first reaction to a stimulus. Several reactions or answers are needed.

According to traditional pedagogues, repetition plays the most important role for learning, and often in combination with punishment.

According to modern pedagogics, repetition is not considered so important, although modern pedagogues do not reject its usage totally, especially when learning some specific skills, such as computer programming or vocabulary of a foreign language.

The effectiveness of repetition is influenced by the following attributes:

- **Frequency.** If a task is repeated too frequently, the child might be bored, which does not provoke learning. Whereas, if the task is repeated in very long time intervals, the child won't be benefited by the repetition.

  A task can be repeated in fixed time intervals or in increasing time intervals. The latter is called "spaced repetition", which was first introduced by Mace [1932], and it aims at exploiting the psychological spacing effect [Wikipedia August 2001].

- **Content.** The content of the task can be:

  ◊ **Identical.** On each repetition the task is exactly the same. This is a common technique for learning e.g. vocabulary.

  ◊ **Modified.** On each repetition the task is slightly modified, in order to avoid boredom, which does not helps learning.

- **Intention.** The intention of the repetition can be:

  ◊ **Learning.** The repetition is not considered to be a chore and usually the content of the task is modified.

  ◊ **Punishment.** The child is forced to repeat a specific task due to a mistake or misbehavior. The repetition is considered to be a chore and usually the content of the task is identical. E.g. when a student misspelled a word, the teacher would punish the child by forcing him or her to write the word for 100 times, in order for the repetition, along with the unpleasant feeling of punishment, to help imprinting the knowledge to the child [Fragkos 1977].

2.1.2.4. Stimulus

According to Pavlov [Chance 2013], a stimulus that is accompanied by a reaction helps learning. Showing, for example, the picture of an animal to a child of the first grade of elementary school and naming that animal, helps the child to absorb the name of the animal, because the relevancy that is formed between the stimulus (picture) and the name contributes to the knowledge [Guthrie 1952].

The effectiveness of stimuli is influenced by the following attributes:

- **Type of Stimulus.** A stimulus can differ, depending on the sense it intents to stimulate. A stimulus can stimulate:
  - ◊ Vision
  - ◊ Audition
  - ◊ Gustation
  - ◊ Olfaction
  - ◊ Somatosensory
- **Duration.** The duration of the stimulus should neither be too short, because children won't have time to link the stimulus with a specific reaction, nor too long, because they might link the stimulus with more than one reactions.
- **Intensity.** The intensity of the stimulus should neither be too weak, because children won't be able to link the stimulus with a specific reaction, nor too strong, because it might be unpleasant and unsuccessful to provoke learning.
- **Lucidity.** The stimulus should not be ambiguous, in order for children to be clear regarding their reaction with respect to the stimulus.
- **Collective Consciousness.** Collective consciousness was defined by sociologist Émile Durkheim [2014], as the set of shared beliefs, ideas and moral attitudes, which operate as a unifying force within a society. According to that, principles that reside, for example, in religion, in laws or principles that have been passed to a child by an authority figure, such as a parent or a teacher, are accepted as correct even if logic contradicts these principles. Hence, the reaction of children to a stimulus can be based on the collective consciousness of the family, school and/or society environment they live in, instead of their own individual experience or knowledge.
- **Fantasy.** Jung, on what he called collective unconsciousness [1981], stated that children have not experienced enough of reality to cancel out their mind's enjoyment of archetypal imagery, thus they fantasize a lot.

Therefore, Jung believed that children could react to a stimulus according to their fantasy, instead of logic.

2.1.2.5. Reward / Punishment

Rewarding a child after or even before learning something is important, in order for this child to link learning with something pleasant.

The effectiveness of both reward and punishment is influenced by the following attributes:

- **Age.** Choosing the appropriate reward depends on children's age. Rewarding a small child with a smile may suffice but an older child would like something more, like a high grade.

  Equivalently, punishing older children with just a warning might not prevent them from repeating what caused the need for punishment in the first place. Whereas, young children might learn with just a warning, due to the fact that they perceive a teacher or a parent as an authority figure, thus it's more probable to comply with their instructions.

- **Type of Reward/Punishment.** There is not one reward or punishment that works in every occasion. Choosing how to reward or punish children depends on their character as well as to their age, as explained above.

- **Time.** Reward should be applied on the appropriate time, either before of after learning something new, in order for children to link their action to the reward.

  According to Guthrie, punishment should be practiced while the stimulus is still around [Wikipedia September 2005], otherwise it may cause the opposite result.

- **Frequency.** Rewarding children too often will cause them to lose interest on the reward. Rewarding children rarely will cause them to lose their motivation for learning.

2.2. Entertainment Elements

The primary purpose of games is to entertain users. Many people perceive entertainment as fun, but entertainment is much more than fun. According to Oxford Dictionary [Simpson et al. 1989], entertainment can be an idea or a task, but is more likely to be one of the activities or events that have developed over thousands of years specifically for the purpose of keeping an audience's attention.

The same thing occurs in other languages too. In French, the origin of the word is interpreted as "to engage, keep occupied, the attention, thoughts or time of a person", whereas in Greek it means to spend time in a pleasant way.

But which are the individual elements that provoke entertainment?

According to Aristotle [1911], in order to hold an audience's attention, the creator(s) of a public presentation, e.g. a play or a game, must design their presentation thoroughly, based at least on one of the following attributes:

- **Plot.** Defined as the scenario or storytelling.
- **Character.** Defined as the character presentation and evolution.
- **Meaning.** Defined as the intellectual stimulation.
- **Dialog.** Defined as dialogs that are memorable.
- **Music.** Defined as the music that enhances a play or a game.
- **Spectacle.** Defined as an exciting and spectacular visual presentation.

Although Aristotle thought that one of these attributes must be developed thoroughly in a play or a game, he believed that more or less all of these elements should be included.

According to Malone [1980], in order for something, either a play or a game, to be entertaining, it should provoke:

- **Fantasy**. Defined as the mental images evoked by the user through the game environment. And/or,
- **Curiosity**. Curiosity was later also researched by Garris et al. [2002] and

renamed to Mystery. According to Garris et al., mysteries presented in a game can evoke curiosity in the individual, pushing a desire for discovery.

Garris et al. also proposed that **Sensory Stimuli** is a key element for entertainment, since stimulating our senses leads to stronger motivation.

Finally, Csikszentmihalyi, through his work about the theory of Flow [1991], noticed that diminishing the extraneous distractions causes increased **Concentration**, which facilitates Flow and entertainment.

2.3. Game Elements

Games are designed, or the intention of game designers is, to keep players engaged and excited. But the greater question is, which are the game elements that designers should have in mind, when designing a game?

And this question becomes even more complicated when the game is a serious game. Making the content of a game both exciting and educational has been researched since ancient Greece as we examine it in detail on the “Education and Learning” section.

2.3.1. Research in Literature

Since a game is, by default, entertaining, it includes one or more of the entertaining attributes and elements, we described on the previous section. Besides these attributes/elements, there are some additional characteristics that a game designer should take into account. These characteristics are:

- **Rules.** Rules limit the players’ actions and describe how the game works [Salen et al. 2004].
- **Goals**. Goals are necessary in games for player to judge their performance [Malone 1980] and to motivate them.
- **Challenges**. Challenges must be carefully designed, in order not to be too boring or too difficult to accomplish. The balance between skills and challenges, described by Csikszentmihalyi [Csikszentmihalyi 1991], is depicted on the Figure 3.

- **Feedback**. Feedback should be clear and on time, regarding player's performance.

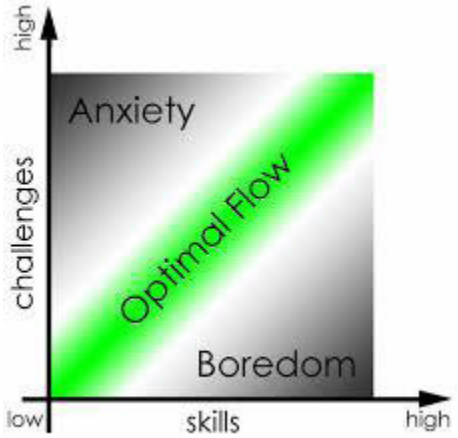


Figure 3: The diagram of optimal flow according to Csikszentmihalyi

2.3.2. Game Design Document (GDD)

Despite our research on the educational aspects of games and on their core elements, designing an environment with the intention to replace the traditional GDD would not be possible if we had not thoroughly examined the theory and practice of game design, including the possible ways to structure and construct a GDD. Examining several GDDs enabled us to distinguish the core elements that are present on every game, regardless its genre or purpose.

Our goal is to cross reference the GDD with the findings from our academic research to come up with the final model, which would be benefited both from the professional input of experienced game designers and from the state of the art research on the area of game design.

We expected that most of the game elements would be present both on the GDDs and the academic research but we believed that examining GDDs would offer a more detailed insight on these elements and on how they are structured in terms of content and flow.

After searching on the internet for a GDD that would most precisely give us an general overview of this area, we ended up using three GDDs [*Estudo e Concepção De Jogos 2015*][Runaway Studios 2015][An Ants Lide 2015][*Game Design Document Template 2015*]. Examining these GDDs helped us in two ways. On the one hand, we identified one important game element that was absent from the lit-

erature, Levels. On the other hand, GDDs enabled us to better understand how to group the game elements, in order for the content of each category to be relevant to each other and to the category itself.

2.4. Design Techniques

Game design is not a strictly defined area within the game industry. Most of the universities offering game design courses, or a complete game design degree, do it under the umbrella of computer science. Whereas several researchers consider game design to be a form of art [Rollings et al. 2003 & Crawford 1984]. Other researchers disagree with both standpoints, they believe that game design is an emerging discipline and that it should be studied within its own disciplinary space [Salen et al. 2004]. Despite these views on game design, there have been several approaches to define more explicitly games and specifically to give more structure to the creative part of them.

In the next three sub-sections, we analyze techniques, such as models and frameworks combined with theories, in the areas of traditional games, serious games and educational games.

2.4.1. Game Design Techniques

Ermi et al. [2005] presented a gameplay experience model, where they analyzed the different aspects of immersion. The model's intention is to drive attention to the complex dynamics that that are involved in the interaction between a player and a game. The authors managed to distinguish three dimensions of gameplay experience based on a previous interview they have conducted on Finnish children. The three dimensions of gameplay experience are:

1. Sensory Immersion, which includes the audiovisual content of the games, like 3D graphics and stereophonic sound.
2. Challenge-based Immersion, which is based on interaction and includes the completion of goals and the acquirement of abilities.
3. Imaginative Immersion, which is when players can use their imagination, empathize with the characters or generally be immersed by the fantasy

aspects of the game.

The authors, based on the model they developed, constructed a questionnaire to examine how the three types of immersion appear on modern video games. The results they obtained show that participants identified all three types of immersion, more or less, on all games. The balance between these three types and the intensity of each type was strongly depended on the genre of the game.

The Mechanics, Dynamics and Aesthetics (MDA) framework [Hunicke et at. 2004] decomposes game design into three core elements, the mechanics, the dynamics and the aesthetics. According to the authors approach, the game designer designs the mechanics of a game, players interact with the game through the aesthetic element and the interaction between the mechanics and the aesthetics forms the dynamics of the game. The aesthetics are influenced by players' input, which consequently influences the dynamics of the game. Thus, the game designer can directly adjust the mechanics of the game and only through them to indirectly influence the game experience. Figure 4 depicts the framework's structure. Additionally, the game designer can modify the mechanics, meaning the game design, through an iterative process of playtesting and game balancing (Figure 5).

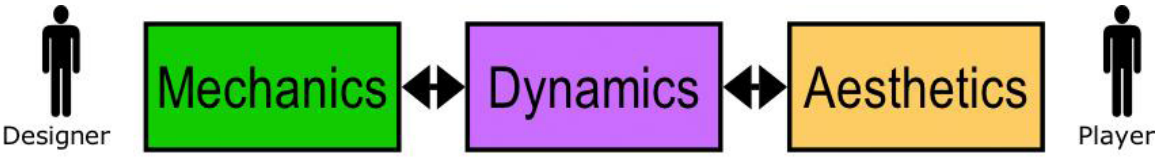


Figure 4: MDA's structure

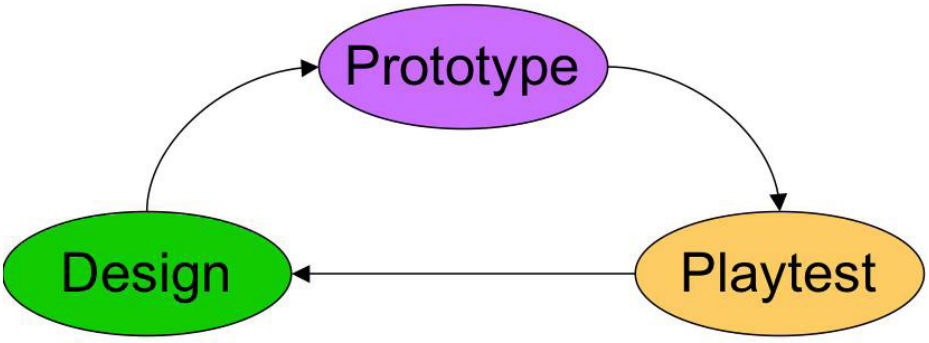


Figure 5: The iterative designing approach of MDA

Jason Vandenberghe, creative director on Ubisoft, on his presentation on Game Developers Conference in 2012 [GDC Vault 2012-1], presented his research on the five domains of play he identified and on their correlation with the five aspects of the motivational model O.C.E.A.N. [Wikipedia December 2004]. According to his research, the five domains of play are:

1. Novelty. It distinguishes open, imaginative experiences from repeating, conventional ones.
2. Challenge. It deals with how much effort and/or self-control the players is expected to use.
3. Simulation. It deals with the simulation level and social engagement of play.
4. Harmony. It reflects the rule of player-to-player interactions.
5. Threat. It reflects the game's capacity to trigger negative emotion in the player.

Figure 6: The 5 domains of play according to Jason Vandenberghe

By correlating these two models and by adding to his analysis the six facets that each aspect of the O.C.E.A.N. model has, he was able to draw some conclusions related to how players' motivation is related to the way they play. His first conclusion was that people tend to play games for the same reasons they live. His second conclusion was that there are techniques on game design that can target most of the spectrum of human motivation and that the game designers can adjust their target group by focusing on one or both sides of each of the thirty facets.

2.4.2. Serious Game Design Techniques

In the area of serious games, Huynh-Kim-Bang et al. [2010] studied and analysed 20 serious games, in order to identify patterns on their design that allow both fun and learning to coexist on a game. They identified 5 main patterns varying from game design to project management decisions.

