Sherlock Dengue 8: A Serious Game for Teaching about Dengue Fever Prevention with Collaboration and Competition

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Figure 1: From left to right: (a) SD8 login menu, (b) SD8 in-game screen, the player is accessing a fact near the park sector using the third person camera, (c) SD8 in-game screen with the chat and FACT menus opened.

Abstract

The Dengue fever is one of the most important diseases caused by arbovirus due to its global spread, high infectious rate and the expressive number of deaths. There is no dengue fever vaccine available yet thus raising people awareness about this problem seems to be the only solution at hand. As videogames are considered engaging and entertaining, especially for children and youngsters, this paper presents the development of a Serious Game about dengue fever prevention as a new free version of the Sherlock Dengue sequel, titled as: Sherlock Dengue 8: The Neighborhood. The gameplay includes a new game mode which is collaborative competition, i.e. players will team up in pairs to help each other and, at the same time compete against another pair. The paper discusses the design of such game that has to fulfill and balance collaborative, competitive and pedagogical requirements at the same time that keeps it as fun and playable - a game - as possible.

Keywords: serious game, collaboration, competition, dengue fever

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1. Introduction

Dengue fever is one of the most important endemic diseases transmitted by arthropods that affect the mankind which, according to researches, affects about 50-100 million humans annually, and kills 22 thousand [Guzman and Istúriz, 2010; Ratnam et al. 2013]. The disease records show that the virus is currently widespread over the globe, but is most present in the tropical and subtropical countries of all continents, due to the favorable conditions for the disease breeding: heat and rain [San Martín et al. 2010]. Besides the global spread, there is no healing treatment and no vaccine available for preventing the disease yet [Ratnam et al. 2013; Rajapakse et al. 2012].

There are already some dengue fever vaccine researches being conducted with promising results [Ratnan et al. 2013]. However, while the vaccines are not ready, the most effective measure in order to prevent major dengue fever outbreaks seems to be the raising of people awareness about this problem. Still, incite and motivate the citizens to learn how to prevent this disease is not an easy task.

The traditional learning process is considered as tedious and as little motivating for the learners, especially by the new generation called digital natives whom are interested by new media and technology [Prensky 2001; Selwyn 2009]. Considering the lack of motivation in the traditional learning process and the interest in features used in videogames, a new branch of study emerged: the Serious Games (SGs). Despite some arguing on the concept of SGs [Pourabdollahian et al. 2012], they can be introduced as applications that mix serious subjects – as behavior change, learning, training etc. – with a playful and interactive gameplay where the main objective goes beyond the player's entertainment [Alvarez and Djaouti 2011].

Recent studies have started to explore the various types of interaction in SGs – individual, collaborative and competitive – pointing out some benefits and drawbacks related to their use [Collazos et al. 2007; Hämäläine et al. 2006; Liu et al. 2013]. Also there are some researches suggesting the use of collaboration and competition together [Fong-Ling et al. 2009] since it could combine the benefits of each type of interaction. In fact there are already a few studies that

actually used or designed collaborative competitive altogether SGs [Buchinger and Hounsell 2013].

As the citizens need stimulus for learning how to prevent and fight against the dengue fever, it seems reasonable to design and use a collaborative competitive SG about this disease. However, merging a serious content with such type of game interaction is not an obvious task. There must be a balance between the pedagogical aspect and the fun and entertainment of the gameplay. In this way, the design process and development of a new SG about dengue fever prevention is presented in this paper – the Sherlock Dengue 8: The Neighborhood – highlighting the privileged aspects in the design decisions.

In order to present the Sherlock Dengue 8, this paper was organized as follows: in the second section some background content is shown; in the third section some related works are presented; in the fourth section the Sherlock Dengue project is presented along the eighth version, emphasizing its game design and development; in the fifth section are the conclusions, followed by the acknowledgments and the references.

2. Background

2.1 Dengue Fever

Dengue Fever is a viral infectious disease transmitted by arthropods being endemic in many countries over the globe. There are four know serotypes of the disease [Ratnam et al. 2013] but recently, scientists discovery a fifth serotype in Malaysia [G1 2013; Fiocruz 2014] – fortunately not found in other countries yet. The dengue fever infectious could be asymptomatic or limited to a fever, but many other symptoms could arise like: rash, headache, runny nose, myalgia, seizures, petechiae, ecchymosis, arthralgia, nausea and vomiting [Ratnam et al. 2013; Jain and Chaturvedi 2010; Guzman and Isturiz 2010]. There is also a chance for the illness to evolve to dengue hemorrhagic fever or dengue shock syndrome, which are more lethal than regular cases [Ratnam et al. 2013].

