

# Dengueside Survival: Providing a serious board game to fight against the Aedes aegypti mosquito

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## Abstract

The *Aedes aegypti* mosquito is the vector for transmitting diseases that represent a recurring public health problem. Different educational campaigns and activities have been developed for mosquito prevention and control, such as the production of educational games. This paper presents the final result of the conception, design, construction and validation of the “Dengueside Survival”, a serious board game that presents the fight against the *Aedes aegypti* mosquito in a cooperative perspective. Dengueside provides five initial missions for players who must act as health agents to complete the proposed combat and control missions against the mosquito. For the validation of the proposed game, matches in physical and virtual environments were carried out, together with the application of the MEEGA+ questionnaire on the respective players, showing as a result the viability of the proposed game as a playful tool to support awareness of the fight against mosquitoes.

**Keywords:** *Aedes aegypti*, Educational game, Serious game, Board game

## 1 Introduction

The *Aedes aegypti* mosquito is the vector for transmitting diseases that represent a recurring public health problem, with alternating outbreaks and epidemics that are difficult to fight, such as dengue, yellow fever, chikungunya and zika virus Cardoso et al. (2015). Currently, all Brazilian states have the presence of this vector Braga and Valle (2007), since their socio-environmental conditions are favorable to the mosquito proliferation Silva et al. (2008).

Dengue and related diseases depend on ecological and socio-environmental conditions that facilitate the dispersion of the vector, and, in the absence of a vaccine, combating the mosquito development foci represents the main preventive action against the same Damasceno et al. (2017). However, the fight against the mosquito is only possible through the consent of the community and the joint effort of the whole society in order to meet the informed prevention actions Santos et al. (2007); Steffler et al. (2011). As a consequence, several educational campaigns have been developed and expanded over the years in mosquito prevention and control, involving science, education and arts activities coordinated with schools, students, parents and teachers Pitta and Oliveira (1996).

The application of games together with the transmission of a certain knowledge constitutes an effective and pleasant way of teaching. Games amuse the player while motivating him, simplifying learning and maximizing the retention capacity of what is being transmitted, exercising as a result the mental and intellectual functions of the player Moratori (2003). Digital games are also recognized as an important learning tool able to motivate students to develop different levels of personal experience, such as the construction of new discoveries, the development of personality, among other positive aspects Oliveira Neto and Ribeiro (2012).

Among the game genres and game categories currently available, *serious games* go beyond entertainment, offering other types of experiences focused on training and learning Barnes et al. (2009). In this sense, several serious games have been developed for the health area Ricciardi and De Paolis (2014); Wang et al. (2016), assisting in the diagnosis and treatment of health problems, as well as in the production of more creative and effective ways of disseminating information about different diseases McCallum (2012); Wattana-soontorn et al. (2013); Drummond et al. (2017).

This paper presents the conception, design, construction and validation of **Dengueside Survival** Azevedo et al. (2019), a serious board game for raising awareness of the fight against the *Aedes aegypti* mosquito. It is a cooperative game where players represent health agents who must work as a team to complete combat and control missions against the mosquito. As a result, the Dengueside game provides a playful and innovative environment for learning preventive actions to combat mosquito outbreaks, as well as the understanding of how collaborative and community work is important to successfully prevent the spread of the mosquito and its transmitted diseases.

## 2 Related Work

*ZikaZero* Goulart et al. (2019) provides a game with the main character as a health worker who runs through game maps eliminating mosquito outbreaks before citizens are infected. Mosquitoes are released by spawning points that are randomly distributed across the map, which can be eliminated by the agent's weapon during a match.

In the collaborative and/or competitive aspect, *Sherlock Dengue 8: The neighborhood* Buchinger and da Silva Hounsell (2014), presents a game where two pairs compete against

each other, winning the one that, at the end of the match, eliminated a greater number of *Aedes aegypti* spawning points. The game dynamics is based on 4 elements: dengue “deposits”, unique fact, partial fact and curiosity. The dengue “deposits” are spawning points of the mosquito and, to be eliminated, a question must be answered. This question is asked based on information about *Aedes aegypti* and the diseases it can cause, which are present in the facts viewed by the player throughout the match. A unique fact is one that is displayed in full to the player, while the partial fact is displayed in parts for each player, in a pair, where they must communicate in order to connect them.