1. In order to balance fun and learning on serious games, they propose to make the knowledge experts and the game experts (development team) work separately before combining them.
2. They also propose several different ways for the user to interact with the game according to the content and the context of the game. These ways are the following:
    - ◊ Questions and Answers
    - ◊ Pavlovian Interaction. Repetitive tasks with stimulus
    - ◊ In Situ Interaction. Providing detailed narrative and emotional context
    - ◊ Microworld Interaction. User can build or modify the environment
    - ◊ Social Pedagogical Interaction. Users can reveal their different attitudes and standpoints towards a topic
    - ◊ Serious Varied Gameplay. A combination of different gameplays
3. In order to cope with the problem of teaching high-level knowledge, they suggest to conduct practice and training sessions.
4. While, for informing players for their progress, they propose to represent acquired knowledge with virtual goods that players collect.
5. Finally, they strongly recommend a fun reward system to motivate players advancing in the game.

Tang et al. [2008] developed a modeling framework for serious game design by analysing existing software modeling languages and by taking into account the requirements of serious game design. Their conceptual framework consists of three tier design architecture; flow, scenarios and objects, which they manage to model using a combination of various UML diagrams along with additional notation. Al-

though the proposed framework is still too technical, due to the extensive usage of UML, and might be difficult for game designers to take full advantage of it, Tang et al.'s work on decomposing serious game architecture is very insightful.

Winn [2008] expanded the MDA framework [Hunicke et at. 2004] to what he called Design, Play and Experience (DPE) framework with the goal to address the issue of designing serious games. DPE has four layers of components, one of which is the MDA. Each layer has one subcomponent for each of the three pillars of DPE, meaning the Design, the Play and the Experience. The full structure of DPE can be seen on Figure 7. The contribution of DPE is the methodology it proposes in order to analyze and process the design of serious games, which when combined with an agile design environment, it provides a solution applicable to the whole spectrum of serious games.

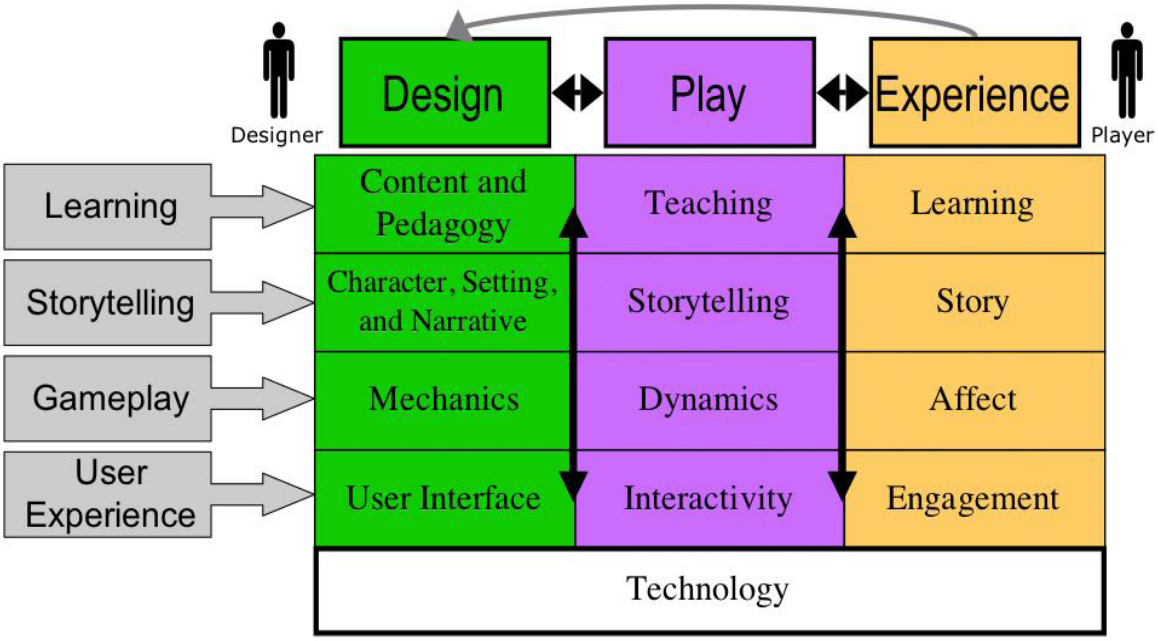


Figure 7: DPE's structure

Using a similar methodology, Mitgutsch et al. [2012] developed a framework, which they called Serious Game Design Assessment (SGDA) framework. According to their approach, a serious game is composed by six key elements. Namely, these elements are:

1. Purpose. In other words, what's the aim of the game and its topic and also what's the designers' intention and their goal to impact the players in a specific way.

2. Content and Information. In other words, which are the information, facts

and data offered and used in the game.

3. Game Mechanics. In other words, “the methods invoked by agents for interacting with the game world” [Sicart 2008].
4. Fiction and Narrative. In other words, the story, plot or scenario of a game along with any fictional elements that accompany it.
5. Aesthetics and Graphics. In other words, all the art and the Graphical User Interface (GUI) elements.
6. Framing. In other words, all the necessary information around the game, like the target group of the game, the prerequisites for playing the game, the genre etc.

A visual representation of SGDA is shown on figure 8.

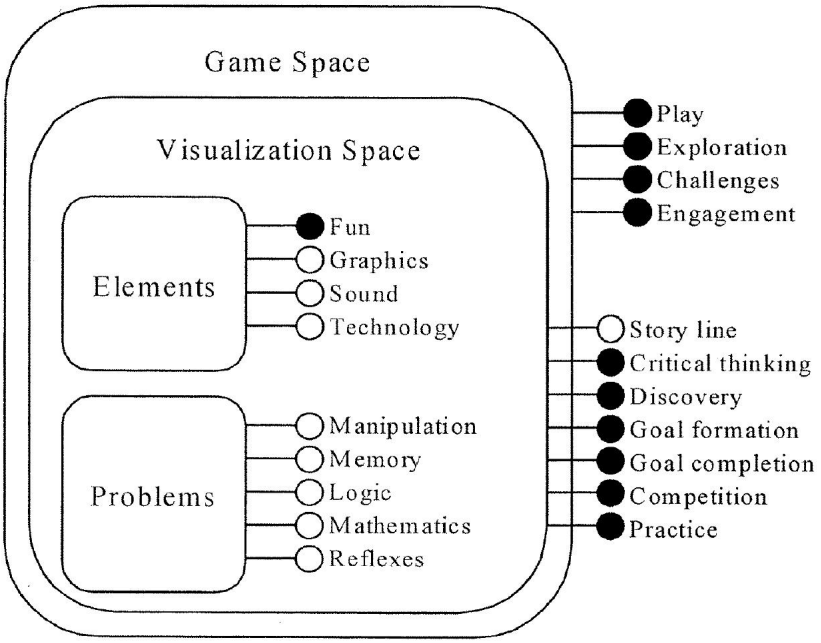
Figure 8: The Serious Game Design Assessment (SGDA) framework

Ross et al. [2014] used SGDA to break down the design of the educational game “Space Tug Skirmish”, which was designed to be used as a teaching and research tool for systems engineering core concepts. SGDA was able to identify the cohesiveness and coherence of the game.

2.4.3. Educational Game Design Techniques

Iza Marfisi-Schottman [2012] developed an online authoring environment, called LEGADEE, similar to ours, that guides designers with a “toolbar” adapted to their role. Her approach is model-driven, which resulted in the GUI environment. LEGADEE’s intention is to offer a methodology and tools to guide the various actors that participate in the learning game conception, such as clients, teachers, game designers and developers. LEGADEE was the only framework from the ones we examined that the proposed model was used to develop an actual environment.

Amory et al. [1999] conducted an experiment on twenty students aiming at identifying which game type is more suitable depending on the learning environment and which are the game elements that students find interesting or useful. Results showed that the preferred genres are the 3D adventure and strategy games, whereas the game elements that students identified as the most useful were logic, memory, visualization and problem solving. Based on the results from the experiment, the authors presented a model that links pedagogical issues with game elements. The visual representation of the model can be seen on Figure 9. The rounded squares represent the game components and the circles represent the interfaces that define the interactive learning environment.



(●—abstract interfaces, ○—concrete interfaces).

Figure 9: Amory et al.’s model

Aleven et al. [2010] propose a framework that is built on three existing components:

1. Learning Objectives. The learning objectives of the game need to be identified and defined and this is accomplished by answering three questions:
   - ◊ What is the required prior knowledge?
   - ◊ What is the knowledge that players will acquire from the game?
   - ◊ What potential knowledge players can learn that goes beyond the scope of the game?
2. MDA. The designers need to define the mechanics and therefore indirectly influence the dynamics and the aesthetics of the game (The MDA framework is analyzed in detail in section 2.4.1).
3. Instructional Principles. The principles for instructional design need to be defined based on research on learning theories.

Finally, the authors strongly suggest that designers need to make the abovementioned components to always work in concert and to have in mind that educational games need to be both educational and fun.

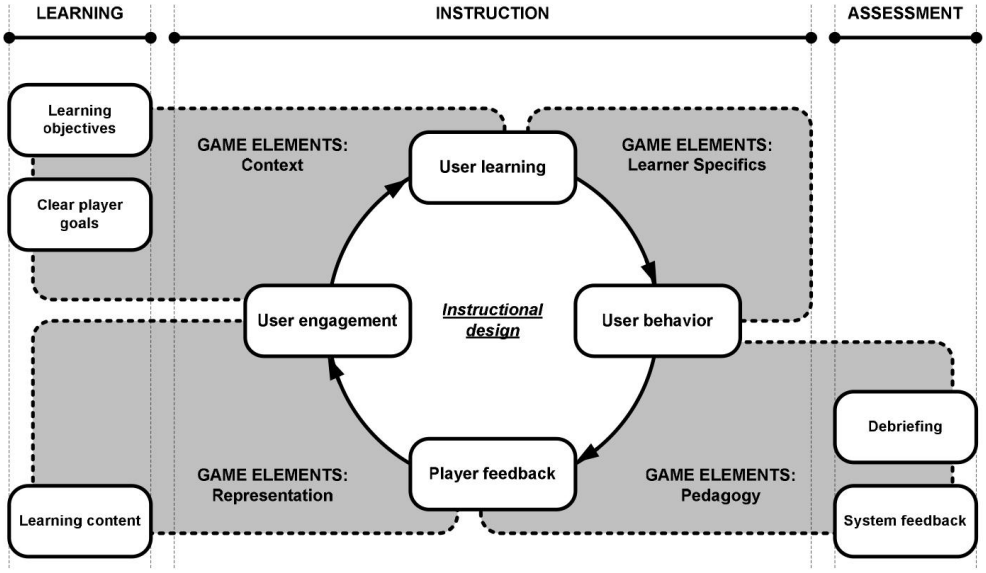


Figure 10: Van Staalduinen et al.'s game-based learning framework

Van Staalduinen et al. [2011] after doing a detailed research on existing frameworks on educational and serious games, they developed a game-based learning

framework that can be used to both design games from scratch and map out the design of existing games. Their methodology is based on three steps. These steps along with the complete design of the framework are shown on Figure 10. They recommend that the designer should follow the steps with a specific order, going from left to right as shown on Figure 10.

Jan Plass, co-director of the Games for Learning Institute of New York University, on his presentation on Game Developers Conference in 2012 [GDC Vault 2012-2], proposed to educational game designers to use two additional mechanics apart from the traditional game mechanics, due to the fact that game mechanics are different when the goal of the game is learning. These two mechanics are:

- Learning Mechanics. During the designing process of learning mechanics, designers should:
  - ◊ Describe the desired outcomes of the game
  - ◊ Apply a learning approach
  - ◊ Design meaningful interactions with the specific subject
  - ◊ Select the appropriate traditional game mechanics
- Assessment Mechanics. During the designing process of assessment mechanics, designers should:
  - ◊ Consider item dependencies
  - ◊ Allow for multiple observations
  - ◊ Not rely on unrelated skills
  - ◊ Not introduce confounds, e.g. irrelevant content or knowledge
  - ◊ Consider emotional response

2.5. Requirement for Games

In the area of requirements engineering, several researchers have proposed ways to integrate, quantify and visualize creativity and emotions on games.

Callele et al. [2005] identify the need to extend traditional requirements engineering techniques to support the creative process in video game development. Their proposal is to better balance the time spended on a project between the pre-production and the production phase and to add gameplay requirements, which are unique to video games, to the requirements engineering process. Callele et al. [2006] also managed to capture and express emotional requirements by introducing visual mechanisms, like emotional terrain maps, emotional intensity maps and emotion timelines. Visualizing emotions enables to link emotions to spatial qualifiers and thus help designers to better understand which elements and where in the game cause certain emotions.

Draper [1999] agrees that fun should be taken as a requirement when designing games but he argues that fun is the only kind of enjoyment that provokes, what he identified as, u-flow (unconscious flow) and c-flow (conscious flow). Hence, he believes that game designers should take into account other kind of enjoyment as well.

Maiden et al. [2004], by conducting creativity workshops, concluded that creativity can be integrated to and enhance requirements engineering with the use of use case précis in text form and multimedia storyboards.

2.6. Conclusion of literature review

In this chapter we did an extensive review of the previous research that has been done on serious games and in the areas related to them. The fields discussed in Sections 2.1, 2.2, 2.3 and 2.5 are necessary ingredients of serious and educational games and need to be taken into consideration when designing such type of games. The Design Techniques field, discussed in Section 2.4, is the actual area where the results from the other fields are employed, in order to develop techniques, frameworks or environments that can help game designers to improve their understanding, and consequently their results, on serious and educational game design.

In this section, we discuss the results of our research from two perspectives. First, we summarize the current state-of-the-art on serious and educational game design and analyze the lessons learned due to this research, and second we identify what is missing and therefore how can our research help.

The techniques presented in section 2.4 share many common features, like game elements and learning elements. While researching these techniques, most of their features were already known to us from our research to the other fields related to educational games.

Examining these techniques helped us twofold. On the one hand, we discover several different approaches on combining elements from completely different areas, like entertaining and learning elements. On the other hand, we realized that serious and educational games use many traditional game elements, like game mechanics.

Our research also allowed us to identify two deficits in the area of serious and educational game design. First, none of the models, with the exception of LEGADEE, has been implemented in a design environment, which game designers can use to design games. Second, the design of all models is high-level, meaning that the elements they incorporate are very abstract. For instance, most of the models use the term learning process without going deeper to the core elements that define learning.

This project will address the abovementioned deficits by using a low-level conceptual model as a blueprint for developing an online environment.