The dengue fever virus is transmitted by two mosquitoes: Aedes aegypti and Aedes albopictus [Rajapakse et al. 2012]. It is the female mosquito of each species that bites humans and other animals seeking for blood, in order to mature its eggs. When a mosquito bites an infected human, it contracts the disease and after a few days becomes a carrier of the disease throughout its life [Guzman and Istúriz, 2010].

Scientist are currently working in a vaccine to prevent the dengue fever disease, however it has shown to be a complex task since it needs to produce a balanced immune response against all serotypes. While the vaccine is not ready to prevent the disease, the primary recommendation is to prevent the mosquito vectors proliferation through the elimination or correct treatment of possible mosquito eggs deposits [San Martín et al. 2010]. Thus, a reduction in the mosquitoes breeding cycle can be reached, reducing the disease cases by consequence.

In the Americas, studies have shown that Brazil was the country with most dengue cases documented (54.5%) and Venezuela was the country with the highest number of dengue hemorrhagic fever cases [San Martín et al. 2010]. Also, it is in the Southeast Asia and Western Pacific regions that the dengue fever is more present: about 75% of dengue fever cases in the world occurs there [Rajapakse et al. 2012].

2.2 Serious Games (SGs)

SGs are a particular kind of videogame. Although there is no exact definition for SGs, they can be said to be videogames especially developed for learning and training [Boyle et al. 2011], mixing serious issues with specific interactions and a playful, fun and interactive environment, in which the entertainment is not the main objective [Alvarez and Djaouti 2011]. Most of SGs definitions present this general idea of merging education with dynamic and playful interactions in an attractive and interesting manner.

SGs could become effective in the teaching-learning process because of the embodied elements of motivation like stories, dynamism and fantasy, but also because of the game dynamics (called gameplay) which may involve several activities: calculation, reading, interpretation, reasoning and understanding [Van Eck 2006]. Motivation seems a keyword in this process and according to Prensky (2003): "A sine qua non for effective learning is motivation". It is possible to obtain better learning environments with the development of a gameplay in which the players can interact – in a motivating way – with the knowledge being taught [Squire et al. 2005].

2.3 Game Design

There is little guidance for the development of SGs for a specific domain [Boyle et al. 2011]. However, there are many aspects and tips that can be availed from usability theories [Cybis et al. 2010]. Also many instructions from the design and developing of regular commercial-off-the-shelf (COTS) games could be followed when designing or developing SGs.

The game design could be understood as a videogame plan of how everything (or most of things) should work, e.g. the plot, the player interactions, the resources used in its production, the personnel etc. [Schuytema 2008]. The difference between the design of regular software and the design of a game is on the fun and the difficulty degree in performing the tasks. While in regular software the users want affordance and easiness to produce something (e.g. create a text file, create a 3D model), in games the users want easy controls as well, but they also want excitement,

challenges in an appropriated difficulty pace, and something that provides determination to overcome those challenges [Cybis et al. 2010].

Nowadays the videogames production incorporates multiple components that involve multiple areas of knowledge. These components could be divided in [Cybis et al. 2010]:

- Gameplay Goals: related to innovation, creativity, game challenges etc.:
  - Gameplay: rules, game balance, learning process, controllers, interactions etc.;
  - Story: content, goals etc.;
- Instrumental Goals: related to the means to achieve the gameplay goals:
  - Graphic: scenarios, characters, text styles, physical consistency etc.;
  - Sound: music, sound effects, etc.;
  - Interface: devices, ease on learning and using the interface, settings etc.

SGs designers should also keep in mind that usually it is important to include fun and immersion. This could be achieved through a number of elements, including [Grassioulet 2002]: challenges optimization, retaining the player's attention in the activity, clear objectives, and clear feedback.

