Identification of Design Patterns for Serious Games in an Educational Videogame Designed to Create Awareness on Dengue and Malaria Fever

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Abstract. An educational videogame may sound like the perfect solution to combine an educational process with a fun experience. Even though this holds true in some cases, most of the times educational games do not guarantee positive results in the cognitive development of the player. This is because they are designed to contain educational-related topics but do not focus on the real impact that is achieved on the player. In this paper, we identify different design patterns in the educational videogame "Pueblo Pitanga: Enemigos Silenciosos" and we share the results of applying these patterns and the impact the players. This videogame was designed to create awareness on Dengue and Malaria fever in young kids and teenagers. It was designed and developed by Green Lava Studios for the Pan American Health Organization (PAHO).

Keywords: Dengue · Malaria · Design patterns · Educational videogames · Serious games

1   Introduction: Creating Fun and Educational Experiences

Nowadays, videogames are part of everyday's life activities in popular culture. They are available in personal computers, mobile devices and specific gaming consoles (e.g.: PlayStation 4, Nintendo 3DS, etc.). These products are getting more popular in current generations, as they have become a basic product of consumption [1]. Younger generations, like Generation X and Y, grew up with these technologies, making these technologies a natural and straightforward environment of virtual interaction for them. Videogames have an important role as entertainment resources for these generations. Through a videogame a player can get involved in decision making processes. This very important characteristic allows the player to learn from a good or bad decision, which enables the player to go through the natural process of learning, as a result of previous actions.

Educational games, also known as Serious Games, are known for being used for purposes outside simple entertainment, e.g.: advertising, military training, social studies, science learning, etc. Serious Games have the potential to adapt the decision making requirements in order to teach a specific topic to a player. For the aforementioned reasons, an educational videogame may appear as the perfect way to educate younger

generations. Even though this holds true in some cases, most of the times educational games do not guarantee positive results in the cognitive development of the player. This is because they are designed to contain educational-related topics but do not focus on achieving a real impact on the player. Moreover, there is a lack of assessment tools to analyze serious games and there is insufficient knowledge on their impact on players [2]. According to Huynh-Kim-Bang et al. [3], a way to achieve positive learning results from an education game is by using appropriate design patterns for educational games. The different design patterns that were considered in this paper are described in Sect. 2.

The **main objective of this paper** is to identify the design patterns that were applied in the educational videogame **"Pueblo Pitanga: Enemigos Silenciosos"** and to analyze if positive learning results were achieved in the players after playing the game. The videogame is an action/adventure platformer game. It was designed to create awareness, in young kids and teenagers, of vector-borne diseases like dengue fever, malaria, and diarrhea. Using a dynamic dialog system inspired by "The Secret of Monkey Island" by LucasArts, the game tells the story of a boy named Fabio. The developers used an approach similar to MDA (Mechanics, Dynamis, Aesthetics). MDA is a formal approach to understanding games that attempts to bridge the gap between game design and development, game criticism, and game research [4], (see example in Sect. 3.2.1).

Plot of "Pueblo Pitanga: Enemigos Silenciosos": Fabio, the main character, finds out that his sister Luisa is in the hospital because of a mysterious illness. Now he must find out all about this disease. As Fabio starts his journey many other residents of Pueblo Pitanga also start getting sick; however, this time they are showing different symptoms to those that Luisa had. During the journey, Fabio and a group of friends will identify different diseases and will recognize the poor hygiene conditions in the town, all while learning how to solve these problems. In the end, the problems are solved thanks to the joint effort of all the neighbors, the government, private entities and schools. The main goal is to teach the players how to maintain a town free of pest breeding grounds. In order to do this, Fabio, with help of the town's community, learns the process of eliminating mosquito hatcheries in a proper way.

Outline of this Paper: This paper is outlined as follows. Section 1 presents the introduction, Sect. 2 summarizes the work developed by Mitgutsch et al. [3], from which the design patterns for educational games that are applied in this paper were obtained. Section 3 identifies the specific design patterns that were applied in the game "Pueblo Pitanga: Enemigos Silenciosos" through concrete examples of the game. Section 4 presents results about the impact of the game in the learning process of the users and their cognitive development in the topic. Section 5 presents the conclusions of the paper.