3. Conceptual Model of Educational Serious Games

In this chapter, we first give an introduction on conceptual modeling and then we describe how we combined the research described in chapter 2 to build a conceptual model that defines the core elements of educational games and that will serve as a main artifact for the model-driven design of educational serious games.

The conceptual model was built around four main pillars: the four main concepts that we identified on the literature review in Chapter 2. These four concepts are:

- Game Content Elements, e.g. Plot, Characters, Music.
- Game Design Elements, e.g. Game Mechanics, Levels, Goals.
- Game Attributes, e.g. Fantasy, Mystery.
- Educational Game Elements, e.g. Learning Elements, Curriculum.

The key factor of this step, in order to come up with a conceptual model that would depict as accurately as possible the core elements of educational games, was to identify the relationships between these elements.

Additionally, we had to decide on the hierarchy of these elements, which would define the structure of the model and consequently the structure of the environment.

3.1. Conceptual Modeling

Conceptual modeling is the abstraction of a simulation model from the part of the system that it intends to represent [Robinson 2010], or in a more general sense, conceptual modelling is the activity of formally describing some aspects of the physical and social world around us for purposes of understanding and communication [Mylopoulos 2008]. Therefore, a conceptual model's intention is to simulate a system and its importance lies on the fact that it can simulate the system even if the system does not exist but also when a real simulation is not possible, for reasons such as lack of data, lack of time or if it is not feasible to simulate the needed phenomenon. For example, if a civil engineer wants to simulate how a building will behave in case an earthquake happens, he or she most probably will not be able

to do it in real world. The reasons we decided to first simulate our system by using conceptual modeling are described in detail in section 1.5

Conceptual modeling is concerned with “things”, often referred to as entities [Wand 1999]. The association among these entities are referred to as relationships. Conceptual modeling, as we know it today, has its roots in Peter Chen’s work on ER diagrams [1976]. This representation is similar to the most modern one of object oriented approach, except that the entities are replaced by objects.

By definition, an association between two or more entities is a relationship [Wand 1999]. On the other hand, relationship can take up the semantic meaning indicated by the connectivity between the occurrences of entities (one to many, many to many or one to one); this is cardinality which can be optional or mandatory. These two however do not provide the underlying meaning of the relationships. The underlying meaning of conceptual model relationships can be derived by the application of ontological theories.

Based on ontological theories, Wand et al. [1999] came up with rules for modeling composite things, based on which we built our conceptual model. Namely, these rules are:

1. A composite functional schema and its components should be represented as classes or entity types.
2. The emergent properties of the composite functional schema should be modeled as attributes and relationship types.
3. Each component should be linked with the composite via a directional part-of relationship, representing a binding mutual property.

3.1.1. Validation

Validating conceptual models is important because every model of a system can only be an approximation of the real system, regardless of the time spent to build the model and the level of precision [Martis 2006]. This means that, if the approximation produced by the model is not close enough to the real system, then there is the possibility that the conclusion from such a model could be faulty and divergent, which in turn might lead to mistakes in any process the model is intended to be

used on.

Validity depends on the availability of data in the actual system, although there are some contradicting statements that an absolutely valid model does not exist. In addition to this, model credibility request can be made for the intended use of a model, as well as the set circumstances under which the conceptual model testing has taken place. Validation of a model should be about the process implemented in building the confidence that the conceptual model is suitable for the intended purpose.

Considering all of the above, validating a conceptual model is necessary. It is important to note that the most powerful model is the model that expresses the valid relation in the simplest way. Also, the validity of a model cannot be asserted by the use of a single test. As the model passes from one test to the next, the confidence level of a model increases gradually. Validation is carried out by the modeler in communication with the system client. Both the clients' and modelers' satisfaction is the determinant of the model's validity. The reason is that a conceptual model is an approximation of the real phenomenon which makes it unavoidable to make approximations and encounter errors.

Regarding our conceptual model, the first step towards validation is the fact that we heavily relied upon literature to identify the elements of educational games, as well as the relationships that are formed between them. The second step of the validation is the evaluation we conducted, which is presented thoroughly in chapter 5.

There are viewpoints that characterize validation [Martis 2006]. Namely, these viewpoints are:

- The judgment of a conceptual model should be based on its usefulness as opposed to its absolute validity. In our case, we cannot state that the model is absolutely valid for every game but we can state that it is useful, based on the 2-step validation, meaning the literature review and the interviews we conducted.
- Absolute validity is not possible for a conceptual model but model validity can be possible, for the purpose the model is built. In our case, as stated in the previous point, we expect for the model to be valid, for the purpose it is built, based on the 2-step validation.

- Validity cannot be judged based on one test. In our case, we validate the model based on two tests.
- Model confidence is enhanced as model passes from one test to the next. In our case, the first test was the usage of the literature to built the model. We consider that the model is further validated on the second step, the evaluation.
- Failing a test enables the rejection of a wrong hypothesis but passing a test does not prove the validity of the model. In our case, even if multiple people have a positive opinion about the model, it cannot be considered valid. But, contrary to this viewpoint, if an interviewee has a negative opinion about the model, it does not mean the immediate rejection of the model.
- More acceptance should be given to qualitative and quantitative validity criterion. In our case, this was not applicable.
- Consistency of the model is checked by the use of real system information. In our case, we evaluated the model by interviewing game designers.
- It is not acceptable to reject a model that fails to produce an exact match of the past data. In our case, this was not applicable.
- It is not acceptable to reject a model that fails to provide a prediction of a specific event in the future. In our case, this was not applicable.

3.2. Relationships

Combining the findings from several different areas required a new research on how their elements are correlated. Correlating these elements is of major importance, in order to build one model with a beginning and an end and not just merge two independent models, meaning a Game model and an Educational model. In the table 1 below, we provide a list with all the elements that we identified from our initial study on the literature and the game design documents.

Element	Research Domain	Source
Plot	Entertaining Elements	Literature
Character	Entertaining Elements	Literature
Meaning	Entertaining Elements	Literature
Dialog	Entertaining Elements	Literature
Music	Entertaining Elements	Literature
Spectacle (Visual)	Entertaining Elements	Literature
Fantasy	Entertaining Elements	Literature
Mystery/Curiosity	Entertaining Elements	Literature
Concentration	Entertaining Elements	Literature
Rules	Game Elements	Literature
Challenges	Game Elements	Literature
Goals	Game Elements	Literature
Levels	Game Elements	Game Design Documents
Feedback	Game Elements	Literature
Readiness for Learning	Learning	Literature
Motivation	Learning	Literature
Repetition	Learning	Literature
Stimulus	Learning	Literature
Reward/Punishment	Learning	Literature

Table 1: Educational game design elements

During our research, we defined the:

- Form of the relationship between several elements, but always between two elements at a time, which in most cases was accomplished by the use of a verb. E.g. Fantasy **enhances** Motivation.
- Cardinality of each relationship, whenever it was possible. Meaning how many elements of the Source Element are or can be related to the Destination Element. E.g. **1...n (one or more)** Goals define Challenge.

Our research method on identifying the relationships was done on two steps:

1. We identified relationships between the elements based on common sense, e.g. 2…* (two or more) Characters participate in Dialog.

2. We enhanced the list of relationships and justified most of the relationships we came up on the first step, by doing a literature research. For those relationships that we could not justify through the literature, we give a detail description of our rationale, which led into identifying each of these relationships.

3.2.1. Relationships from the Literature

For most of the relationships we identified, we were able to justify them through the literature research we conducted. The advantage of identifying these relationships was twofold. On the one hand, it helped us structure the conceptual model and thus the environment, by taking into account the connections between the elements. On the other hand, justifying these relationships through the literature research, provided a theoretically more solid background on our results.

Table 2 below shows the results of our research.

Source Element	Relationship	Destination Element	Cardinality	Reference
Characters	participate in	Dialog	2…*	Simpson et al. 1989
Music	provokes	Stimulus	1…n	Yamada et al. 2001
Spectacle	provokes	Stimulus	1…n	Ju et al.1997
Fantasy	provokes	Curiosity/Mystery		Asgari et al. 2004
Fantasy	enhances	Motivation		Asgari et al. 2004
Fantasy	enhances	Challenge		Malone 1980
Spectacle	enhances	Challenge	1…n	Malone 1980
Curiosity/Mystery	provokes	Challenge		Harter 1981
Stimulus	enhance	Fantasy	0…5	Greer et al. 1991
Reward/Punishment	define	Challenge	1…n	Nijholt et al. 2009
Challenge	define	Goal	1…n	Juul 2007
Feedback	provokes	Concentration		Csikszentmihalyi 1991
Motivation	provokes	Concentration		Vockell 2004
Curiosity/Mystery	influences	Motivation		Vockell 2004
Repetition	influences	Motivation		Hawkes 2009

Table 2: Relationships between elements identified in the literature

Each relationship needs to be justified before it is implemented in the conceptual

model. There is the possibility of assuming that some relationships can be deducted by common sense, like the fact that two or more Characters participate in Dialog. There is also the possibility of assuming that other relationships are not so obvious and thus we provide a brief explanation for them in addition to the references above. Given all relationships, it is a requirement to provide a justification with a viable explanation.

Music and Spectacle provoke Stimulus: Music and spectacle, meaning any audiovisual effect, stimulate the senses. A stimulus, either auditory or visual, that is accompanied by a reaction helps learning [Chance 2013]. Showing, for example, the picture of an animal to a child of the first grade of elementary school and naming that animal, helps the child to absorb the name of the animal, because the relevancy that is formed between the stimulus (picture) and the name contributes to the knowledge [Guthrie 1952].

Fantasy provokes Curiosity / Mystery: When someone fantasizing on having a specific experience, he or she automatically becomes curious on how it would feel to actually have this experience. Fantasies are mental images evoked by the user through the game environment [Malone 1980]. Mental images present the player with different instances of mysteries raised by curiosity [Malone 1980]. Mysteries presented in a game can evoke curiosity.

Fantasy enhances Motivation and Challenge: On the same spirit, when someone fantasizing on having a specific experience, he or she becomes more motivated on actually having this experience and makes the whole procedure more challenging. This is more or less an indirect relationship. We have seen that according to Malone [1980], fantasies are mental images, which present the player with different instances of mysteries, which in turn raise curiosity. In a different case, according to Garris et al. [2002] mysteries in a game can evoke curiosity in the individual, pushing a desire for discovery. A desire for discovery brings about motivation and the awareness of the challenge. The challenge would be to bring to reality the fantasy.

Spectacle enhances Challenge: Goals are necessary in a game to motivate the players as well as judging their performance [Malone 1980]. Goals in a game are presented as a target to be reached which is portrayed by the performance achieved. Seeing the task at hand through having a goal enhances the challenge.

Curiosity / Mystery provokes Challenge: When a player is curious on discovering

something new on a game and acts accordingly, a new set of challenges is “unlocked”. According to Garris et al. [2002], mysteries in a game can evoke curiosity in the individual, pushing a desire for discovery.

Stimulus enhance Fantasy: Applying audio, visual and/or tactile stimulus, especially when the reason is not clear, makes player to fantasize what is the reason and what is coming next in the game. Jung [1981] states that children fantasize a lot due to their lack of experience in reality. From this statement, Jung believed that children react to a stimulus according to their fantasy instead of logic.

Reward / Punishment define Challenge: This is a two-way relationship. The type and size of the reward, and consequently the severity of the punishment, must be adjusted in order to be fair given the challenge the player face. Seeing this relationship the other way, the intensity of a challenge must match the reward and punishment associated with it. According to Fragkos [1977], repetition is considered to be a chore and usually the content of this task is identical. For instance, a student can get punished by the teacher for misspelling a word. The punishment would be for the student to write the misspelled word 100 times. This presents the child with a challenge both in form of the task and the unpleasant feeling that comes with the punishment. The student will work towards never misspelling words again.

Challenge define Goal: Goals are necessary in a game to motivate the players as well as to judge their performance [Malone 1980]. There must be a balance between the players’ skills and the challenges [Csikszentmihalyi 1991], which eliminates too much difficulty and too much boredom making the goals achievable. Reaching a specific goal within the game means completing a number of challenges. The level of difficulty these challenges have define the level of difficulty of the goal.

Feedback provokes Concentration: Feedback is based on the player performance and it should be clear and on time. Giving the player an immediate and clear feedback (audio, visual or tactile) keeps the player engaged on the game and thus more concentrated.

Motivation provokes Concentration: According to Simpson et al. [1989], entertainment can be an idea or a task. But it is more likely to be one of the activities or events developed for the purpose of keeping an audience’s attention. Plot, character, meaning, dialog, music and spectacle are some of the attributes of presentation which are capable of holding an audience’s attention [Aristotle 1911]. These

attributes are designed to motivate the audient to watch hence concentration. Motivating players either intrinsically, by creating entertaining challenges, or extrinsically, by offering significant rewards, keeps players concentrated.

Curiosity / Mystery influences Motivation: The greatest motivation for learning is interest [Rousseau 1762]. Children are interested only for things that they consider useful and these things need to satisfy their interest now. Therefore, designers should motivate players, by creating entertaining challenges that can trigger players' curiosity and sense of discovery.

Repetition influences Motivation: The way tasks are repeated in a game can influence significantly players' motivation. E.g. repeating a task many times will become boring for players and will decrease their motivation. Repetition should be exercised in a practical way and with slight modification [Piaget 1964]. Repetition of a reaction to stimuli is considered an exercise and learning is achieved through several reactions to stimuli and not one. In combination with punishment, repetition is an effective way of influencing learning motivation.

3.2.2. Relationships without literature support

Apart from the relationships we were able to justify through the literature research, we also identified some additional relationships. Despite the fact that we couldn't find a relevant reference for them, we believe that these relationships exist and that they are important on constructing and structuring a GDD.

Table 2 below shows the unreferenced results of our research.

Source Element	Relationship	Destination Element	Cardinality
Stimulus	enhance	Curiosity/Mystery	0…5
Rule	define	Challenge	1…n
Readiness for Learning	influences	Meaning	
Readiness for Learning	influences	Challenge	
Goal	define	Level	1...n

Table 3: Relationships between elements that are not referenced

Since we were not able to justify these relationships through the literature review, we provide below a detailed explanation, along with an example, to show the ra-

tionale behind our choices.

Stimulus enhance Curiosity/Mystery: Audio, visual and tactile stimulation create a sense of curiosity on the players when the reason of the stimulus is not obvious. E.g. If players hear a sound that is intriguing but the source of the sound is not visible, or known, it is probable that they will be encouraged to discover where the sound came from, which enhances their curiosity and imparts an element of mystery.

Rule define Challenge: This is a two-way relationship. Rules, like physics rules or game rules, define how challenges are built. Seeing this relationship the other way, if designers want to design a challenge must adjust the rules associated with it. E.g. If gravity, as we know it, is part of the rules then the designer cannot design a challenge where the player will have to fly.