Regarding board games aimed at fighting the mosquito, *Goodbye-to-Dengue* Lennon and Coombs (2007) test the effectiveness of an educational board game for increasing knowledge, positive attitudes and self-efficacy for preventing dengue in a sample of Filipino school children and adolescents. The game consists basically of 33 interactive question cards and a board with 30 squares. The game objective is to circle the game board more times during the game time. The main content areas covered in the game were mosquito characteristics, dengue control, dengue treatment and dengue symptoms.

*Neighborhood Battle* Sampaio and Sarinho (2019) is a board game where each player controls a type of neighbor, which can be: the *responsible*, who aims to control the mosquito, or the *sloppy*, who helps the mosquito propagation. Each side of the battle has its own “general”, which represent important neighbor types that are used by the player during the match. Each general must strategically manipulate his troops in order to defeat his opponent. Each general has a unique ability, which can be used once per turn, with an interval of one round to use it again. The personality and achievable actions of each general are identified as common society stereotypes, such as barbecue chef, shower singer, gossip, gardener, landowner and tire repairman, being all of them related to the dengue theme.

*Aedes Infestation* Trindade et al. (2019), is a board game that applies mechanics and dynamics of the classic game *War*, which consists of dominating territories based on a predefined objective at the beginning of the game, but in this case within the theme of dengue for children and adolescents. For *Aedes Infestation*, the representation of states in the Brazilian territory to be conquered on the board was applied. Thus, the objectives of the game may be to conquer Brazilian regions or even to eradicate one of the classes of the game, in this case agent, reckless, victim or dengue.

Finally, *All Against Dengue* Beinert et al. (2015) is a game that emerged as a result of an assessment of the growing demand for a better approach to educating young people about the dengue epidemic. The game consists of a board, six pawn pieces, six-sided dice, a set of 34 green playing cards with easy-moderate questions, a second set of 25 yellow playing cards with moderate-hard questions, a dengue glossary and a small “Rules and Instructions” pamphlet. The game was developed to be played by small groups (3-6 participants) of students in schools and in healthcare environments with an ever-present facilitator.

### 3 Methodology

Dengueside Survival was developed by the combination of modern board games dynamics with real elements and actions collaboratively performed by health agents. It is the result of conception, design, construction and validation steps in order to provide an educational tool capable of teaching methods to combat the mosquito and making players aware in a playful way.

#### 3.1 Conception

Since the reintroduction of the *Aedes aegypti* in the country at 1976, the brazilian population has been experiencing constant dengue epidemics for several decades Tauli (2001). As a result, the *Aedes aegypti* is a growing and recurring problem in Brazil, and the Health's Department is responsible to prepare health agents to guide the population to fight against the mosquito.

Health agents are extremely important in the brazilian scenario, which are responsible to teach all the guidelines for combating the mosquito, as well as being concerned with ensuring that the information has been correctly understood Evangelista et al. (2018). They perform daily inspections in various properties in order to identify possible places for the mosquitoes, collecting information about the address (whether it is a house, school, or abandoned place, for example) which result in a series of details that will be reported to the Health Secretary.

During inspections, health agents eliminate all places where the mosquito can hide with the application of insecticides, and guide the residents to collaborate in the fight against the mosquito. As Tauli (2001) explains, “dengue prevention actions need the involvement of other society sectors”, showing that prior education is needed to prevent an epidemic recurrence, and leaving this function only to the population would not be viable because not everyone has access to the same information.

Following the importance of the health agents work, Dengueside Survival is conceived to be a serious board game by the application of modern board game strategies, which offer new gameplay dynamics, re-playability and design opportunities to include a variety of playful themes. In this sense, an exploration and combat game style was applied to Dengueside, with resource management and teamwork based on *Zombicide*<sup>1</sup> game, where players must work together to defeat hordes of zombies that proliferate during the gameplay. As a result, there is the conception of the Dengueside game, in which health agents are able to eliminate mosquitoes foci and try to warn residents about mosquito prevention in order to combat dengue hordes in the community.

Moreover, by replacing the zombie theme with the dengue theme, a fun game was designed, which is able to combine the contexts and actions of the real world in mechanics that are easy to internalize, generating an experience capable of making players feel the size of the problem caused by diseases and their vectors. Furthermore, Dengueside is an attempt to show the dengue “point of view” for game players, whose name is well known by brazilian citizen and it is

<sup>1</sup><https://www.zombicide.com/>

directly associated with the mosquito representation for the brazilian population. Finally, Dengueside is an opportunity to explore the growth of the board game market in Brazil, as well as the possibility to try to make people disconnect (for a few moments) from the digital world.