2   Design Patterns

An educational system must be able to successfully implement a learning process in order to teach and transmit knowledge to the user. Serious Games need to include such a learning process during the gameplay time in order to successfully teach the specified

topic to the player. A way to implement this is by using the design patterns for educational games identified by the authors of the paper "Design Patterns in Serious Games: A Blue Print for Combining Fun and Learning" [3].

Design patterns allow a more effective design of an educational game. In the work of Mitgutsch et al., design patterns were identified using an empirical method to understand the difference in patterns used in videogames and serious games [3]. The authors identified and classified common methods to create fun and educational fun environments. They identified which elements were ludic (playful) and which conducted to the learning process.

The design patterns were arranged in six main categories and they were organized by the level of abstraction: **Context, Learning Agents** and **Fun Aspects**. In Table 1, the six categories are represented with letters A, B, C, D, E and F, each category is subclassified in design patterns (each bullet point is a design pattern). These patterns should be applied during the game design.

Table 1. Pattern classification, as proposed in [3]. The patterns that were identified in the game analyzed in this paper are underlined.

CONTEXT	LEARNING ASPECTS
A- When do you need to combine entertainment and learning?	**B- How to make interaction instructive?**

• Serious Games
   o Game-based Learning Blend
	• Instructive Gameplay
	   o Questions-Answers
	   o Pavlovian Interaction
	   o In-Situ Interaction
	   o Microworld Interaction
	   o Social educative Interaction
	   o Teachable Agents
	   o Varied Serious Gameplay
	• New Perspectives
	• Rapid Feedback

FUN ASPECTS	**C- How to initiate the reflective process?**

E- How to motivate users?	• Time for Action / Time for Thought
	   o Debriefing
	   o Reified Knowledge
	• Advanced Indicators

• Fun Reward
   o Serious Boss
   o Graduating Ceremony
   o Object Collection
   o Local Competition
   o Protégé Effect
   o External Competence Validator
• Fun Context
   o Fantasy World
   o Comic relief
   o Serendipity
   o Narrative Structure
	D- How to convey information without disturbing game immersion?

F- How to help users advance in the game	• Hollywoodian Introduction • Museums • Informative Loading Screen • On the grapevine
• Smooth Learning Curve o Tutorials • Pace and path choice	

3 Pattern Identification

In order to identify the design patterns in the game "Pueblo Pitanga: Enemigos Silenciosos", the description of the design patterns presented in [3] were thoroughly studied

and afterwards recognized in the videogame. It was possible to identify that the developers applied several design patterns in their videogame. The design patterns that were distinctly applied and recognized are listed below:

- CONTEXT: A: Game-based Learning Blend
- LEARNING ASPECTS: B: Questions-Answers
- LEARNING ASPECTS: B: In-Situ Interaction
- LEARNING ASPECTS: C: Time for Action/Time for Thought
- LEARNING ASPECTS: C: Reified Knowledge
- FUN ASPECTS: E: Fun Reward/Object Collection.

The identified patterns are underlined in Table 1. In this paper, each of the identified patterns is described with the help of an example taken from the videogame "Pueblo Pitanga: Enemigos Silenciosos". Due to the fact that multiple design pattern were recognized in the game, including patterns related to ***context, learning aspects*** and ***fun*** aspects, it is expected that results of the impact in the users will be positive. The results of the evaluation of the impact in the players will be shown in Sect. 4.

3.1   Context

3.1.1   Pattern A: When Do You Need to Combine Entertainment and Education?
Pattern: Game-Based Learning Blend. As it is described in [3], this approach is achieved by involving teams with different expertise: the game experts and the knowledge experts. In this case, Green Lava Studios was in charge of the entertainment and the medical doctors in PAHO were in charge of providing the knowledge related the different diseases. In this project, Green Lava had creative freedom to create a proposal. The doctors provided basic ideas about how the game had to be played. In the end, both parties proposed their different solutions and decided that a dynamic dialogue system was the best choice to blend the educational information and humor in a simple flowing conversation with the different characters. At this point, Green Lava took the decision of simulating the style of Monkey Island's humorous dialogue system.