Rules limit the players' actions and describe how the game works [Salen et al.2004]. According to the three dimensions of gameplay [Ermi et al. 2005], one dimension is the challenge-based immersion, which is based on interaction and it includes the completion of goals and the acquirement of abilities. Rules define how the game works, which includes how to complete the goals and how to acquire abilities. Given all of the above, we can state that rules define challenge. In other words, a challenge has to be set first before the rules, which the designer wants to work alongside the challenge, are put into place. Bottom line, a challenge cannot function without rules.

Readiness for Learning influences Meaning: Readiness for learning, meaning the age and the level of knowledge of each player, influences not only the general idea but also the intellectual stimuli of the educational game. E.g. The intellectual stimuli of an educational game aimed at 6 year-old children will be significantly different from a similar game aimed at 14 year-old children.

Readiness for Learning influences Challenge: Equivalently, the way the challenges are designed, both in an intellectual and in a practical level, is influenced by the age and the prior knowledge of the players, whom these challenges are designed for.

Goal define Level: Each level requires from the players to complete certain goals, defined by the designer. A level can include one or more goals depending on its purpose. E.g. In an educational game about mathematics, a level about addition

can have as goals: 1. Answer correctly at least 10 questions, 2. Collect at least 100 coins, etc.

3.2.3. Correlations and Patterns among Elements

By identifying and modeling these relationships, we constructed several patterns. By patterns, we mean either correlations among multiple elements or a chain of dependencies that causes elements to be indirectly related, and thus influenced, by other elements.

Specifically, we noticed how elements are related indirectly between them. The two most important patterns were:

- Music and Spectacle stimulate the senses and enhance the Fantasy of a player. The stimulation of the senses and Fantasy influence Challenges. Therefore, the Audiovisual elements indirectly influence the impact of a Challenge and consequently they should be chosen carefully, by designers.
- Challenges define Goals. Goals define Levels. Therefore, Challenges indirectly define how appealing Levels are and how they should be designed.

Considering these patterns and the individual relationships, a conclusion is that the design of a level is influenced by the Audiovisual elements, the Rules and the Reward/Punishment system the game designer chooses to follow. It is a significant conclusion because it adds validity to the content of the literature and it also provides more specificity than the literature does, on design principles.

Identifying these patterns gave us an insight on how elements influence and are influenced by other elements. Such an insight can potentially be very helpful for educational game designers, because it reveals the greater picture of the design of an educational game.

3.3. Structure

After defining the elements of the conceptual model and the relationships between them, the final step before building the model was to decide how to group the elements into categories. This last step is implemented on the conceptual model either through defining an element as a subclass or as an attribute of another element.

Combining our research in the literature with several GDDs [*Estudo e Concepção De Jogos 2015*][Runaway Studios 2015][An Ants Lide 2015][*Game Design Document Template 2015*] helped us to identify where each element belong. Studying these GDDs gave us a broader idea on how different game elements co-exist in a game and along with the state-of-the-art on game design, it enabled us to group the elements into two categories and five subcategories. These categories and the subcategories that belong in each of them, along with the elements, are:

- Game Elements
  - ◊ Game Content Elements
    - > Plot
    - > Characters
    - > Music
    - > Spectacle
  - ◊ Game Design Elements
    - > Game Mechanics
    - > Goal
    - > Challenge
    - > Feedback
    - > Level
  - ◊ Game Attributes
    - > Fantasy

        - Curiosity/Mystery
        - Concentration
        - Stimulus
- Educational Game Elements
    - Learning Elements
        - Readiness for Learning
        - Motivation
        - Repetition
        - Stimulus
        - Reward/Punishment
    - Curriculum
        - Knowledge

3.4. Model

The model we developed was a combination of the research we did on GDDs, on education, on educational serious games and on the relationships formed between their elements. The visual representation of the model was done by using UML's class diagram because it offers connectivity between the elements and is simple and well documented. Additionally, class diagram provided an hierarchical structure, which was a key feature for visually distinguishing the different categories each element belongs in.

Below, we present some key components of the conceptual model and we describe the logic behind our choices. The complete conceptual model can be found on Appendix A.

3.4.1. Game

An educational game is a game explicitly designed with educational purposes [Wikipedia, January 2015], thus it has most of the characteristics a game has. Through our research, we came into the understanding that a game has three main types of elements (Figure 11). The game content elements, like the plot and the characters participating in the game, the game design elements, like the game mechanics and the different levels the game consists of, and the game attributes, meaning these elements that stimuli the different senses or provoke fantasy and/or concentration.

Our research also enabled us to identify the cardinality between a game and these types of elements. As indicated in Section 4.4, a game must have at least one of the elements that belong on the Game Content Elements category, in order to be able to capture people's attention. Additionally, a game must have at least one of the elements that belong on the Game Design Elements category, since these are the elements that define its inner structure and logic.

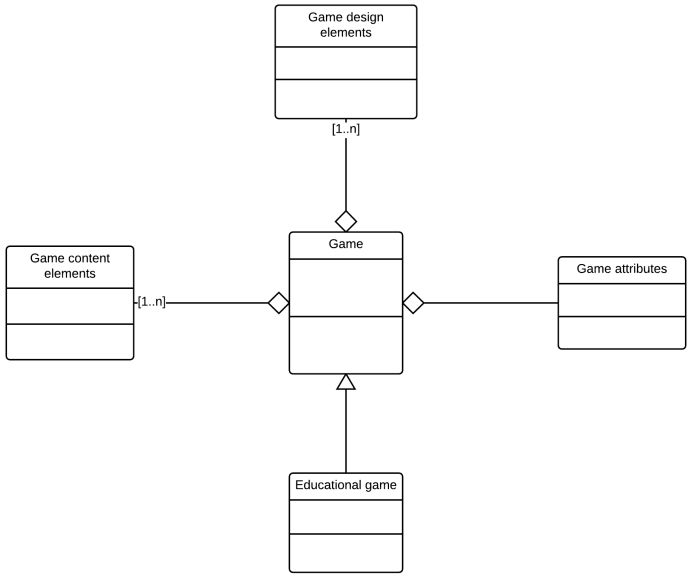


Figure 11: A game's subclasses

3.4.2. Educational Game

An educational game, besides incorporating most of the elements of games, it also has its own distinctive characteristics (Figure 12). An educational game's purpose is to provide learning by including in its core logic the curriculum of one or more

subjects, like mathematics, physics etc.

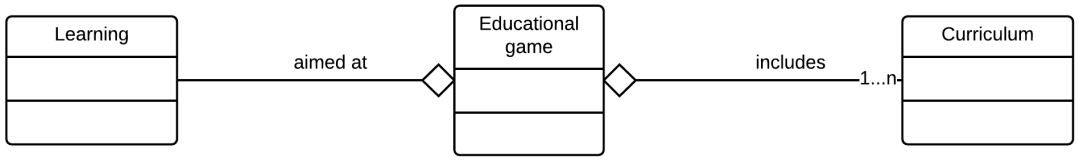


Figure 12: An educational game's subclasses

3.4.3. Levels

As indicated in section 4.5, researching the literature allowed us to identify four core game design elements. By additionally researching GDDs, we were able to distinguish one more element that is present in all games, the Levels. Levels, one way or another, are incorporated in every game. The way levels are structured depends on each game's logic, but usually some requirements should be met before entering a level. The only exception on when someone starts a game and thus enters the first level.

On an educational game, a level embodies not only some or all of the abovementioned game elements but also the "knowledge" element (Figure 13). According to our model, a level can have learning, testing or entertaining purpose. Depending on its purpose, it may require and/or deliver knowledge.

A learning level might requires a specific knowledge but it is certain that will deliver knowledge. A testing level is certain that it requires knowledge but it will not deliver knowledge. Finally, an entertaining level neither requires nor delivers any amount of knowledge.

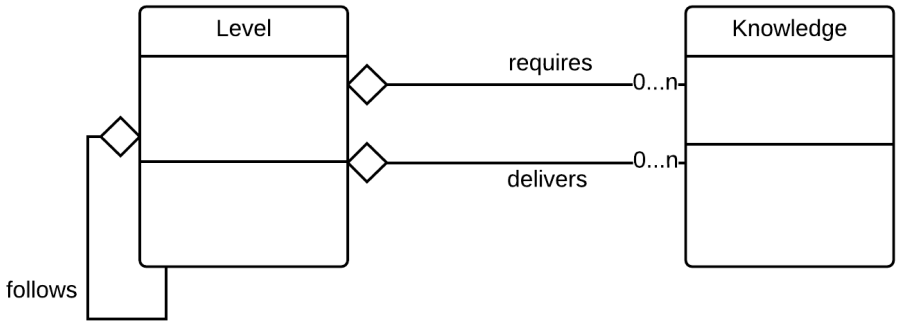


Figure 13: Level's connection with Knowledge

4. A Web-based Design Environment

In order to put the conceptual model, described in chapter 3, in practice, we design and develop a web-based, model-driven design environment for educational games.

But why use a web-based environment and not built an environment using also popular and even more powerful programming languages like C++ or Java? The answer to this question is the multiple advantages that derive from the use of web-based environments. Namely, these advantages are:

1. Accessible from everywhere and from multiple users.
2. Only requires a browser which makes it cost effective to develop. The application development is only for one operating system which eliminates various testing options and configuration issues which could be costly.
3. It is easy to customize web-based applications where updates of the application's look and feel are made easier. It is also possible to customize information as it is presented to different groups of people.
4. Web-based environments allow for the accessibility of application through a variety of devices as long as the device is connected to the internet.
5. In comparison to desktop environments, web-based environments make it possible to achieve greater levels of interoperability.
6. Installation as well as maintenance is less complicated since maintenance is mostly done through upgrading.
7. In a web-based environment, increasing the capacity of the processor helps with the adaptation of the increased workload.
8. During the deployment of a web-based application, security is ensured since it is done on dedicated servers.

From the above list, points 1, 3, 4 and 5 are the main reason we believe a web-based environment can help overcome the problems, we identified to be, related with game design documents. More specifically, the structure, which the conceptual model aims to provide, along with the fact that web-based applications can be

accessed from multiple users, from everywhere and from many different devices, are a strong indication that such an environment can enable:

- Game designers to built the game design document piece by piece and with structured menus, which can ensure a consistent development.
- Game designers to more easily and more frequently update the game design document.
- A game development team's members to instantly access all the relevant, to them, game information.

In the previous chapter, we presented the conceptual model. In this chapter, we analyze in detail the environment we developed. We describe the software architecture we adopted, the innovative features of the environment and finally, the key design decisions we made.

4.1. Technical Realization and Architecture

The environment we built is a web-based environment and its architecture is the Model-View-Controller software architectural pattern for implementing user interfaces. Below, we describe the rationale behind our choices and give some details regarding the actual implementation.

4.1.1. Web-based

The environment was developed using some of the most commonly used web programming languages. We used PHP for the backend, Javascript for the frontend and AJAX for the asynchronous interaction of users with the environment.

PHP

PHP (Hypertext preprocessor) is a scripting language on the backend or server side; it is therefore executed on the server. PHP is an open-source language hence widely used since it is free for download and use. It is powerful, deep and easy to use. In the creation of a PHP file, it is possible to include HTML, text, CSS,

PHP code and JavaScript. The PHP code execution happens on the server where only plain HTML is returned to the browser.

PHP allows for data encryption hence discretion is maintained. PHP has many capabilities such as data collection from forms, file manipulation fthe server, data modification in the database among other features. In addition to this, PHP runs on many different platforms and is compatible with most, if not all, server in application today. PHP was a viable choice because it supports many databases.

Javascript

JavaScript is a programming language for frontend development. It allows the scripts on the client side to interact with the application or game user. It allows browser control and asynchronous communication between the two. The main reason for using JavaScript is because one can submit data to the server through AJAX without the need to reload the page and it is possible to animate page elements as well as including interactive contents.

AJAX

AJAX is the acronym for asynchronous JavaScript and XML. They are techniques in web development that allow creation of asynchronous web applications in the client side. The main reason for using AJAX, in this scenario, is because through Ajax, it is possible to send and retrieve data from the server in the background without interrupting the functionality (both in display and behavior) of the displayed page, hence the designer can remain focused on building the game.

Image 14 and 15 show how we implemented AJAX on our environment to enable designers to quickly edit previously created objects.

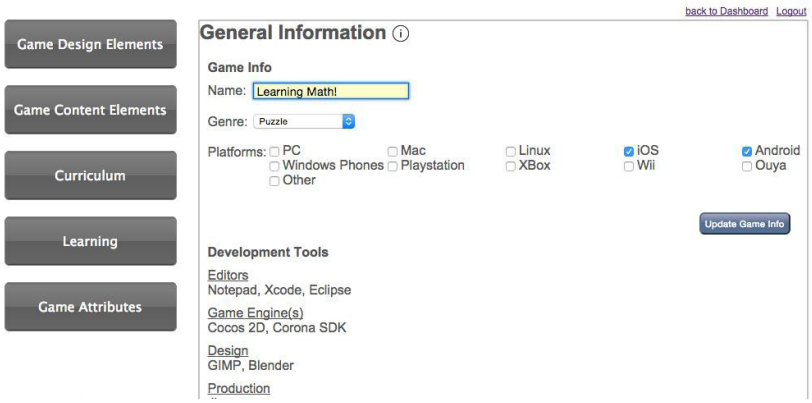


Figure 14: Using AJAX to change the name of the game without reloading.

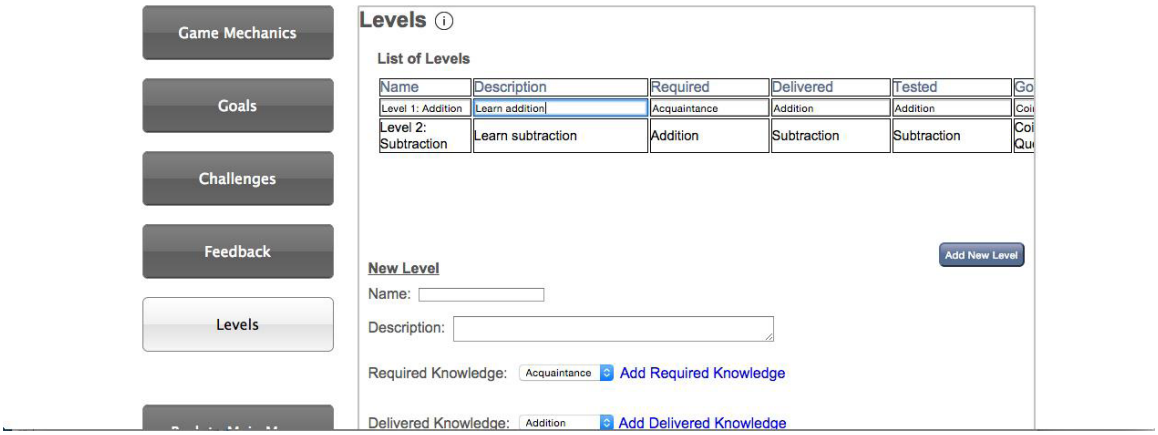


Figure 15: Using AJAX to edit the list of Levels without reloading

4.1.2. Model-View-Controller

The software architectural pattern that we used, in order to develop our environment, was the Model-View-Controller (MVC) pattern (Figure 16).