### 3.2 Design

It is important to provide innovative tools capable of improving individual and collective health care, with an emphasis on the need to reduce and eliminate potential breeding sites for the mosquito that transmits dengue Zara et al. (2016). In this sense, the Dengueside project was based on the mechanics of board games that allowed players to work as a team (Zombicide in particular). The intention is to provide a familiar environment for more experienced players, but also with simple and diversified arts capable of creating greater interest in new players. In this sense, Dengueside was developed to be played by 1 to 6 people, where the number of players interferes in the number of health agents controlled by each player (1 player controls 4 characters, 2 players controls 3 characters, 3 players controls 2 characters, and one for one over 3 players).

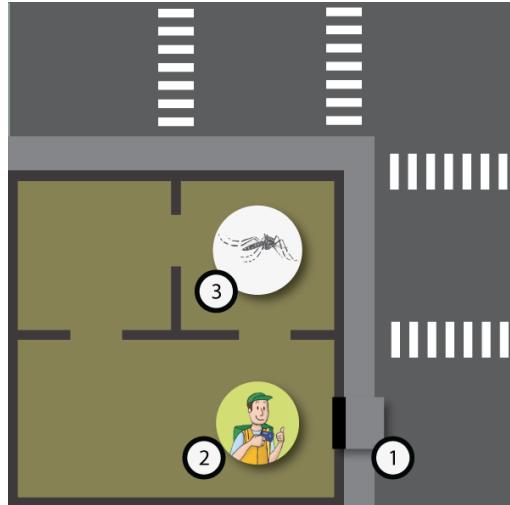
Having a playing time of 30 minutes to 90 minutes, varying depending on the chosen mission and the time of strategy and reasoning of the players, the game is aimed at children and young people, but can also be played by adults and other interested groups. Moreover, due to the time and complexity of the game developed, it is initially geared towards contexts outside the classroom, prioritizing a playful and relaxed learning.

For the configuration of each suggested mission in the game, the following components are available: 9 environment boards (quadrants) with 2 sides each; 6 characters with skill sheets; six 6-sided dice; 62 equipment cards; 42 mosquito foci cards; 18 disease cards (Zika, Dengue and Chikungunya); 18 CO<sub>2</sub> tokens; 1 first player token; 12 door tokens; 24 skill counters; 6 experience markers for the cards; 15 garbage tokens; 6 water tank tokens; 1 output token; 60 mosquitoes; and 6 non-cooperators.

#### 3.2.1 Game rules

The available missions determine how the board should be structured (**Figure 1**), the objectives of the player group, where to place the tokens and where each player will start. For the beginning of the game, a character is elected the first player and he has 3 actions among these: move to an adjacent quadrant; search for an item per turn within a building or residence; open a door; carry out a combat action attacking a mosquito if its equipment allows; or raise awareness of someone who is not collaborating in the fight against the mosquito.

Once a character has finished his actions, it is the next player's turn, and so on. When all players finish their actions, it is the turn of the mosquitoes, which takes place by performing a single action, which may be walking a quadrant or attacking a health agent who is in the same quadrant as him. Mosquitoes always move towards the highest concentration



**Figure 1.** Example of a board quadrant populated by an agent (2), a closed door (1) and a mosquito (3).

of carbon dioxide (CO<sub>2</sub>), with each health agent already representing a CO<sub>2</sub> token. This mechanics is based on the fact that mosquitoes have carbon dioxide receptors on their legs, which helps them to find higher concentrations of individuals with an active metabolism, in this case, targets for feeding. As stated by van Loon et al. (2015), "mosquitoes orient themselves according to the pulses of carbon dioxide (CO<sub>2</sub>)". Therefore, as people release CO<sub>2</sub> when they exhale, and this gas does not immediately mix with the air around them, the mosquitoes are attracted to each one as a result.

After the movement of mosquitoes present in the game, it is the turn of the spawn points to generate more mosquitoes. Thus, each water and garbage token present on the board receives a mosquito foci card, which dictates the amount of mosquitoes generated according to the level of the player who has the highest level in the match. At the end of this phase, the first player's token passes to the next character and he now begins the turn. The game is over when the agents complete their mission, or if the mosquitoes make all the agents completely sick, in this case when each health agent has two disease cards.

#### 3.2.2 Disease cards

When a player is in a quadrant where there is a mosquito and the current turn belongs to the mosquitoes, they will use their action to attack the agents in that quadrant. Their attacks can be distributed as they wish among players, since when each mosquito attacks, it generates a random disease card, and if there are two agents and a mosquito attacking, players need to decide who gets the disease. The game has 3 types of disease cards with their respective symptoms and game consequences, as shown in **Figure 2**. It is worth noting that disease cards occupy a mandatory space in the inventory, thus limiting the number of equipment of a character.