3.2   Learning Aspects

3.2.1   Pattern B: How to Make Interaction Instructive?
Pattern: Questions and Answers. This approach is mainly used when the amount of information that will be included in the game is not yet defined or clear. The implementation of questions and answers during the gameplay provides flexibility, since content can be adapted easily in this way [3]. Since the dengue problem includes a wide amount of factors, it was decided to adapt the content using this pattern. This was implemented by inserting questions during the conversations with characters. In the game, three options are given to the player in order to answer the character's question, see Fig. 1. If the player selects an incorrect answer, the progress to complete the level gets slower. Green Lava designed the dialogue system in a way to allow the player perceive the questions as a regular conversation, this falls under the MDA approach.

Fig. 1. Example illustration the pattern *Questions and Answers*. Please note that for every question there are three possible answers. The progress in the game depends on the answer.

Pattern: In-Situ Interaction. According to Mitgutsch and Alvarado [3], to make learners more aware of abstract concepts, it is useful to let them experience narrative and emotional contexts. Dengue and Malaria are problems that are related to bad hygiene of a community. These communities often face poverty and have a bad infrastructure. In order to make learners more aware of the abstract concept of this problem, the scenes were made with high details in terms of narrative and emotional context, for example: there is a neighborhood in the game where characters with good intentions want to collaborate to fight the mosquito spread, but they are not on a financial position to fix their own roofs (the player experiences the associated limitations). Later in the game, the city mayor helps fixing these roofs in order to keep the rest of the town safe (Fig. 2).

Fig. 2. Example illustration the pattern *In-Situ Interaction*. In this case the conditions of the neighborhood are experienced by the player.

3.2.2   Pattern C: How to Initiate the Reflective Process?

Pattern: Time for Action/Time for Thought. The method of this design pattern is to create intensive action phases and to conclude with a less intensive phase dedicated to thought and reflection [3]. The topic that was identified to use this method was the fumigation process during a mosquito breeding emergency. Even though fumigation is used for mosquito control, the community must be aware that this action is needed only in extreme cases. This is because fumigation has a negative impact in the environment and because mosquitoes can gain resistance to the venom. In the game, the player controls a fumigation machine in order to kill mosquitoes. After this action phase, the player discovers that a beekeeper has lost his small business because "something" killed all his bees. At this point, the purpose of the scenario is to make the player reflect on the fact that fumigation can affect other species, and that it is better to avoid fumigation when possible. A solution is fighting against the mosquito in an earlier phase of the mosquito breeding emergency (Fig. 3).
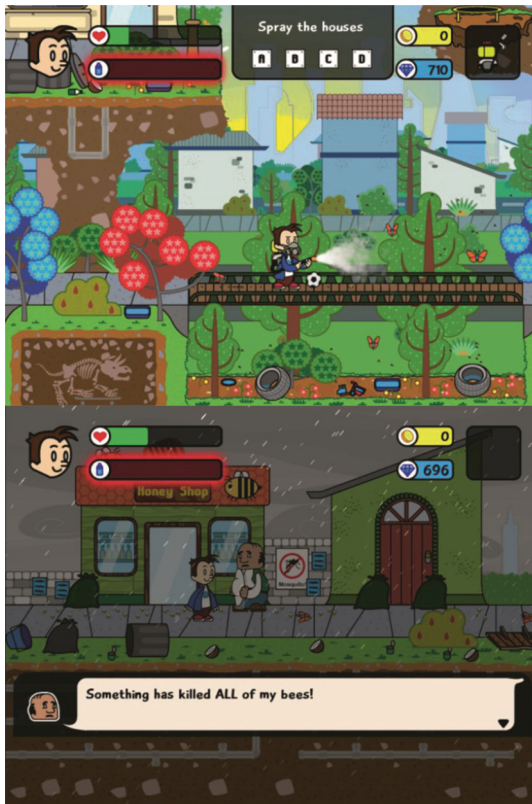

Fig. 3. Example illustration the pattern *Time for Action/Time for Thought*. The first illustration shows the action (fumigation) and the second illustration the consequence (bees been killed).