MVC is a design pattern which assigns the application's objects to either model, view or controller roles. The pattern provides a definition for the role the objects play in the provided application as well as the way of communication between the objects. The three roles are separated by abstract boundaries and communication

between the objects occurs across the boundaries.

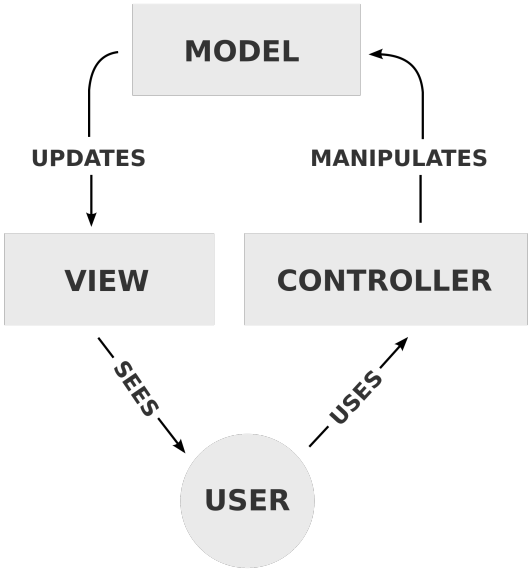


Figure 16: The Model - View - Controller (MVC) pattern

The Model object encapsulates an application's data that is specific to it and defines the computation and logic that processes and manipulates that data. On our environment, the Model object includes all the logic of our conceptual model, that we built, along with all the queries towards the database.

The View object is an application object that is visible to the user. In other words, it provides the user interface and all the interactivity between the user and the system. On our environment, the View object includes the frontend (HTML, CSS, Javascript, AJAX) and all the features that are described in section 4.2.

A Controller object takes the duty of an intermediary between application View objects, one or more, and its Model objects, which can also be one or more. In other words, the Controller updates the View when the Model changes or triggers changes on the Model upon a user's request.

Our environment has, like most of web applications have, a 3-tier architecture. A 3-tier architecture is a client-server architecture that incorporated three layers. The Presentation layer, with which the user interacts and in our case this includes the View and the Controller object, the Data Access layer, which is responsible for accessing and retrieving or altering data on the database, and the Business layer, which is the "glue" between the Presentation and the Data Access layer and in our case this includes the Model object. Figure 17 shows how the 3-tier architecture

co-exists with the Model-View-Controller pattern.

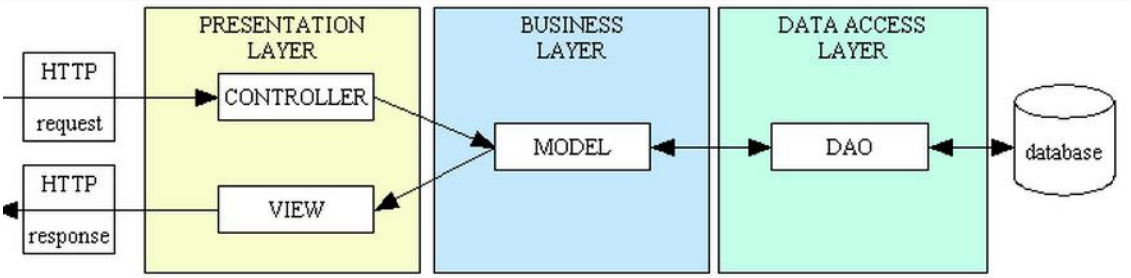


Figure 17: 3-tier architecture with MVC pattern

There are many reasons for using the MVC pattern; one is the tendency to increase the reusability of many objects in the applications and define the object's interfaces better. Applications utilizing MVC are easily extensible compared to other applications.

4.1.3. Environent's Logic

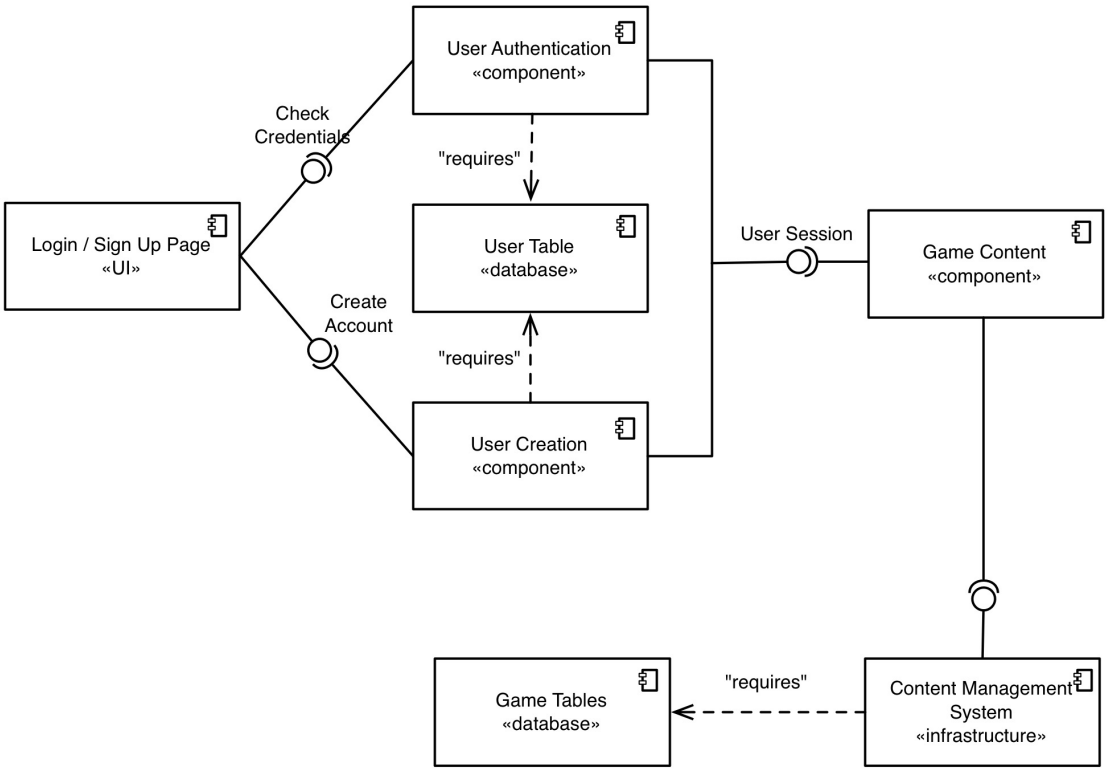


Figure 18: Component Diagram of our environment's architecture

In this section, we will get into more details regarding the logic of the environment we developed.

The first page users will encounter is the Login / Sign Up Page. Once they create a new account or login in their account and the user authentication is finished, they are redirected into the main part of the environment, the Content Management System (CMS). The CMS, by accessing the database, retrieves all the information relevant to the selected game and then users can view and edit the content of the game. Figure 18 shows the component diagram of our environment's architecture and the incorporated logic.

4.2. Innovative Features and Key Design Decisions

While the main structure of the environment was based on the conceptual model, there were several decisions we had to make regarding the design of the environment and specific features we wanted to implement.

We implemented innovative features that we believed would enable game designers to create GDDs faster and more structured. Additionally, we used several design patterns, especially regarding the user interface and consequently the user experience.

4.2.1. Innovative Features

The innovative features our environment has are:

- A semi-structured design environment. We wanted to take advantage of the fact that many game elements are common on all types of games but we also had in mind that game designers would want to have enough freedom to communicate the design. We therefore designed the environment in a semi-structured way, with the intention to be more flexible than fully structured environments and at the same time more rigorous than free text. An example can be seen on the image below, where designers can freely describe a level but the required, delivered and/or tested knowledge, along with the goals of the level, can be chosen from a predefined menu.

- Two features to link game objects, which are:
  - ◊ Hyperlinks. In many cases, wherever we implemented free text areas, designers can choose objects that they have already created, such as goals, challenges, character or even audio files, to either mention them on the text or link them with other objects from the database. An example can be seen on the Figure 19, where designers can choose the object they want to insert in the text. Additionally, the object is inserted as underlined text, in order to stand out from the rest of the text, and users can see all the details of the object, i.e. the description, by hovering the underlined word (Figure 20).

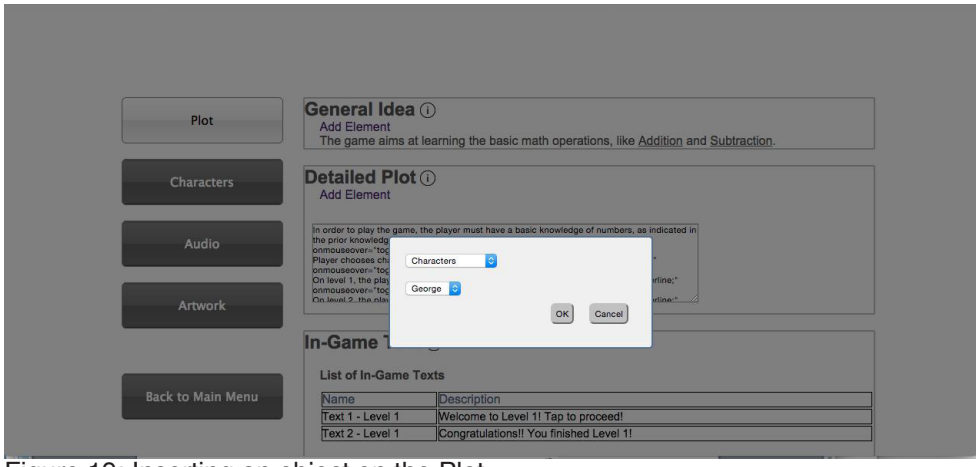


Figure 19: Inserting an object on the Plot

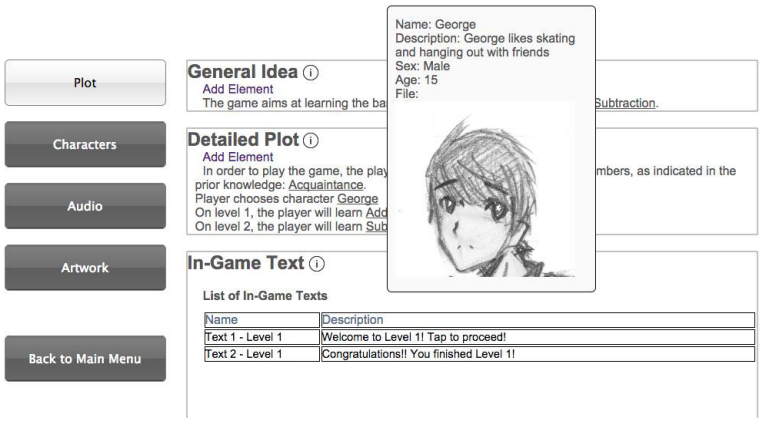


Figure 20: The pop-up windown when hovering an object

Hyperlinks are a feature that has been widely used for years on applications with multiple ways. Almost every application has icons that perform a specific action and hovering on these icons usually shows

you a hint of what this icon does. On the web, hyperlinks with hidden information are also very common and they are used on almost every website [Scott et al. 2009], and almost always hovering on them reveals additional information regarding this specific link.

The benefit of such a feature is that you can have immediately available any information regarding multiple objects, without filling the user interface with too much text and overwhelming the users.

◊ Dropdown Menus. The structure, that the conceptual model offered us and that we implemented on the environment, enabled us wherever it was applicable to provide dropdown menus. E.g. on Figure 21 (page of the Level), the required, delivered and tested knowledge and the goals, that are part of the level, can be chosen from the dropdown menu, which includes knowledge and goals that designers have previously created.

Another example, where the dropdown menus were utilized, was when we implemented the relationship between Challenges, Goals and Levels. Figure 22 shows how multiple Challenges can be included in a Goal, where designers can choose, from the dropdown menu, the Challenges that they have previously created. Similarly, Figure 21 shows how the created goals appear on the dropdown menu when creating a new Level.

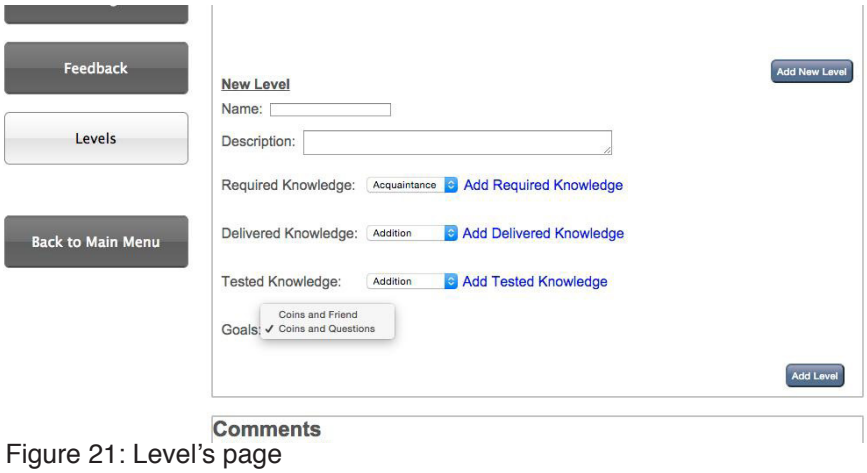


Figure 21: Level's page

The usage of dropdown menus can help game designers twofold. On the one hand they can only link objects that they have created and

thus eliminating the risk of inconsistency from non-existing elements. On the other hand, if designers make changes in an object, this linkage can prevent them from: a) inconsistencies between the initial linkage and the current state of the objects, and b) applying the changes to every place in the game design document, where they use the changed object.