As each disease has different symptoms in the real world, each disease affects the player in different ways. Fever, for example, decreases the agility of the affected agents, who lose one die for any use of available equipment. If an equipment uses more than one die, the agent will be unable to use it. The itchiness causes the player to suffer with the precision



Figure 2. Disease cards of the game.



Figure 3. Examples of available equipment cards.

of his attacks, since the player itches a lot during his actions, losing as a consequence a roll value. That is, if an equipment needs the player to take 5 or more on a die, with the itch he will need to take 6 or more. Finally, the pain makes the player unable to use an action. Thus, if the player has a total of 3 actions available, if he is in pain, he will have only 2 actions available for use.

### 3.2.3 Fighting the mosquito

Each equipment card has attributes for: *distance of use*, measured by the number of tiles in a straight line (equipment does not pass through **closed doors**); *amount of rolled dice*, showing how much dice are used for an attack with that equipment; *value needed for a hit*, where for each die that reaches this value or higher a mosquito is defeated; *damage caused by the equipment*, all mosquitoes have one life; and if it generates a CO<sub>2</sub> token on the spot after the use. For illustration purposes, **Figure 3** presents some examples of equipment cards (short pipe smoker and bicycle) able to be used by the game characters.

For each mosquito killed by the player, a clip that starts at the “zero” position (in green) on the player’s skill sheet advances one space. As players gain experience, in addition to gaining new skills, mosquitoes start to appear in greater numbers in each quadrant. The amount of mosquitoes is determined by “mosquito foci cards”, whose value is based on the level of the player with the highest status in the match, according to the color on the mosquito foci card indicated by where the clip is on the player’s skill sheet.

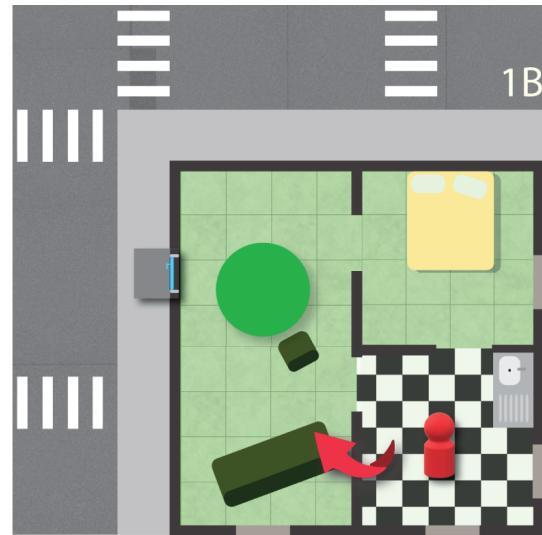


Figure 4. Non-cooperative clockwise movement.



Figure 5. Clockwise movement of the non-cooperative and the placement of a garbage token on the other side of the door.

### 3.2.4 Opening doors

When an agent opens a door of a residence, in which there was no open door, he needs to be careful, because it is necessary to use a mosquito foci card for each room of the residence, since it is not known how the infestation was inside the house.

### 3.2.5 Non-cooperators

Some missions have people who do not believe in the problems that the *Aedes aegypti* mosquito represents for our society, which are called *Non-Cooperators*. These are people who stay in their homes and walk clockwise at each mosquito turn (**Figure 4**). If they are next to a door on the mosquitoes’ turn, in addition to continuing walking, they generate a garbage token outside the door of the residence (**Figure 5**), thus facilitating the mosquitoes’ chances of winning the game. Agents can, at the cost of one action, raise awareness among non-cooperators, or remove the respective trash from a quadrant on the board.

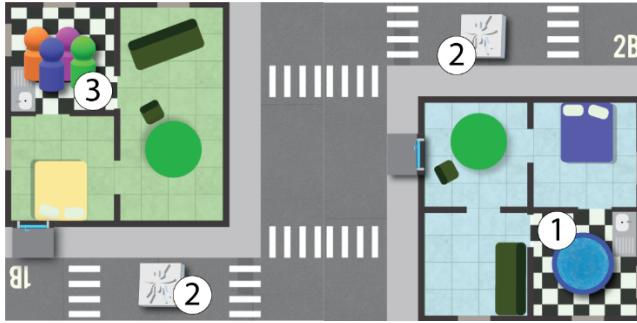


Figure 6. First Mission - Tutorial.