Pattern: Reified Knowledge. Sometimes, the educational topic is an abstract concept that is hard to be identified as "gained knowledge" by the players. To make the player aware of this "gained knowledge", the "gained knowledge" should be represented as an object or game item [3]. An example of this kind of concepts, is the learning process of communicating a message to a community. In the game, the player must alert other neighbors about the presence of the mosquitoes, the threat they represent and the way in which they should fight them. After successfully completing this task, the player will receive "the communication medal". In this way, the game shows the player that a new knowledge was acquired (Fig. 4).

Fig. 4. Example illustration the pattern *Reified Knowledge*. The first illustration when Fabio is receiving a "communication medal" after completing a task.

Fig. 5. Example illustration the pattern *Fun Reward – Object Collection*.

3.3   Fun Aspects

3.3.1   Pattern E: How to Motivate Users?
Pattern: Fun Reward - Object Collection. During the gameplay, diamonds are given to the player when they complete a task. The player can buy additional mini-games inside the game and complete achievements. These games are not related to the main topic of the game, they are designed for pure entertainment. This gives the player a different motivation to finish the game (Fig. 5).

4   Results and Analysis

In order to evaluate if the videogame provided more than just entertainment to the users, several testing sessions were made during and after the development of the game. As described in Sect. 3, it was identified that several patterns were implemented in the game "Pueblo Pitanga: Enemigos Silenciosos" in order to increase the chance of success during the learning process. The objective of this section is to show if a considerable difference in the knowledge of the students was be observed before and after they played the game.

In this paper we have considered that a difference in correct answers of more than 10 % with respect to the first attempt is considered successful. This percentage of 10 % was selected by the design team. The tests were made with a focus group of 80 Costa Rican students from 9 to 16 years old. These tests consisted on a set of questions in a separate paper about the educational material. The same set of questions were asked before and after playing the game.

The game itself was evaluated as "excellent" by 90 % of the students (see Fig. 6). Also specific elements of the game, such as graphics, characters, music and sounds were evaluated as "excellent by more than 75 % of the students. Additionally, 90 % of the students considered the game itself "very fun", therefore the goal of making a fun game was achieved. Regarding the learning experience (see Fig. 7), before playing the game, the correct answers from all the players gave a total of 54.7 %. Once the players finished the game, the total of correct answers increased to 75.3 %. An increase in correct answers was observed in 100 % of the students of the focus group. An improvement of 20.6 percent points was achieved. This indicates that the objective of the game was attained and that the application of the design pattern proved to create positive results. The game not only provided entertainment, but did comply with the requirements stated by the PAHO and the expectation of the designers.
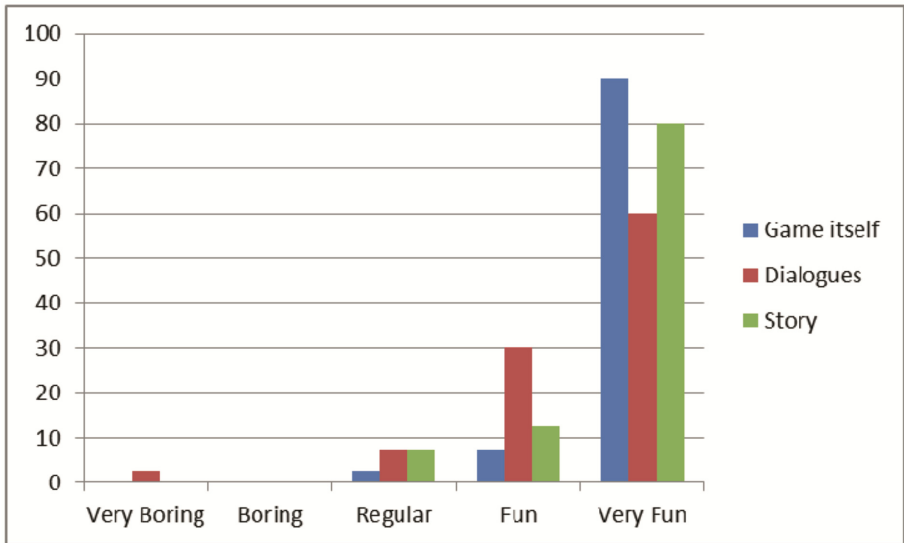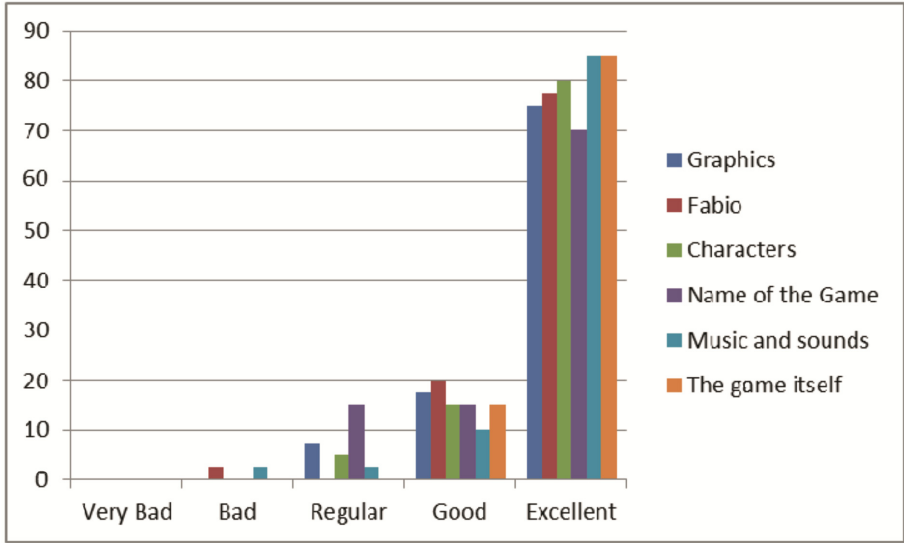
Fig. 6. Results of the answers given by the students about the videogame