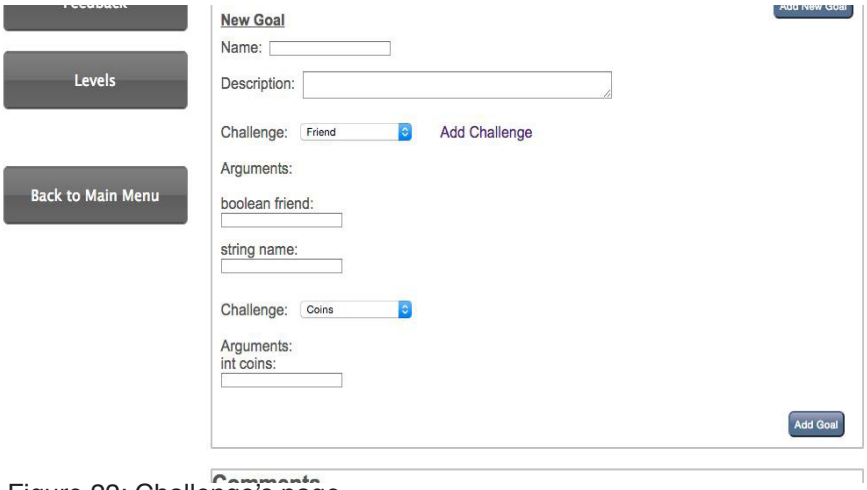


Figure 22: Challenge's page

4.2.2. Key Design Decisions

1. No predefined flow

   An important design decision, that came up while building the environment, was whether we should allow designers to document and/or design any part of the game at any given time, without any restrictions or we should force designers to follow a specific path while documenting and/or designing the game. For example, should designers be able to start designing a level before they design any challenge or the levels should be designed after challenges have been built?

   According to Meredith [2006], decision makers on a design process face the dilemma: too much structure may stifle the creative process, while too little structure provides inadequate support. Therefore, given that we had already introduced a relatively structured environment, we decided not to force designers to follow a specific sequence while designing their game. Hence, the overall design was based on that of a content management system, where users can navigate freely to whichever page they

want. The latter not only gives more freedom to designers but also offers a known, and thus more user-friendly, user interface.

2. Progress page and Export options

Since the environment allows designers to freely browse into different game elements and edit whichever they need at any given time, we wanted to also take precautions against the creation of a chaotic environment, on which designers would be lost during the creation of a big game. Therefore, we built a progress page, which designers can easily access and check the status of each element. For example, in one page they can see how many challenges they have created and how far they are from their target and at the same time also check the number of characters and the list of levels.

Since a game design document's purpose is to communicate the design of a game to all the stakeholders, it is important to communicate only the relevant information to each stakeholder. Therefore, we have partially implemented a feature that will allow designers to customize the exported document, depending on the stakeholder, for whom is intended for.

3. Usability guidelines

According to ISO definition, usability is the degree, to which specified users can use a product, in this case our environment, to achieve the specified goals with [ISO 9241-11]:

- ◊ Effectiveness, which is defined as the users' accuracy and completeness in achieving the set goals.
- ◊ Efficiency, which represents the resources used to complete goals.
- ◊ Satisfaction, which is defined as the users' attitude towards using the environment.

Our environment aims at helping game designers in the process of game creation and one of its main characteristics is that it is a web environment. Therefore, during its development, we followed several usability

guidelines, related to website development. Vaughan [2012] came up with a list of guidelines that web designers should implement, in order to improve the user experience of their website. Namely, these guidelines are:

1. Great first impression, which is achieved through attaining credibility, trust, professionalism and meeting the users' needs.
2. Consistency, where elements should remain consistent from one page to the next.
3. Usage of the right images in the process, since images transmit a subconscious message to the website's users. The wrong image transmits the wrong message.
4. Navigation system that is intuitive and solid.
5. Accessibility, which is the website's ability to accommodate all users, including the physically challenged, like blind people.
6. Limited use of animations and flash.

Vaughan [2012] also gives several advices for designing an intuitive website. Namely, these advices are:

◊ Proper use of colors, which can draw users' attention to specific elements.

◊ Minimized usage of animations, gadgets and media, except when it is needed to support content and information.

◊ Website navigation.

◊ Usage of white spaces and avoidance of clutter.

◊ Proper typography, which includes font family, font size and font color.

Sabina [2013] expands Vaughan's list of usability guidelines, by adding 5 more guidelines. Namely, these guidelines are:

1. Learnability, meaning how easy to use is the website, in that it does not require instruction for use. Learnability is also enhanced by con-

sistency.

2. Credibility, meaning trust issues.
3. Availability, meaning that the content of the website should be available when needed.
4. Clarity, which contributes to user friendliness by maintaining user concentration.
5. Relevancy, meaning that a website should provide the required information.

During the development of our environment, we considered several of these guidelines, especially the ones related to the core design of the environment, such as:

◊ Consistency. We utilized, wherever applicable, the terminology used in the literature and the game design documents, avoiding to introduce new terms. E.g. the utilisation of the words: Game Mechanics, Rules, Controllers and many others.

◊ Learnability. Not only the elements themselves, but also their categorization and sub-categorization, came from researching the literature and the game design documents, aiming at developing an intuitive, and thus more easy to learn and navigate, environment. E.g. the utilisation of the words: Game Design Elements, Curriculum etc.

◊ Clarity. We designed the prototype with as less distractions as possible, focusing on its essence, which is designing a tool to help overcome specific problems. Each page displays only the content of the element for which it is intended for and the menu provides a simple, yet effective way, to navigate into the different game elements.

◊ Relevancy. We kept the content of the environment strictly related to the conceptual model, ensuring that irrelevant information or elements will not distract designers from their process. In other words, the environment was structured based on the conceptual model and on how we defined the relationships between the elements.

5. Evaluation

In this chapter, we describe the process we followed to evaluate our environment and we also analyze the results. We consider the evaluation to be an important step towards further validating our environment and to extend our conceptual model. Since our environment is heavily based on the conceptual model, we previously built, we expect that, by evaluating the environment, we will also get feedback regarding the conceptual model.

The aim of the evaluation is to check the accuracy, and therefore the validity, of the conceptual model, the usability of our design decisions, the actual benefits of features like hyperlinks and dropdown menus and finally to give us an insight to what extend our environment and Web 2.0 technologies in general can help game development teams to overcome the inconsistency and the lack of updates on game design document and the problems associated with communication within serious game development team.

5.1. Methodology

The methodology we followed included interviews with experts in the area of serious games. As with every evaluation process, we had to come up with a plan and take several decisions with regards to the conducted interviews. Namely, these decisions were [Wohlin et al. 2012]:

5.1.1. The Interview Type

Interviews can be divided into [Robson 1993]:

- Unstructured interviews, which have open questions for discussion between the researcher and the interviewee and the interviewee might also suggest questions.
- Semi-structured interviews, which have a mixture of closed and open questions. And

- Fully structured interviews, which have closed question and the answers are usually limited.

We decided to conduct semi-structured interviews, meaning to utilize a questionnaire (Appendix B.1) within a semi-formal interview. The reasons for this decision are that a questionnaire, if properly used, can give structured and concrete results and at the same time a semi-formal interview can give more flexibility, which is required in an area such as game design, and increased validity [McLeod 2014]. The questions, in the questionnaire, have as a possible answer either Yes/No or a grade between 1 and 5, depending on the question. The exact explanation of each number in the scale is: 1: Not at all, 2: Slightly, 3: Enough, 4: Very much, 5: Extremely.

5.1.2. The Data Collection Technique

According to Lethbridge et al. [2005], data collection techniques can be divided into three levels:

- First degree, where the researcher is in direct contact with the subjects and collect data in real time. For example, a face-to-face interview.
- Second degree, where the researcher directly collects raw data without actually interacting with the subjects during the data collection. For example, utilizing our environment and then answering the questionnaire online.
- Third degree, where already available and sometimes compiled data is used.

We decided to conduct face-to-face interviews into subjects' working place, meaning the first degree of the data collection techniques. The reasons for this decision are a) the option to demonstrate the environment in detail and also give them the opportunity to experiment with it, after the presentation, b) the option to verbally explain aspects of the environment wherever the documentation was not sufficient, c) the visual observation of the interviewees, which could provide additional feedback regarding their interaction with the environment, and d) the informal comments of the interviewees regarding aspects of the environment that would not be possible through an online questionnaire.

5.1.3. The Selection of Subjects

The sampling of a population can be [Wohlin et al. 2012]:

- Probability Sampling, where the probability of selecting each subject is known.
- Non-probability Sampling, where the probability of selecting each subject is unknown.

We decided to use Non-probability Sampling and more specifically Convenience Sampling, aiming at interviewing subjects, who are experts in the area of serious game design. Moreover, we decided to interview experts from both the academic world and the commercial gaming market. The reason for this decision is that on the one hand, since this is a master thesis, we wanted to produce academically valid research. On the other hand, since as part of this thesis we developed an actual product, we also wanted to research its validity and its usefulness with market experts.

In total, we interviewed eight experts, from whom three are working on serious game companies and five are working in the academia. The subjects working in serious game companies are:

- Interviewee 1: Male, Game Designer Director of a serious game company located at Leeuwarden, The Netherlands
- Interviewee 2: Male, CEO of a serious game company located at Rotterdam, The Netherlands
- Interviewee 3: Male, Creative Director of a serious game company located at Amsterdam, The Netherlands

The subjects working in academia are:

- Interviewee 4: Male, Post-Doc Researcher on serious games at Delft, The Netherlands
- Interviewee 5: Female, Professor on serious games at Wageningen, The

Netherlands

- Interviewee 6: Male, Researcher on computer science at Utrecht, The Netherlands
- Interviewee 7: Male, Professor on serious games at Utrecht, The Netherlands
- Interviewee 8: Male, Lecturer on game design at Utrecht, The Netherlands

5.2. Results

The results we obtained from the individual interviews were generally positive. All the interviewees find the idea very interesting and the feedback we received from them, gave us an insight on how the academic and the commercial communities of games perceive the present and the future of game design.

The number of the interviewees does not allow us to make a statistically reliable generalization of the results. Nevertheless, given that the interviewees are not random persons and not even just professionals working on the game industry, but experts on the development of serious games, we believe that the results are a strong indication of how our environment can be adopted by academics and by professionals and can be potentially useful for the design of serious games and for further research.

Below, we analyze separately the results, for each question, we obtained from the market and the academic experts. The personal information of the interviewees', like name, position, company and their detailed answers on each question, can be found on appendix B.2.

5.2.1. The Commercial Point-of-View

From the commercial market of serious video games, we were able to interview three experts. All three found the idea very interesting and their feedback was positive. Compared to the academic experts' feedback, market experts gave us much more feedback regarding the user interface of the environment and regard-

ing functionalities that would facilitate the workflow of a serious game project.

In Table 4, we give a summary of the results. The first column indicates the question. The second column shows the average, wherever a question was answered to the scale of 1-5. The third and fourth columns show the amount of positive and negative answers respectively, wherever a question was answered with a 'Yes' or 'No'. Below, we also analyze the results for each question.

Question	Type	Answer
Are all elements present?	Yes/No	Yes = 3, No = 0
Non-predefined flow?	Yes/No	Yes= 2, No = 1
Easy to navigate?	1-5	2.33 (sd = 0.6)
Linking objects important?	1-5	5 (sd = 1)
Dropdown menu efficient?	Yes/No	Yes = 3, No = 0
Dropdown menu faster?	Yes/No	Yes = 3, No = 0
Hyperlink efficient?	Yes/No	Yes = 3, No = 0
Hyperlink faster?	Yes/No	Yes = 3, No = 0
Hyperlink good idea?	1-5	4.67 (sd = 0.58)
Consistency on our environment?	1-5	3.67 (sd = 0.58)
Consistency on web?	1-5	5 (sd = 0)
Updates on our environment?	1-5	3 (sd = 1)
Updates on web?	1-5	3.67 (sd = 1.53)
Communication on our environment?	1-5	3.67 (sd = 0.58)
Communication on web?	1-5	4.67 (sd = 0.58)

Table 4: Summarized results of market experts

Question 1: Are all the elements, both learning and entertaining, of educational games, which you know of, included in the environment?

All three interviewees answered 'Yes'.

Question 2.1: Do you prefer the non-predefined flow of the environment and why?

Two out of the three interviewees answered 'Yes'. Although, there comments show that their true preference lies somewhere in between. Interviewee 2 and 3, who answered 'Yes', indicated the need for the tool to warn designers when an object

is modified and it is linked to another object. Interviewee 1, who answered ‘No’, indicated that he wants the pre-defined flow to be defined by him for each project.

Question 2.2: How easy was to navigate through the pages and find each element?

This question was answered in the scale 1-5. The average was 2.3, a little bit higher than being ‘Slightly’, which was expected given the interviewees’ familiarity with commercial products, which have intuitive and fully functional user interface.

Question 3: To what extent is linking game objects in a GDD important?

This question was answered in the scale 1-5. The average was 5 (‘Extremely Important’), which confirmed our intuition that linking game elements is extremely important.

Questions 3.1.1 & 3.1.2: Do you find the idea of dropdown menus efficient for linking game objects between them? And do you think that dropdown menus provide a faster way for linking game objects between them compared to free text?

All interviewees find the dropdown menus an efficient, and also faster, tool to link game objects, compared to traditional text editors.

Questions 3.2.1, 3.2.2 & 3.2.3: Do you find the idea of hyperlinks efficient for linking game objects between them? Do you think that hyperlinks provide a faster way for linking game objects between them compared to a free text? And to what extent do you find useful the idea of hovering over a hyperlink and seeing all the information of this particular object?

Similarly as in questions 3.1.1 and 3.1.2, all interviewees find the hyperlinks an efficient, and also faster, tool to link game objects, compared to traditional text editors.

Question 3.2.3 was answered in the scale 1-5. The average was 4.67 (Between ‘Very Useful’ and ‘Extremely Useful’), which show the extreme usefulness on the hyperlink tool.

Questions 4.1.1 & 4.1.2: To what extent, do you believe that our environment helps get a consistent GDD? And to what extent, do you believe that Web 2.0 technologies help get a consistent GDD?

Both questions were answered in the scale 1-5. The average was 3.67 for question 4.1.1 (Between 'Helps Enough' and 'Helps Very Much') and 5 for question 4.1.2 ('Helps Extremely'), which show that our environment already can help designers to overcome consistency problems but there is room for improvement.

Questions 4.2.1 & 4.2.2: To what extent, do you believe that our environment helps on keeping the GDD updated? And to what extent, do you believe that Web 2.0 technologies help on keeping the GDD updated?

Both questions were answered in the scale 1-5. The average was 3 ('Helps Enough') for question 4.2.1 and 3.67 for question 4.2.2 (Between 'Helps Enough' and 'Helps Very Much'), which show that our environment already can help designers to keep GDDs updated but there is room for improvement.

Questions 4.3.1 & 4.3.2: To what extent, do you believe that our environment helps overcome problems associated with communication? And to what extent, do you believe that Web 2.0 technologies help overcome problems associated with communication?