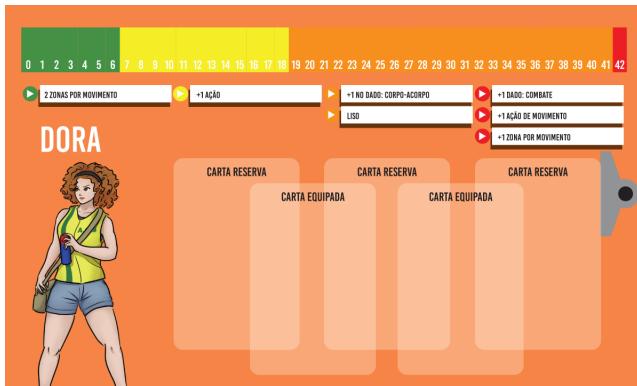


Figure 7. Character skill sheet of Dora.

### 3.2.6 Game missions

Regarding the proposed missions for the Dengueside game, one tutorial mission for beginning players and five missions with different levels of difficulty were included. Each mission describes the initial placement of the game tokens in a match, along with the mission objectives and a brief story about the characters who are entering in the current mission for immersion purposes.

**Mission 00 - Tutorial** The Dengueside tutorial mission is the first step for beginning players. It was built in a way that resembles **Figure 6**, where the objective is to cover the water tank marked with the number “1” and eliminate the mosquitoes marked by the number “2”, with the players starting in the region marked by the number “3”.

To begin, players must choose one of the available health agents, where each has a “tree” of skills that are unlocked as the character progresses through the game. The character name information, his possible abilities, his current level marker and his equipment cards are all contained in the character skill sheet, as shown in **Figure 7**.

The game starts with a character being the first to play the turn. He has 3 actions and, for explanatory criteria, he decides to first look for any item inside the residence where he is. In this action he finds a “poison bomb” (equipment card represented by **Figure 8**) and equips it on his character sheet. As a second action he moves to the next quadrant closest to the door, and with his last action he decides to open the door. However, Dora’s agility allows her to resist a mosquito bite, as shown in her file (**Figure 7**), allowing her to move 2 spaces with one action. After this action, the player ends his turn, and the same set of actions is repeated for the other



Figure 8. Equipment card - “poison bomb”.



Figure 9. Mosquito foci card example that indicates the level of mosquito proliferation according to the player with the highest level.

player’s characters in the game.

Once all players have completed their actions, it is the mosquitoes turn. For each mosquito that is already in the game, they have an action, and, as the closest agent is Dora and she has a CO<sub>2</sub> token, the mosquitoes will go towards her. The mosquito closest to the initial residence moves to the same quadrant as Dora, and the second tries to get closer to the agent. The “non-cooperator”, on the other hand, just moves one house to the left and nothing else happens to him. As soon as all the actions of the actors in the game are completed, a mosquito foci card is drawn, as in **Figure 9**, to the water tank in the upper region of the map.

As no mosquito was killed until now, the level of the most skilled player is still green, thus only one mosquito appears in the quadrant of the water tank. After a round is completed, the “first player” token is passed on to the next player, restarting the turn. The game is over when the mission objective is completed, or all agents get sick.

**Mission 01 - Divide and conquer?** This mission was designed to encourage players to really discuss whether they should split up or not in order to survive and reach the goal. To this end, water tanks are distributed at distinct points across the board, requiring players to use different strategies

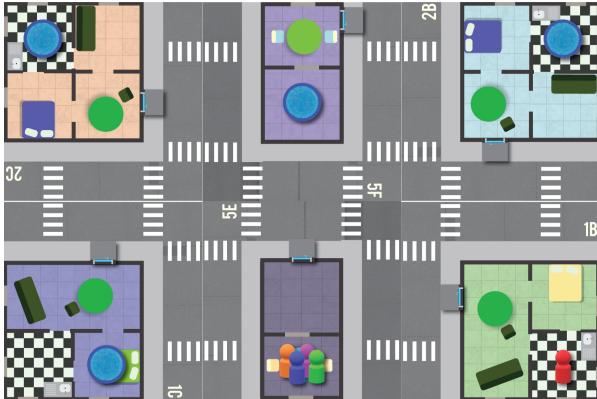


Figure 10. Mission 01 - Divide and conquer?

during a match.

In this sense, the following quadrants are used for this mission: 2C, 1C, 5F, 2B and 1B, as shown in **Figure 10** map. In addition to the placement of the water tanks in the respective buildings, a non-cooperative was also added to the last residence. As a special rule for this mission, when raising a non-cooperator or closing a water tank, the player receives 5 experience points.