2.4 Collaboration and Competition

Since the introduction of SGs the researches have been focused in single player games (Liu et al. 2013). Still, there are recently some researches focusing especially in the interactions that could be instigated in SGs. In this way, many competitive SGs and collaborative SGs were created and analyzed regarding their benefits and drawbacks [Collazos et al. 2007; Hämäläine et al. 2006; Han-Yu and Gwo-Jen 2013; Liu et al. 2013].

Fong-Ling et al. (2009) study revealed that collaborative activities seems to instigate a stronger social presence and influence more synthetic abilities, whilst competitive activities seems to instigate a more challenging atmosphere and influence more the analytic abilities. Moreover, the same study shows that competitive-collaborative activities could combine both benefits. Although there are already competitive-collaborative SGs, the main focus still in their design, development and use [Buchinger and Hounsell 2013].

It is said that there are two types of cooperation and competition: both could be exogenous or endogenous [Malone and Lepper 1987]. An exogenous cooperation occurs when the activity is independent; therefore the players could play independently. An endogenous cooperation occurs when the activity is composed by dependent sub-activities; therefore one player depends on the other. An exogenous competition occurs when the actions of a player could not interfere in the other player's activity. On the other hand, an endogenous competition occurs when the actions of a player could interfere in the other player's activity. Malone and Lepper (1987) claim that the endogenous interactions are more motivating, thus they should be sought when designing a game.

3. Related Work

As the dengue fever is a global problem, there is already some work trying to motivate or improve the learning about dengue fever. Several studies are actually merging the dengue fever content in games.

In The Philippines there was a study that has measured the influence of gaming on the dengue fever learning process [Lennon and Coombs 2006]. A board game called "Goodbye-to-Dengue" was created. In this game, there are interactive cards that present dengue fever information. Although it is not a videogame, and therefore it is not a SG, it is a good example of a research intending to mix games with dengue fever content and evaluating the learn process obtained.

In Venezuela a game was created with the support from the Pan American Health Organization and World Bank: "*Jugando em salud: dengue*" [Vivas and Guevara 2003]. This game was designed especially for Venezuelan school children, intending to study the efficacy of a game as a learning tool for dengue fever content. In this research, the game was well accepted by the audience, and the group that used the game had bigger increase in dengue fever knowledge than the group that followed the regular learning program.

In Brazil three projects with different approaches could be highlighted. One of them is the Role Playing game (RPG) "*Exterminadores de dengue*" which puts the player in the role of a character that finds that one of his/her relatives has contracted dengue fever [Silva et al. 2011]. Besides presenting dengue fever content, the game also emphasize the Brazilian northeast geography, living standards and culture. The second is an arcade game – similar to the popular Mario World – called "*Contra Dengue*" in which the player has to explore the 2D environment, overcome obstacles and eliminate deposit spots for the dengue fever mosquitoes [Pereira et al. 2011]. The third is a sequel of eight versions of SGs about dengue fever called "Sherlock Dengue" [Sherlock Dengue 2014]. All versions are investigative-arcade games with different design and technological approaches. They will be presented in the next section.

In addition to the SGs about dengue fever there are also COTS games available [Ludo Educativo 2014; MrJogos 2014; Tom's Games 2014]. These games are online versions with a 2D Flash style and look, with the main focus on the entertainment, and they mostly lack of dengue fever content besides presenting the information separately from the game itself.

One can notice that some games (SGs or not) give more emphasis in the fight against mosquitoes by killing it, while others emphasizes the fight against the mosquito proliferation. According to the current trend, the second alternative is more advisable [San Martín et al. 2010]. Note also that there is no game about dengue fever that has endogenous cooperation and competition interactions except the proposed SG.

4. Sherlock Dengue Project

The Sherlock Dengue (SD) is a project from the Laboratory for Research on Visual Applications (LARVA) – a research group from Santa Catarina State University – intending to bring attention toward the dengue fever problem through the use of virtual reality with different technologies and designs [Schmitz et al. 2004]. The project name refers to the famous detective Sherlock Homes and his investigative skills, alluding to the thorough search by deposits for the dengue fever mosquitoes.