In future work it would be interesting to analyze if a correlation with age and background exists. The designers of the game agree that the application of the selected identified patterns were crucial for the success of the results.
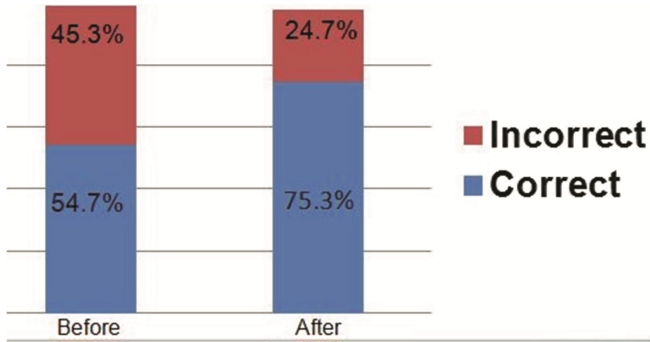
Fig. 7. Results of the answers given by the students before and after playing the game

5   Conclusions

The main objective of this paper was to identify the design patterns that were applied in the educational videogame "Pueblo Pitanga: Enemigos Silenciosos" and to analyze if positive learning results were achieved in the players after playing the game. Design patterns are strong tools for the game design and development of an educational or serious game. They help the game experts and knowledge experts to simplify tasks in order to communicate and teach a specific topic in the game, always looking for a balance between fun and learning.

The patterns and results exemplified in this paper help to understand how to correctly implement game mechanics and educational topics with different techniques or methods. Depending on the topic of the serious games, the implementation of these patterns are always subject to the amount and quality of detail of the educational material that the knowledge expert intends to teach. The game experts are the ones in charge of finding a balance between education and entertainment using these design patterns. The game experts will need to identify the desired pattern in relation with the type of knowledge or data that the player must learn.

From the results it can be observed that there was a significant improvement in the answers of the students. An improvement of more than 20 percent points in good answers was obtained in the test after the students played the videogame "Pueblo Pitanga: Enemigos Silenciosos". The designers of the game agree that the application of the selected identified patterns were crucial for the success of the results.

In future work it would be interesting to compare two versions of the same game, one in which the educational design patterns are applied and one in which they are removed. This would allow an even more precise quantification of the benefits of using the described design patterns.

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