*Difficulty:* Medium.

*Game story:* The agents work all day going from house to house to alert the population about the risks of *Aedes aegypti* outbreaks. Sometimes they have to deal with huge houses and neighborhoods that are difficult to access. They usually do this awareness with all residents together on the same street. After this work, they meet again to discuss how the process was conducted, from the conversation with each resident to leaving the place in question. But this time there was a situation that got out of control in the neighborhood. In the last few weeks many people were bitten by the mosquito and an outbreak started. The polyclinic ran out of vacancies and the local newspaper in the city went there to find out what happened. After an investigation on the spot, it was discovered that several houses at the end of the street had not been inspected for mosquito control for a few months. Some were abandoned and others the residents made access difficult. Knowing this, the agents team went into combat! But this time, they had to separate, as the situation was in chaos and everything needed to be resolved as soon as possible so that no one else would be harmed.

*Agent 1:* - Hey man! And these little houses there? Are there people living? We will need to take a look to make sure that the mosquito isn't spreading out!

*Agent 2:* - It seems that not all houses are abandoned. And, damn, there are too many houses for us to handle! The side streets also need us.

*Agent 3:* - Wow guys! What to do now?

**Mission 02 - A narrow street** The narrow street mission was designed to put the management of the players movement to the extreme, and to provide to the mosquitoes a temporal advantage in order to prepare several “waves” of attacks against the players.

The following quadrants are used for this mission: 3C, 7B, 5F, 2C, 2B and 1B, as shown in **Figure 11** map. As a special rule for this mission, when raising a non-cooperative or clos-



Figure 11. Mission 02 - A narrow street.



Figure 12. Mission 03 - The abandoned mansion.

ing a water tank, the player in question receives 4 experience points.

*Difficulty:* Medium.

*Game story:* The Beco neighborhood is well known by its narrow streets and complicated access that is full of ramps, slopes and tight corridors. The agents are already imagining all the exercise they need to do to reach some homes. But health comes first and there is no bad time for our agents. After a heavy rain, there were several landslides and the situation only got more complicated. Many points of proliferation of the mosquito appeared and some residents were already complaining of pain in the body. The agents went to the site to understand how the situation was, and found themselves in a narrow and very long street, and, due to the rain, it was full of mud and garbage along the way. Now the agents need to face yet another challenge in this journey to fight the mosquito.

*Agent 1:* - My goodness! My legs are already hurting just to imagine how we are going to get there!

*Agent 2:* - HAHAHA! But they will really hurt if we leave those water tanks open, right? I don't even want to think about that headache.

*Agent 3:* - And these houses, are they empty?

*Agent 4:* - Ahhh, we will only know when we cross that path!

**Mission 03 - The abandoned mansion** This mission was designed to make players think about the preparatory aspects to enter in a large abandoned residence, in this case an environment tending to a greater outbreak of mosquitoes. This mission also provides to the players the challenge to manage the fight against a large number of mosquitoes at the same time.

For the configuration of this mission, the following quadrants are used: 2C, 3C, 2B, 1B, 7B and 5B, as illustrated in **Figure 12** map. As a special rule for this mission, when raising a non-cooperative or closing a water tank, the player in question receives 7 experience points.

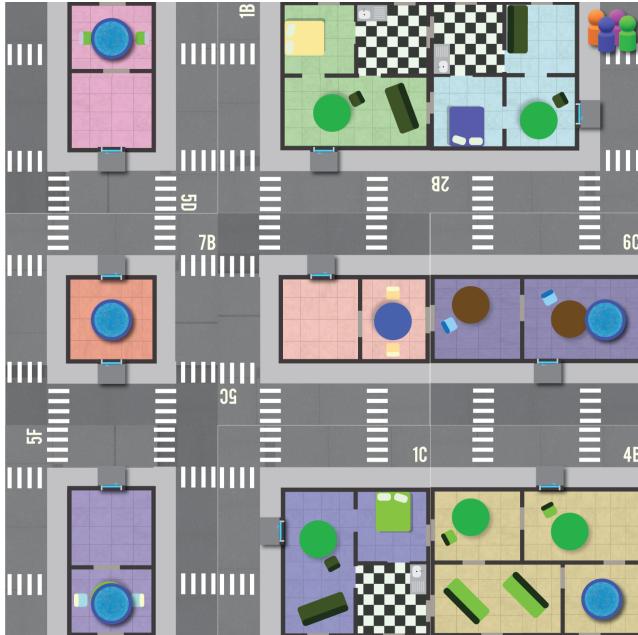


Figure 13. Mission 04 - A “small” neighborhood.