The SD project target audience is mainly children and youngsters aged between 8 to 15 years old. Currently the SD sequel is composed by eight versions – all freely available – that evolved through design improvements and technology innovation:

- SD1 The Begins – developed using VRML, contains just one scenario (a shanty house) with random elements, and use an approach based on the old belief of true and false deposits for the dengue fever mosquitoes [Schmitz et al. 2004];
- SD2 It is Everywhere – also developed with VRML, has eight levels alternating between two different scenarios (a shanty house and an apartment), and use a quiz approach [Hounsell et al. 2006a];
- SD3 Buzzing Around – this version have extended the SD2 including sound effects and speeches for each textual information [Hounsell et al. 2006b];
- SD4 Augmenting the Search – this version have also extended the SD2 version including augmented reality technology, therefore the scenarios (real world) could be organized with markers for each game object (augmented world) [Corsani et al. 2009];
- SD5 The Eliminator – developed with Flash technology, used an approach based in the match of deposits for the dengue fever mosquitoes vector and the correct item or procedure used to fix or clean each deposit [Hounsell et al. 2010];
- SD6 You are not Alone – this version has also extended the SD2 using Xj3D, and exchanging the individual gameplay by a collaborative gameplay [Buchinger et al. 2012; Buchinger and Hounsell 2012];
- SD7 PRO – this version has also extended the SD2 exchanging its content from basic information to professional information, being recommended for doctors and health agents instead of children and youngsters [Santos 2014];
- SD8 The Neighborhood – this version was developed using Unity 3D Game Engine [Unity 2014] and will be presented in this paper.

The SD content – with exception of the SD1 and SD5 that have different gameplays – covers the main aspects of the dengue fever disease. It includes the mosquito vector characteristics, disease symptoms, treatment, disease control, and also some historical remarks about the disease. SD7 is the only version that includes specific and advanced information about dengue fever. Furthermore, the SD content was revised and adapted by Joinville Board of Health.

The next subsections present the design decisions during the development of the SD8. During this process, some aspects from the SD games were revised because they were used or adapted for this new version. Moreover, the SD8 game design was influenced by literature about game design, human-computer interaction, theory of motivation [Malone and Lepper 1987], a review of competitive-collaborative games [Buchinger and Hounsell 2013] and pedagogical aspects. Furthermore, each design decision was evaluated seeking to increase the re-play factor (stimulate the player to play again) and balance three main aspects: (1) entertainment, (2) collaboration and competition, and (3) pedagogy.

4.1 Interaction and Scenario

To all versions of SD the players play the role of a virtual dengue inspector, and in most versions (SD1, SD2, SD3, SD4, SD5 and SD7) the players play alone, competing with other players to see who make more points in the single player game (exogenous competition). In SD6 the game introduced a collaborative game play in pairs (endogenous cooperation), in which again the players could also compete with other pairs to see which pair makes more points (exogenous competition). As studies suggested, a competitive and collaborative activity should increase the efficacy of the game as a learning tool; moreover, an endogenous cooperation and competition should also increase the player's motivation [Malone and Lepper 1987]. So, the SD8 was designed to have endogenous competitive and collaborative interaction with a total of four players: two pairs of two players, in which the players collaborate with their partner and compete against other pair.

The SD2, SD3, SD6 and SD7 have two small dynamic scenarios (dynamic because the main objects' positions are randomly chosen by the system): a shanty house and an apartment. In tests with the sixth version, a slight difficulty on the movement through the scenario could be noticed because of the scenario's size, the collision between players and the number of objects in each level. In this way, it was decided that a new bigger scenario would be designed for SD8, a place with more environments, showing the players that dengue fever mosquitoes could breed in many

environments. Thus, the proposed scenario was a neighborhood, which gave the eighth version its name.

The neighborhood scenario was modeled as a rectangular area divided in four main sectors, as shown in Figure 2, each one representing a level of the game: the first sector (within the red borders in Figure 2) contains an epidemiological station (Figure 2a) with two floors, three different shanty houses (Figure 2b) and an ordinary house (Figure 2c); the second sector (within the green border in Figure 2) contains a park; the third sector (within the blue border in Figure 2) contains a graveyard; and the fourth sector (within the yellow border in Figure 2) contains a four-story building (Figure 2d), three houses (Figure 2e), an abandoned house (Figure 2f), and another shanty house (Figure 2g). From the buildings, seven of them have an interior modeled (i.e. accessible interior): epidemiological station, all four shanty houses, the four-story building and the abandoned house.

Figure 2: SD8 neighborhood scenario map.