Both questions were answered in the scale 1-5. The average was 3.67 for question 4.3.1 (Between 'Helps Enough' and 'Helps Very Much') and 4.67 for question 4.3.2 (Between 'Helps Very Much' and 'Helps Extremely'), which show that our environment already can help game design teams to communicate the design of a game better.

5.2.2. The Academic Point-of-View

From the academic world, we were able to interview five researchers in the area of serious games. Similarly to the interviewees from the game market, all academic

researchers found the idea very interesting and their feedback was positive.

In Table 5, we give a summary of the results the same way we did for the market experts. Below, we also analyze the results for each question.

Question	Type	Answer
Are all elements present?	Yes/No	Yes = 4, No = 1
Non-predefined flow?	Yes/No	Yes = 4, No = 1
Easy to navigate?	1-5	3.8 (sd = 0.8)
Linking objects important?	1-5	4 (sd = 1)
Dropdown menu efficient?	Yes/No	Yes = 5, No = 0
Dropdown menu faster?	Yes/No	Yes = 4, No = 1
Hyperlink efficient?	Yes/No	Yes = 5, No = 0
Hyperlink faster?	Yes/No	Yes = 4, No = 1
Hyperlink good idea?	1-5	4.8 (sd = 0.45)
Consistency on our environment?	1-5	3.4 (sd = 0.89)
Consistency on web?	1-5	4.2 (sd = 0.84)
Updates on our environment?	1-5	3.6 (sd = 1.14)
Updates on web?	1-5	4 (sd = 1.41)
Communication on our environment?	1-5	3.8 (sd = 0.45)
Communication on web?	1-5	4 (sd = 0)

Table 5: Summarized results from academic experts

Question 1: Are all the elements, both learning and entertaining, of educational games, which you know of, included in the environment?

Four out of the five interviewees answered ‘Yes’. The comment we got from Interviewee 8, who gave a negative answer, was that there is not a specific element missing but rather the fact that due to the numerous different game genres and game types, the possibilities are infinite.

Question 2.1: Do you prefer the non-predefined flow of the environment and why?

Four out of the five interviewees answered ‘Yes’. From the interviewees that answered ‘Yes’, interviewees 4 and 7 believed that it also depends on the design team and interviewee 5 that although the flow should not be forced, it would be

useful to suggest a specific flow. Interviewee 6, who answered 'No', also stated that the decision on whether the environment should be, or not, predefined does not actually affects the rest of the design procedures.

Question 2.2: How easy was to navigate through the pages and find each element?

This question was answered in the scale 1-5. The average was 3.8, a little bit lower than being 'Very Easy', which we consider a very good score, given that our environment is a prototype and it has much room for improvement, regarding its user interface.

Question 3: To what extent is linking game objects in a GDD important?

This question was answered in the scale 1-5. The average was 4 ('Very Important'), which confirmed our intuition on the importance of linking game elements.

Questions 3.1.1 & 3.1.2: Do you find the idea of dropdown menus efficient for linking game objects between them? And do you think that dropdown menus provide a faster way for linking game objects between them compared to free text?

All interviewees find the dropdown menus an efficient tool to link game objects and four of them find the dropdown menus also faster than traditional text editors. Interviewee 8's comment, who gave a negative answer, was that it is not speed the advantage of dropdown menus but rather consistency.

Questions 3.2.1, 3.2.2 & 3.2.3: Do you find the idea of hyperlinks efficient for linking game objects between them? Do you think that hyperlinks provide a faster way for linking game objects between them compared to a free text? And to what extent do you find useful the idea of hovering over a hyperlink and seeing all the information of this particular object?

Similarly as in questions 3.1.1 and 3.1.2, all interviewees find the hyperlinks an efficient tool to link game objects and four of them find the hyperlinks also faster than traditional text editors. Interviewee 8's comment, who gave a negative an-

swer, was that it is not speed the advantage of hyperlinks but rather consistency.

Question 3.2.3 was answered in the scale 1-5. The average was 4.8, which show the extreme usefulness of the hyperlink tool.

Questions 4.1.1 & 4.1.2: To what extent, do you believe that our environment helps get a consistent GDD? And to what extent, do you believe that Web 2.0 technologies help get a consistent GDD?

Both questions were answered in the scale 1-5. The average was 3.4 for question 4.1.1 (Between 'Helps Enough' and 'Helps Very Much') and 4.2 for question 4.1.2 (A bit more than 'Helps Very Much'), which show that our environment already can help designers to overcome consistency problems but there is room for improvement.

Questions 4.2.1 & 4.2.2: To what extent, do you believe that our environment helps on keeping the GDD updated? And to what extent, do you believe that Web 2.0 technologies help on keeping the GDD updated?

Both questions were answered in the scale 1-5. The average was 3.6 for question 4.2.1 (Between 'Helps Enough' and 'Helps Very Much') and 4 for question 4.2.2 ('Helps Very Much'), which show that our environment already can help designers to keep GDDs updated but there is room for improvement.

Questions 4.3.1 & 4.3.2: To what extent, do you believe that our environment helps overcome problems associated with communication? And to what extent, do you believe that Web 2.0 technologies help overcome problems associated with communication?

Both questions were answered in the scale 1-5. The average was 3.8 for question 4.3.1 (A bit less than 'Helps Very Much') and 4 for question 4.3.2 ('Helps Very Much'), which show that our environment already can help game design teams to communicate better and also that our environment's capabilities, regarding overcoming communication problems, are very close to the best possible result, which we considered to be the average of question 4.3.2.

5.2.3. Similarities and Differences between Experts

Although the number of subjects, we included on our evaluation, does not allow us to talk about similarities and differences with statistical significance, there are a few comment that we can make, when comparing the results between experts.

Table 6 shows the summarized results from the two expert categories.

Question	Market Experts	Academic Experts
Are all elements present?	Yes = 3, No = 0	Yes = 4, No = 1
Non-predefined flow?	Yes= 2, No = 1	Yes = 4, No = 1
Easy to navigate?	2.33 (sd = 0.6)	3.8 (sd = 0.8)
Linking objects important?	5 (sd = 1)	4 (sd = 1)
Dropdown menu efficient?	Yes = 3, No = 0	Yes = 5, No = 0
Dropdown menu faster?	Yes = 3, No = 0	Yes = 4, No = 1
Hyperlink efficient?	Yes = 3, No = 0	Yes = 5, No = 0
Hyperlink faster?	Yes = 3, No = 0	Yes = 4, No = 1
Hyperlink good idea?	4.67 (sd = 0.58)	4.8 (sd = 0.45)
Consistency on our environment?	3.67 (sd = 0.58)	3.4 (sd = 0.89)
Consistency on web?	5 (sd = 0)	4.2 (sd = 0.84)
Updates on our environment?	3 (sd = 1)	3.6 (sd = 1.14)
Updates on web?	3.67 (sd = 1.53)	4 (sd = 1.41)
Communication on our environment?	3.67 (sd = 0.58)	3.8 (sd = 0.45)
Communication on web?	4.67 (sd = 0.58)	4 (sd = 0)

Table 6: Summarized results of both expert categories

One observation, regarding the results, is that the difference on the averages, between the two expert categories, on the question about the easiness of navigating through the environment (Question 2.2), appears to be notable (2.33 for the market experts and 3.8 for the academic experts). Another observation is that in all the questions regarding the extent to which our environment and web 2.0 technologies in general, help overcome problems associated with game design document, the difference, in the average, between our environment and web 2.0 technologies, is greater on the market expert than in the academic experts (1.33 for the market experts and 0.8 for the academic experts for the consistency, 0.67 for the market experts and 0.4 for the academic experts for the updates and 1 for the market ex-

perts and 0.2 for the academic experts for the communication).

5.3. Conclusion of the Evaluation

In this chapter, we presented the evaluation we conducted regarding our environment. Despite the fact that due to the small number of interviewees, the results of the evaluation can not be considered statistically significant, both the conceptual model and the environment were considered a very good idea with much potentials.

Experts from both categories find that linking game objects is an important step, while developing games. Therefore, an environment, like ours, which can provide structure and facilitate the linkage of game objects can be of great help.

Another important finding, from the interviews, is that there is not a game-specific tool that can help game designers with documenting a game, which indicate that there are potential for an environment like ours.

Finally, we noticed how market experts perceive issues like user experience and user interface friendliness almost as important as the actual functionality of the environment, opening a whole new area for us to explore and improve.

Most of the results were, more or less, expected, including the difference, in some questions, between market and academic experts. Moreover, the feedback we got from these two categories of experts gave us an insight on the future work that can be done in all aspects of our research.

6. Conclusion

In this final chapter, we discuss our research's overall contribution in the design of serious games. We also present several aspects of our study that could benefit from future research.

In this thesis, we built a conceptual model, which was based on extensive literature review and on the study of several game design documents. Moreover, we developed an online environment, based on the conceptual model, with the aim to:

1. Further test the validity of the model. During the interviews, which we presented in chapter 5, all interviewees interacted with the environment and answered the questionnaire. This step was the second test towards the validation of the model, with the first test being the usage of literature to built the conceptual model.

2. Explore the potentials of such an environment, as a serious game design tool. Some of the interviewees were professionals working in the serious game development industry. The feedback we got from them, apart from helping us answer the research question of our project, it also gave us an insight to the needs of this particular industry.

The results from the evaluation that we conducted showed that:

1. The conceptual model, although it might require some more thought regarding the categorization and sub-categorization of the game elements, appears to be complete and due to the fact that it is low level, it can be customized to fit the specific needs of a game and/or a development team.

2. The environment, despite being in a prototype stage, has the potentials, once the improvements indicated in section 6.2 are implemented, to help serious game development teams overcome the problems associated with game design documents.

6.1. Answers to the Research Questions

In section 1.4, we stated our main research question and six research subquestions and our goal was to answer them, throughout this thesis. Although our findings can be enhanced and improved by further researching this domain and by conducting an evaluation with more subjects, we were able to tackle all questions.

Below, we briefly present our findings regarding main research question and each of the six research subquestions.

Research Question: How can GDDs for educational games be structured, in order to be an effective and efficient tool for game design?

The conceptual model, which we built based on the research we conducted in chapters 2 and 3, served as the basis for developing an online environment, which we described in chapter 4 and presented its evaluation in chapter 5. The evaluation indicated that our environment, and consequently our conceptual model, can help overcome problems associated with GDDs and be an effective and efficient tool for educational game design.

This environment is just one way, in which the conceptual model can be translated into an actual game design tool. Given the advantages of conceptual models, as described in section 3.1, someone can develop a different environment, in terms of programming language, depending on his or her needs.

Research Subquestion 1: What are the factors that affect the effectiveness and efficiency of GDD based educational game design?

In section 1.4, based on several different research papers and books, we identified these factors to be:

- Consistency of the game design document
- Condition of the game design document, in terms of updates
- The heterogeneous users that a game development team has, like programmers and artists

- Communication of the game development team

Although our research cannot ensure that these are the only factors that determine the effectiveness and efficiency of GDD based educational game design, they are the ones that were identified by researchers to be the most influencial.

Research Subquestion 2: What are the factors that inhibit the effectiveness and efficiency of GDD based educational game design?

In section 1.4, based on several different research papers and books, we identified these factors to be:

- Inconsistency of the game design document
- Outdated game design documents
- Oral communication, which can result in lost communication
- Multiple communication channels, which can results in lost communication or in communication overload

Same as in research subquestion 1, our research cannot ensure that these are the only factors that inhibit the effectiveness and efficiency of GDD based educational game design, but they are the ones that were identified by researchers to be the most common.

Research Subquestion 3: Which are the elements of educational games that can be identified in the literature?

In chapter 2, we identified several elements of educational games spanning in areas like learning, game design and entertainment. The most important findings of our research were a) since an educational game is a category of games, then ir should incorporate game elements related to games in general, like Plot, Game Mechanics, Levels etc., b) since the purpose of an educational game is not mere entertainment, it should also incorporate a curriculum.

Research Subquestion 4: To what extent do existing state-of-the-art approaches support effective and efficient GDD based educational game design?

In section 2.4, we researched several entertaining, serious and educational game design approaches but we were not able to find a research that explores the effectiveness and efficiency of GDD based educational game development. Several researchers proposed frameworks aiming at helping game designers but none of them was GDD based.

Research Subquestion 5: What is a conceptual model that supports the effective and efficient GDD based educational game development?

In chapter 3, we presented an additional literature review, based on the elements we identified in chapter 2. Combining the research from both chapters allowed us to categorise each educational game element, which led us in building a unified conceptual model.

Research Subquestion 6: To what extent does the application of current technologies, like modern web 2.0 programming languages, help overcome problems associated with GDDs?

The results from the evaluation, in chapter 5, although does not allow us to make generalized conclusions, show that experts from both the game market and the academia believe that web 2.0 technologies can help overcome problems associated with GDDs. A future evaluation with more experts could potentially allow to have more statistically solid results.

6.2. Discussion

In chapter two, we presented several frameworks, which intend at helping serious game designers in different ways. Most of them were high level and without an actual environment to support them. The only framework with an environment was LEGADEE. Compared to LEGADEE, our approach is different with regards to several factors. Firstly, we developed our environment using modern web technologies, which allow cross-platform and cross-device compatibility and which also

enable us to implement some innovative features, such as linking objects from the database along with free text. Secondly, we focused on how game designers can communicate their creation to not-like-minded people, like programmers, instead of creating a collaborative tool. Lastly, the conceptual model we developed, on which the environment we built was based, was more focused on the game components that are part of educational games.

Additionally, our approach, compared to the frameworks we presented, is more focused in helping serious game designers overcoming problems associated with game design documents.

6.3. Future Work

Due to the broad nature of serious and educational games, our research was focused on several areas, like education, game design etc. Additionally, we developed a prototype environment based on the conceptual model we built. Each of these aspects of our research can be benefited from further investigation. We identified three major aspects, where there is ground for further research. Namely, these aspects are:

1. The Conceptual Model. Further research can identify any missing core element of educational games and also more intuitively re-group them. Since the conceptual model is the basis of our environment, as indicated in chapter 4 where we explicitly say that the conceptual model is the Model object of the Model-View-Controller pattern that we followed, any improvement on the conceptual model can be also translated as improvement on the environment.

2. The Environment's User Interface & Frontend Features. The environment's user interface is in a prototype stage, which was enough for conducting our evaluation, but is not enough for further evaluating the environment and research its potentials as a serious game design tool. Therefore, many improvements can be done on the frontend of the environment, including the ability to host multiple users, which will allow for an evaluation in a development team, as well as follow all the usability guidelines, mentioned in section 4.2.2.