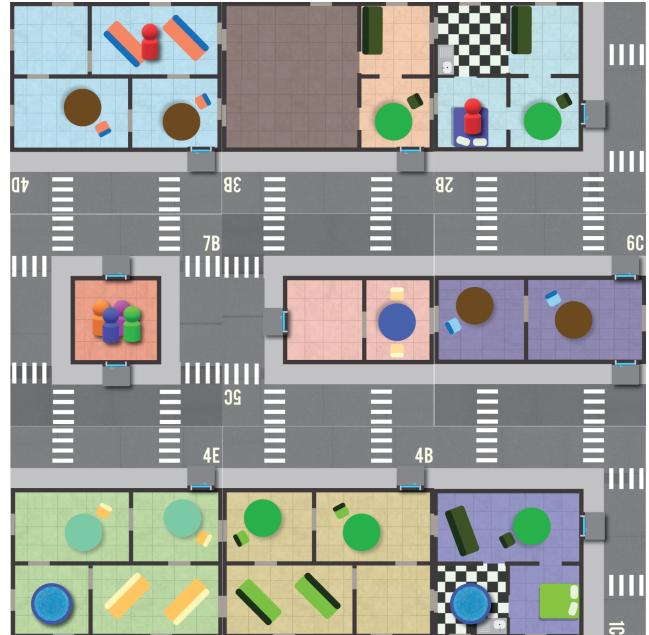


Figure 14. Mission 05 - The twin houses.

#### Difficulty: Hard.

*Game story:* The Jatobá mansion had been abandoned a few months ago due to family debts. Everyone who lives in the Lago Azul neighborhood, especially for the children, knows it. They love to play hide and seek near a water tank left around the big house. What the children didn't realize was that huge water tank was attracting a lot of mosquitoes and unfortunately the *Aedes aegypti*. Over time, most of the children and some adults in the neighborhood had already been bitten. Because of this situation, the agents were called upon to clear the entire mansion, in order to prevent the occurrence of a major outbreak that is about to come.

*Agent 1:* - Damn! Time didn't make things easy for this big house!

*Agent 2:* - Wow it's true! We need to be prepared to get in there, otherwise we will be in trouble.

*Agent 3:* - Hey guys! Look at how many abandoned water tanks. Can that neighbor help us?

*Agent 4:* - I don't think so, the last time we came here last year; he didn't even let us in!

**Mission 04 - A “small” neighborhood** In this mission, players now have to deal with the fact that they start the game outside a house, where they can enter to find items. What is needed now is to go after equipment to be able to handle the large amount of water tanks scattered in this “small” neighborhood.

For the configuration of this mission, the following quadrants are used: 1D, 1B, 2B, 7B, 5C, 6C, 5F, 1C and 4B, as illustrated in **Figure 13** map. As a special rule for this mission, when raising a non-cooperative or closing a water tank, the player in question receives 5 experience points and the doors in 5C and 6C are open.

#### Difficulty: Hard.

*Game story:* The Hortências neighborhood underwent some changes in the last year and ended up almost doubling in size, and the agents had not yet gone to the neighborhood

after this expansion. The streets had new residents and many were unaware that a few years ago the neighborhood had experienced a wave of cases of the *Aedes aegypti* mosquito. On a sunny afternoon, agents were recruited to map and raise awareness for both new and old residents. When they arrived at the place, they were frightened, because the neighborhood is not so “small” anymore.

*Agent 1:* - Guys! I think we're unprepared! I knew the neighborhood was growing but not that much!

*Agent 2:* - We need repellents, poison bombs and rackets, if we really want to finish this mission!

*Agent 3:* - Let's go to some resident's house and ask for an insecticide, ok!

*Agent 4:* - Good idea! Now, someone is going to have to open the door and lure the mosquitoes away while the rest of us go after equipment.

*Agent 5:* - You can leave it to me!

**Mission 05 - The twin houses** This mission has the same premise as mission 03 - The abandoned mansion but with two types of problems in each region of the board, taking the team to discussions on a more complicated and intimidating level.

For the configuration of this mission, the following quadrants are used: 4D, 3B, 2B, 7B, 5C, 6C, 4E, 4B and 1C, as illustrated in **Figure 14** map. As a special rule for this mission, when raising a non-cooperative or closing a water tank, the player in question receives 5 experience points. In addition, non-cooperators move only in homes of the same color.