4.2 Pre-Game

As an online game, SD8 already requires internet connection, so it was decided that each player would have to register and login (see the login menu in Figure 1a) to play the game. The login feature was also chosen because of two other main reasons: to give the player a profile, fostering the re-play factor, and to keep track of game data to allow further analysis.

In order to provide more demographic data the players could inform their birth date, city, country, current school and schooling when registering. For log in, the players are recognized exclusively by their e-mail address, and in case they forget their password, the game has a 'forget my password' feature.

After logged in, the players have some options: they could revise and alter their profile data, see their game status (total victories, draws, defeats, points, and playing time), search for other players and see their profile and game status information, read or play a game tutorial, see the ranking and log out. Moreover, the game has also an achievement system in which the player obtains badges according to his deeds when playing the game (this system will be presented in another subsection). The players could see their own achievements and other players' achievements. Also, the game has an option menu in which the player could choose the language – currently just Portuguese is available because, despite the framework being ready, the dengue fever content also needs to be translated to other languages – set the music volume and the sound effects volume.

Besides these options, the players could also choose the Play Game option. When this option is chosen, they should first select an avatar to play with. There are a total of ten avatars, five males – including Sherlock Holmes and Dr. Watson – and five females. All avatars are free online 3D mannequins found in the internet (published in the game credits) in which some of them require adjustments and bone rigging (the bones are used for avatar's movement). Some avatars however are locked and could be just used under some conditions according to the player status (e.g. Sherlock Homes is available just after the player has earned a total sum of 1500 game points). It has been considered that this design option would foster the game re-play.

After selecting the avatar, the players enter in the game lobby in which all created games are shown with some information about them (host player and number of current players waiting). In this lobby, the player can choose between enter in a pre-created game or create their own game. In any choice, the players are sent to a new menu which shows information about the players currently waiting in the game room. When four players enter in a game room, an algorithm is triggered to choose the pairs according to the player's earned points (supposedly their ability). According to Liu et al. (2013), balancing teams in a competitive activity could be positive because it tends to create a more challenging game in which the player endeavor and focus more on the activity, even in serious aspects (pedagogy). Furthermore, the host player device chose randomly the game objects position and sent it to the other players, in order to all participants load the same dynamic scenario. Finally, the selected pairs are shown to the players in a new menu, and the game scenario starts to be loaded. When it finishes loading for all players, the game starts. Note that some alternative game flows were omitted here – e.g. what happens if a player close the game window while loading the scenario – but were considered in the implementation.

4.3 Gameplay

First of all, as the SD8 is a pair competitive game, it is important to distinguish each team during the game, and make clear what team the player belongs to. For this reason the game distinguish each pair by two colors: blue and red (common in some sports). The game also presents a scoreboard (Figure 1b-1c at the

top-right corner) which shows the scores of each team identified by 'us' and 'them', written in the corresponding team colors. In this way, the players could easily identify their own team. In addition, each avatar was designed to show its player nickname over their heads, written in the corresponding team's color.

The scoreboard also presents two other important data: the number of the current period (the level is called period in SD8 because its take place in the same scenario) and the time left for ending the current period. When a new period starts, a new scenario sector is unlocked for all players. The locked areas are blocked by a semi-transparent wall – facilitating the identification of the current boundaries – that inhibits access (similar to some COTS games, e.g. God of War). Each period has a different play time: the first and the third period have 12 minutes while the second and the fourth period have 18 minutes. The amount of time takes into account each sector size, the game required interactions and the difficulty.

The main gameplay adopted in SD8 includes interaction with three kinds of objects (Figure 3):

Figure 3: SD8 main objects in the following order: FACT (singular and double), a DEPOSIT and a CURIOSITY.

- FACTS: represented by floating books and tablets, these objects present textual information – a fact – about dengue fever. The books are singular FACTS that present the same information for each member of the pair (same design of SD2, SD3, SD6 and SD7), whilst the tablets are partial FACTS that present half information for each pair member. To know the complete information from tablets, the pair should collaborate and merge both parts of the information;
- DEPOSITS: represented by actual deposits (places where dengue fever mosquitoes can lay their eggs), these objects are linked to a FACT (book or tablet) and a multiple choice question about that FACT content. When the players answer correctly to the question they earn points according to a punctuation scheme;
- CURIOSITIES: represented by floating but static Aedes aegypti mosquitoes with a question mark above them. They emit a mosquito sound effect that aids in their whereabouts' detection. Each CURIOSITY presents additional information – that is not asked in any moment on the game – and gives a small quantity of points to the players, when they interact with it.