3. Case Studies for further validation. Bringing the environment to a fully functional state, can enable us to further validate it, by conducting one or more case studies, where our environment can be part of a serious game development team's workflow. Such a case study would be of extreme importance to identify whether and how our environment can help serious game designers in the real world.

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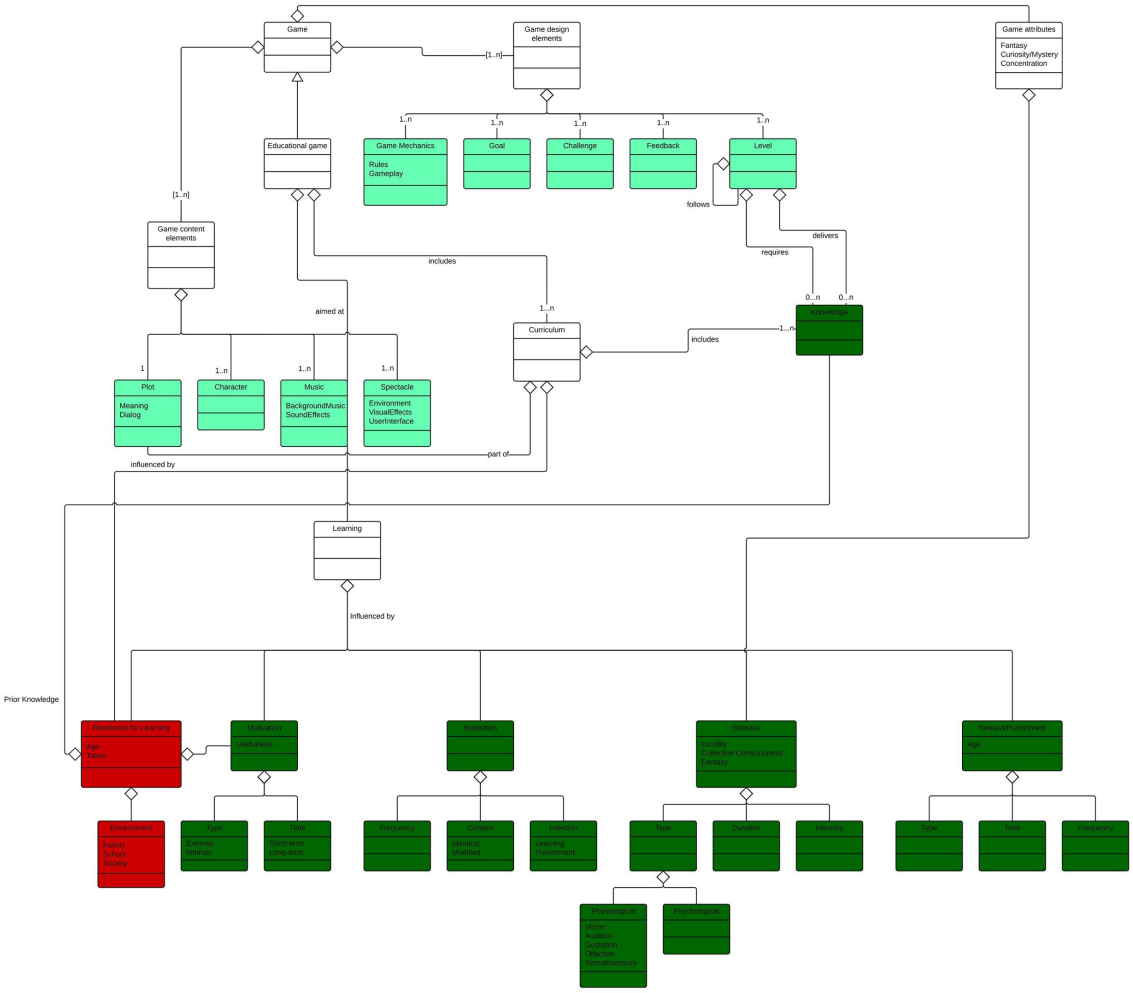
Appendix A - The Conceptual Model



Game Elements that the designer can tweak

Educational Game Elements that the designer can not tweak

Educational Game Elements that the designer can tweak

Appendix B - The Evaluation

B.1. Questionnaire

1. Game Elements

Are all the elements, both learning and entertaining, of educational games, which you know of, included in the environment?

Yes No

If not, which elements are not there?

2. Design Flow

2.1. The environment does not force designers to follow a specific flow when designing a game. Instead, it is designed in order to offer flexibility and let designers choose which part of the game they want to design at each given time.

Do you prefer the non-predefined flow of the environment, like text editors such as Word offer, and why?

Yes No

Comments:

2.2. The environment is currently in the prototype phase, but the main structure will not change. By structure, we mean the way the elements/pages are grouped into categories.

How easy was to navigate through the pages and find each element?

1. Not easy at all
2. Slightly easy
3. Easy enough but there is room for improvement
4. Very easy

5. As easy as it can be

Comments:

3. Linking Objects

In a game, game objects, e.g. characters, are linked between them. Therefore, we find important to provide a way for the designers to link game objects between them.

To what extent is linking game objects in a GDD important?

1. Not important at all
2. Slightly important
3. Important enough
4. Very important
5. Extremely important

Comments:

3.1. Dropdown Menu

Note: Dropdown menus can be found on pages like Level or Goals, where designers can choose to link the element that they currently design (e.g. a Level) with elements that they have already designed and that are related with the current element (e.g. Goals are related with Levels).

3.1.1. Do you find the idea of dropdown menus efficient for linking game objects between them?

Yes No

Comments:

3.1.2. Do you think that dropdown menus provide a faster way for linking game

objects between them compared to a free text alternative, like Microsoft Word?

Yes No

Comments:

3.2. Hyperlinks

Note: The hyperlink feature is still under construction, in the current version it lacks some features and you might experience some bugs. The thought is to be able to see all the information of the underlined object when you mouseover it. E.g. if you have inserted a character, when you mouseover on the name of the character, you will see the age, sex and image of the character.

3.2.1. Do you find the idea of hyperlinks efficient for linking game objects between them?

Yes No

Comments:

3.2.2. Do you think that hyperlinks provide a faster way for linking game objects between them compared to a free text alternative, like Microsoft Word?

Yes No

Comments:

3.2.3. To what extent do you find useful the idea of hovering over a hyperlink and seeing all the information of this particular object?

1. Not useful at all
2. Slightly useful
3. Useful enough
4. Very useful

5. Extremely useful

Comments:

4. Research Questions

4.1. Consistency

An inconsistent GDD means that similar tasks are documented in a different way. For example, a GDD is inconsistent, in most of the cases, when two or more game designers edit it and each of them uses there own personal style and terminology.

4.1.1. To what extent, do you believe that our environment helps get a consistent GDD?

1. Does not help
2. Slightly helps
3. Helps enough
4. Helps very much
5. Helps extremely

Comments:

4.1.2. To what extent, do you believe that Web 2.0 technologies help get a consistent GDD?

1. 1: Do not help
2. 2: Slightly help
3. 3: Help enough
4. 4: Help very much
5. 5: Help extremely

Comments:

4.2. Updates

An outdated GDD means that some or all changes on the design are not passed on the GDD, leading in a difference between the GDD and the actual design of the game. For example, a GDD is outdated, in many cases, when a company has adopted an agile methodology for developing games and the constant changes on the design are not immediately documented.

4.2.1. To what extent, do you believe that our environment helps on keeping the GDD updated?

1. Does not help
2. Slightly helps
3. Helps enough
4. Helps very much
5. Helps extremely

Comments:

4.2.2. To what extent, do you believe that Web 2.0 technologies help on keeping the GDD updated?

1. Do not help
2. Slightly help
3. Help enough
4. Help very much
5. Help extremely

Comments:

4.3. Communication

Low quality of communication on a game development team means that due to either miscommunication or the existence of multiple communication channels, a

significant amount of information is lost, misunderstood or forgotten. For example, communicating the design of a game by using emails, Skype, oral conversation etc. can lead to lost information and/or communication overload.

4.3.1. To what extent, do you believe that our environment helps overcome problems associated with communication?

1. Does not help
2. Slightly helps
3. Helps enough
4. Helps very much
5. Helps extremely

Comments:

4.3.2. To what extent, do you believe that Web 2.0 technologies help overcome problems associated with communication?

1. Do not help
2. Slightly help
3. Help enough
4. Help very much
5. Help extremely

Comments:

B.2. Interviews

A Commercial Point-of-View

Person: Interviewee 1, Male

Position: Game Designer Director

Answers

Question 1: Yes

Question 2.1: No (Comment: I want to be predefined but by me)

Question 2.2: 3 (Comment: I want to dynamically define the structure of each project)

Question 3: 5 (Comment: Always link content when possible)

Question 3.1.1: Yes

Question 3.1.2: Yes

Question 3.2.1: Yes

Question 3.2.2: Yes

Question 3.2.3: 5 (Comment: a. Explore also other ways to link objects, b. For the hyperlinks give the option to click on the link and redirected on the object's page)

Question 4.1.1: 4 (Comment: Can go to 5 if feedback is implemented)

Question 4.1.2: 5

Question 4.2.1: 2

Question 4.2.2: 2

Question 4.3.1: 4 (Comment: Give the option of customizing the export document, depending on the stakeholder, i.e. programmer, artist, investor etc.)

Question 4.3.2: 5

General Comments: Minor improvements regarding the User Interface, Give the option of documenting the requirements.

Person: Interviewee 2, Male

Position: CEO

Answers

Question 1: Yes

Question 2.1: Yes (Comment: But give a notification when you change an element that is related to another element)

Question 2.2: 2 (Comment: Simplify the structure, possible by having a more visualized environment)

Question 3: 5

Question 3.1.1: Yes

Question 3.1.2: Yes

Question 3.2.1: Yes

Question 3.2.2: Yes

Question 3.2.3: 4

Question 4.1.1: 4 (Comment: Can help even more if it can be used as a decision tool, after proper modifications)

Question 4.1.2: 5

Question 4.2.1: 3

Question 4.2.2: 4

Question 4.3.1: 4

Question 4.3.2: 4

General Comments: Link game mechanics with learning objectives, meaning the list of knowledge on the Curriculum page.

Person: Interviewee 3, Male

Position: Creative Director

Answers

Question 1: Yes

Question 2.1: Yes (Comment: But give a notification when you change an element that is related to another element. And use templates depending on the game genre/type.)

Question 2.2: 2 (Comment: Simplify the structure, possible by having a more visualized environment)

Question 3: 5

Question 3.1.1: Yes

Question 3.1.2: Yes

Question 3.2.1: Yes

Question 3.2.2: Yes

Question 3.2.3: 5

Question 4.1.1: 3 (Comment: Can help even more if it can be used as a decision tool, after proper modifications)

Question 4.1.2: 5

Question 4.2.1: 4

Question 4.2.2: 5

Question 4.3.1: 3

Question 4.3.2: 5

General Comments: Link game mechanics with learning objectives, meaning the list of knowledge on the Curriculum page. The environment has to have more Product/Project Management capabilities, which can help to improved consistency.

An Academic Point-of-View

Person: Interviewee 4, Male

Position: Post-Doc Researcher on Serious Games

Answers

Question 1: Yes

Question 2.1: Yes (Comment: But depends on the game)

Question 2.2: 5

Question 3: 3

Question 3.1.1: Yes

Question 3.1.2: Yes

Question 3.2.1: Yes

Question 3.2.2: Yes

Question 3.2.3: 4

Question 4.1.1: 3

Question 4.1.2: 4

Question 4.2.1: 3 (Comment: Potential it can be connected with a Version Control system)

Question 4.2.2: 3

Question 4.3.1: 3 (Comment: Oral communication is always important to communicate and understand several design decisions)

Question 4.3.2: 4

General Comments: On the Plot page, there should be included a field, where the designer can describe the theme that his/her game might have, which is different than the scenario.

Person: Interviewee 5, Female

Position: Researcher on Serious Games

Answers

Question 1: Yes

Question 2.1: Yes (Comment: Show a prefered order but not force)

Question 2.2: 3

Question 3: 5

Question 3.1.1: Yes

Question 3.1.2: Yes

Question 3.2.1: Yes

Question 3.2.2: Yes

Question 3.2.3: 5

Question 4.1.1: 4

Question 4.1.2: 5

Question 4.2.1: 4

Question 4.2.2: 5

Question 4.3.1: 4 (Comment: Conflicts within a game development team cannot be communicated through the environment)

Question 4.3.2: 4

General Comments: There is a need for an overview page where the designer could have a general overview of the design.

Person: Interviewee 6, Male

Position: Researcher in Computer Science

Answers

Question 1: Yes

Question 2.1: No (Comment: But it does not affects a lot the design procedures)

Question 2.2: 3 (Comment: It would be intuitive to have a visible tree structure that would show you where you are)

Question 3: 5

Question 3.1.1: Yes

Question 3.1.2: Yes (Comment: But a more visual environment would be even better)

Question 3.2.1: Yes

Question 3.2.2: Yes

Question 3.2.3: 5

Question 4.1.1: 4 (Comment: Also a visualized overview)

Question 4.1.2: 5

Question 4.2.1: 4

Question 4.2.2: 5

Question 4.3.1: 4

Question 4.3.2: 4

Person: Interviewee 7, Male

Position: Professor in Serious Games

Answers

Question 1: Yes

Question 2.1: Yes (Comment: But it depends on the design team's composition. You can also have a template to guide, as a hint mechanism)

Question 2.2: 4

Question 3: 5 (Comment: More detail in connecting game components)

Question 3.1.1: Yes

Question 3.1.2: Yes

Question 3.2.1: Yes

Question 3.2.2: Yes

Question 3.2.3: 5

Question 4.1.1: 4 (Comment: It can also be considered as a dictionary of elements)

Question 4.1.2: 4

Question 4.2.1: 5

Question 4.2.2: 5

Question 4.3.1: 4

Question 4.3.2: 4 (Comment: But depends heavily on the team)

Person: Interviewee 8, Male

Position: Lecturer on Game Design

Answers

Question 1: No (Comment: There is not a specific element that is missing but rather the fact that due to the many different game genres and game types, the possibilities are infinite)

Question 2.1: Yes

Question 2.2: 4

Question 3: 5

Question 3.1.1: Yes (Comment: But also depends on the size of the game)

Question 3.1.2: No (Comment: It is not about speed but consistency)

Question 3.2.1: Yes

Question 3.2.2: No (Comment: It is not about speed but consistency)

Question 3.2.3: 5

Question 4.1.1: 2

Question 4.1.2: 3

Question 4.2.1: 2

Question 4.2.2: 2

Question 4.3.1: 4

Question 4.3.2: 4

General Comments: Incorporation of an algorithm that will be able to spot inconsistencies.