These game objects are scattered over the scenario, but not all objects will be available right from the beginning. When a new period began new areas and therefore new objects become available, following the order presented on Table 1. Note that there is no easy partial FACT in the game, and the FACTS – and therefore the questions – become more challenging as the period advances (pedagogical aspect). Note that the total number of facts and therefore questions is 50, while the total number of curiosities is 30.

Table 1: New objects per period.

Objects	Periods			
	1st	2nd	3rd	4th
Easy Integral FACTS	6	5	2	0
Regular Integral FACTS	2	6	7	3
Regular Partial FACTS	0	1	2	4
Hard Integral FACTS	0	0	2	4
Hard Partial FACTS	0	0	1	5
CURIOSITIES	3	6	9	12

In order to give a feedback when the player has interacted with a FACT and to show the relationship between FACTS and DEPOSITS, a number above the FACT icon in a pre-determined color is displayed. The number match FACTS with DEPOSITS (e.g. FACT 11 with QUESTION 11) while the color identifies how many times that specific FACT was accessed: yellow number for no access, green number for one access, blue number for two accesses, red number for three accesses, and gray number for four or more accesses.

In most SD versions the DEPOSITS remained without change in the scenario after the player answer correctly their questions. However, it was considered that the SD5 has the better approach of 'fixing' DEPOSITS: transform a DEPOSIT in a regular object that cannot be used for dengue fever mosquitoes for breeding (e.g. put sand in the flower vase's plate). Therefore, this approach was chosen for SD8, in which the DEPOSITS are replaced by 'fixed DEPOSITS' when the player answers correctly their questions, with exception of small deposits (e.g. tins, bottles) that vanishes, as they were placed in a trash can.

In SD8, the pair that ends the game with most points wins. Thus, one of the most important rules in the game is the scoring scheme. It has been decided that the points earned by the players (for their team) would be dependant of four factors:

(a) The base score earned is related to the question's difficulty: 10 points (pts) for easy questions, 20 pts for normal questions and 30 pts for hard questions;
(b) The base score is then decreased according to the number of question's corresponding FACT accesses: 0% for one or no access, 10% for two accesses, 20% for three accesses and 30% for four or more accesses (pedagogical factor);
(c) Another decrease is calculated based on the player's answer order: 0% if the player is the first to answer, 20% if the player is the second to answer, 40% if the player is the third to answer and 60% if the player is the fourth to answer (competitive factor);
(d) The resulting score is finally decreased by 33% for each wrong answer, giving the player's earned score.

If a player, for example, answer correctly an easy question (10 pts) just after another player (2nd to answer, thus decrease of 20%), and has accessed its corresponding FACT twice (decrease of 10%), his reward would be 7 pts. But, if this same player had answered wrong two times to this same question before, the reward would be just 2 pts.

The decrease based on the player's answer order is one way of fostering the exogenous competition, because one team could reduce the amount of points earned by the other team. On the other hand, the decrease by each wrong answer tries to discourage the player to use the trial and error method and, unlike other SD versions, it will not reduce the amount of points already earned by the team, in order to not affect the player's auto-esteem, thus their motivation [Malone and Lepper 1987]. Note also that the earned score is rounded to the closest integer number and it would never be less than 1 point.

Two game characteristics were designed for creating endogenous cooperation, demanding mutual engagement in a coordinated effort (i.e. collaboration [Collazos et al. 2007]): FACT reaccess and partial FACTS. FACT's reaccessing is controlled by a collaborative-decision mechanism, in which the players could just reaccess a FACT if their collaborator allows it because the maximum score that could be earned by the team could be affected by this action. This decision should be made on the fly since the other team is not interrupted, and it fosters communication and strategic decisions. The partial FACTS, on the other hand, forces the players to communicate and join their collected information in order to known the complete sentence. These FACTS make explicit that the information is not complete and the other part is just accessible for the other player.

To prevent a possible unintentional FACT access (or double-click), a maximum safe distance between the player and the FACT was adopted. While the player keeps a certain distance of the FACT (safe distance) any new interaction with that FACT would not be considered as a reaccess. In addition, there is a minimum distance required between the player and any object for interaction. Any long range click in an object would just trigger a message informing that the player is too far away from that object.

4.4 In-game Menus

Some in-game menus were designed intending to aid the players during the game. For accessing or hiding these menus SD8 presents controllers (Figure 1b-1c at the bottom-right corner) that could be accessed by mouse-click or keyboard shortcuts.

The first menu is the chat (Figure 1c at the screen's bottom), available for promoting collaboration between players. Each chat message is identified by the sender nickname and the chat menu is also used for presenting some game information, e.g. when the collaborator answer wrong or correct to a question, a message is received informing the player about those occurrences. The second menu is the scenario map, available for player's self localization. As SD8's environment is larger than all previous versions, it was decided that the map would show the player, FACTS and DEPOSITS positions. However, the fact and deposit map icons are not distinct and they are intentionally not very small, in order to give just the whereabouts of such objects. The collaborator position is not shown in the map as an attempt to foster the collaboration through the chat.

The third menu summarizes the FACTS accesses (Figure 1c at the screen's middle). It shows every FACT currently available in the game and presents their number in the appropriate color, thus informing how many times each FACT was already accessed. Finally, the fourth menu presents the game status summarizing some game information such as: how many questions were answered, how many curiosities were found etc.

4.5 Achievements and Ranking

SD8 has an achievement system that was designed as an additional re-play motivator. This system is based on badges, in which the players earn them according to their deeds in the game. There are two types of badges: shield badges and star badges. The former are intended for global deeds, e.g. answer correctly to all questions, and according to their difficulty could be golden, silver or bronze badges. The latter are intended for period deeds, e.g. find all facts in the first period. Currently there are 11 shield badges and 12 star badges.

SD8 has also a ranking system that was designed as a way of incite competition, but also as another re-play motivator, fostering the players to play again, giving their best to enter in the ranking. The ranking system has currently two arrangements: a global ranking that shows the best pairs (highest scores), and an individual schooling ranking that isolates the player score and groups the players by school level. The first should incite the pair collaboration since to obtain a bigger score the team must play well, whilst the second should incite the individual performance.

4.6 Post-Game

When a SD8 game finishes, it immediately updates each player status on the game's database. After that, a special menu with a digital certification is shown to the players. It informs the game result on the players' perspective: if they won or lose the game, how many points they earned, how many points the pair earned and how long was the game. All these information was though as a way of making the certification similar to a real one that could be further used for teachers to assess the student's performance.

After the certification menu, the game checks if the player earned any badges according to his/her status on

the game. If the player does, the system shows the badges on the screen and updates the database. After notifying the player about all earned badges, the game status menu (the same accessible during the game) is shown to the player as a final menu, displaying all the important status and returning then to the main menu.

4.7 Tutorial

To meet usability criteria, a game (SG or not) should provide some mechanism that facilitates the gameplay learning. In competitive games the use of a tutorial during the gameplay is not common – the player focus would be divided between learning and competing. In those cases it seems common the use of a special scenario that is played individually beforehand (e.g. Civilization, Age of Empires). A common approach for these cases is the Rapid Iterative Testing and Evaluation (RITE) in which the system teaches the player a particular interaction and immediately challenges the player to execute that action giving instantaneous feedback [Cybis et al. 2010]. For SD8, two options were chosen for tutoring: a user manual and a particular scenario using the RITE approach.

4.8 Development Considerations

Online multiplayer games must choose a solution for the NAT traversal problem when the system is intended to be peer-to-peer and not a client-server approach [Müller 2006]. As SD8 was developed using the Unity 3D Game Engine that offers a connection controller (Master Server) and a partial solution for the NAT traversal problem (Facilitator) using the "NAT punchthrough" method, it has been decided that the game would also use this free tools.

The game also needed a database for storing the game data. Note though, that for security reasons the used database could not be accessed by external network solicitations. Therefore, the game contacts the web server requesting for a regular web page and it contacts the database getting the required information and sending the response back to the game.

All SD versions, from SD1 to SD7, use a first person camera. The SD8 however allows the user to change and choose between a first person camera and a third person camera. The third person camera was included to abide to possible player's preference and to allow the players to see their own avatar in the game. A Unity 3D asset was used for creating the cameras and avatar controllers, but they had to be adjusted according to the game style.

One could notice that the technological change from VRML/X3D to Unity 3D has allowed graphics improvements, mostly on the scenario, game objects and avatars. The scenario was modeled in Unity and with its assets aid it was possible to include grass, trees and even lakes without requiring much system resources. Game objects – both interactive and non-interactive – were included in three different ways: some could be reused from the previous SD versions; some were picked from the web (free models); and some were entirely modeled with Blender 3D modeling tool. Finally, the avatars were also improved from static avatars from SD6 (do not moved its arms and legs) to a dynamic avatar that could walk, run and jump with proper animations ("Unity mecanim" was used for this matter).

Nevertheless, as the game was intended to be used on schools, and considering that the school's computers have not many system resources (processor power, memory and graphic card), some graphic optimizations were required. The first optimization was the very common technique of level of detail (LOD): high polygon objects are shown when the player is close, and low polygon objects are shown when the player is far away. In SD8, when the player is too far away from small objects or objects that are inside buildings, they are hidden, decreasing the number of polygons and thus the graphic requirements. Another approach used in SD8 was merging similar objects that are close in the scenario when they are being loaded. Doing so reduces the required work from drawing objects in the screen during the gameplay.

Finally, another important graphics optimization provided is the graphics level menu when starting the game. Unity 3D allows the user to select the level of graphic details according to the developers specifications. For example, in low graphic detail the shadows and extra lights are omitted, while in high graphic detail, the shadows are soft and the lights are all considered when displaying the environment.

At last, there are the music and sound effects. For SD8, some free sound tracks were caught in the web (see game credits), from which the game theme music, game starting music track, in-game music tracks (that plays randomly during the game) and post-game music tracks (for victory, draw or defeat) were chosen. Some free sound effects were also caught from the web (see game credits). They are used mainly for bring the user's attention to something important that is happening in the game, e.g. when a period is ending, new period has started, new chat message etc.

4.9 Preliminary Tests

In order to test the SD8's gameplay, twelve youngsters – all graduating students, except for one that is pursuing a postdoctoral level – have attended to a preliminary test. Three quartets were formed and they have played simultaneously, once, for fifty minutes. Feedback was received from the players throughout the game – through observation and casual chat – and after game – through a questionnaire.

The main negative aspect pointed by the attendees was the orientation difficulty (note that the map menu was not available yet). Some users have complained

they did not remember all the places they had already visited and the game objects were hard to find, particularly the DEPOSITS. Considering these complaints, the map menu was included with the game objects whereabouts, as presented previously.

Two other negative aspects were also highlighted: the avatar slow speed for such big scenario and some interaction difficulty with the third person camera (note that the first person camera was not available yet). The adopted changes were: increase the avatar's speed and provide a first person camera. The attendees also suggested including an informative text when the player tries to interact to objects similar to DEPOSITS, reporting why they are not real DEPOSITS.

5. Conclusion

While a dengue fever vaccine is not ready, prevention should be taught to citizens as one of the most hopeful ways for containing the infections growth until now. With the dawn of the digital era, a promising way to provide learning is the so called Serious Games (SGs). The SGs seems to motivate the learners and researches are suggesting the use of collaborative and competitive interactions since they could incite some different kinds of abilities. Following these ideas, a new version of the Sherlock Dengue (SD) sequel was created, the SD8 The Neighborhood.

The SD8 was created as a competition between two pairs, in which there is exogenous and endogenous competition and cooperation, re-play motivators, recognition systems and a solid content about dengue fever. This paper presented game design decision to achieve such novel approach. They were the results of solving conflicts between gameplay and pedagogical aspects. Through preliminary tests, in which players' difficulties were observed, the game has evolved and the current version was presented in this paper. Next steps include devising a lesson's planning on how to use SD8, and finally, game testing usage in schools.

Initially SD8 was conceived as a competitive-collaborative SG, but the final result allows a more robust version with more two different gameplay interactions – just collaborative and just competitive – with some adaptations on the game coding. With a version like that, a future research could use these three types of similar gameplay and further analyze the benefits and drawbacks of each one.

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