#### Difficulty: Medium.

*Game story:* The GLIV+ Construction Company is well known for building similar houses according to the residents' needs. In Rua das Luz there were several inhabited houses that belonged to the construction company, but one of these houses had been empty for almost a year. The GLIV+ did not properly maintain the two water tanks in the house, which ended up resulting, as expected, in the detection of



Figure 15. Physical and digital models of the Dengueside Survival.

the *Aedes aegypti* mosquito. When the agents arrived in the neighborhood, many residents complained about the amount of mosquitoes and garbage they had in front of the neighboring house. The agents were confused because, according to the description, there were two identical houses, but the residents said that the residences were the same only on the outside. The agents had the keys to prevent and, as soon as they opened the door, ...

*Agent 1: - It won't happen. There's a lot of mosquitoes here guys! It's impossible to clean up this mess!*

*Agent 2: - Listen to me guys! We are here for a purpose! Let's get ready, ok. We'll see that the situation doesn't look so bad.*

*Agent 3: - The situation is bad people! But come on, we have no time to waste!*

### 3.3 Construction

After completing the initial design of the proposed game, the next step was the production of initial prototypes in order to calibrate the proposed game mechanics and dynamics.

In this sense, for the physical prototype, in order to create a resistant and pleasant enough to use board game, a 180g offset paper was used to represent the game board and a wrapping paper with glossy adhesive paper was used for the game cards. The game characters and mosquitoes were modeled and printed in 3D on an Anet A8 3D printer with PLA filament. Moreover, for the game production in a digital format, the Tabletop Simulator online platform was used to provide a sandbox environment for the proposed serious board games. Both developed versions of the game can be viewed in **Figure 15**, which presents game board, game tokens, game cards, player sheets and the game box with a Dengueside illustration.

Regarding the game manual (**Figure 16**), it presents all the game missions and mechanics in detail, together with a

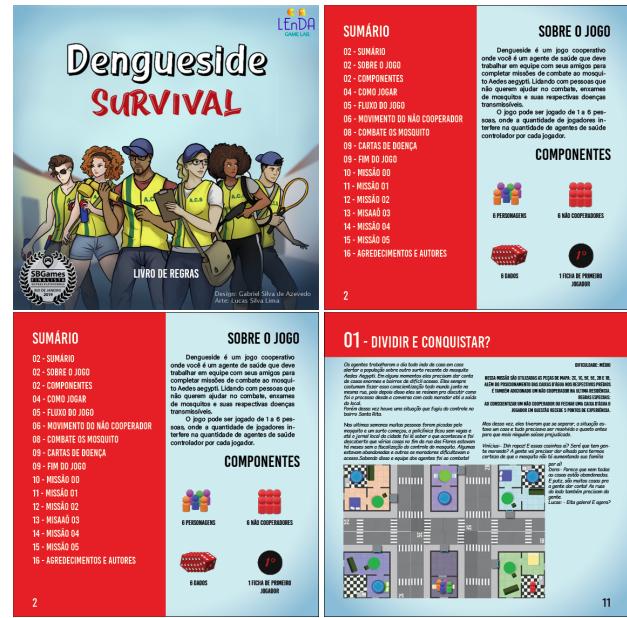


Figure 16. Pages 1, 2, 4 and 11 of the game manual.

more descriptive explanations about game strategies capable of being applied during the gameplay.

According to the manual summary, it is possible to see information about: the game itself, the game components, how to play, indications of game tokens, the execution of the game flow, the mosquito's turn, the movement of non-cooperators, the end of turn indication, the mosquito combat, the importance of disease cards, the game end, and the extra missions to be carried out.

### 3.4 Validation

With the availability of concrete versions of the proposed game, qualitative and quantitative evaluations were carried out on it. Qualitative assessments were applied in game tables held with volunteers at specific times, who were invited at the end of each match to answer a quantitative questionnaire in order to collect more information about the quality of the proposed game.

#### 3.4.1 Evaluation process

For the game evaluation process, it was submitted to the *Games Festival of the Brazilian Games Symposium* (SBGames 2019), having been approved for presentation during the event, thus competing with other analog games in the board games category of the respective festival (**Figure 17**). Other matches were also held within the university environment (**Figure 17**), allowing the execution of appropriate adjustments in the mechanics and dynamics of the game before its presentation during the festival.

Regarding the digital version of the game, it is available at the *Tabletop Simulator* game workshop (**Figure 18**), which was used to carry out online games in the current times of COVID pandemic and physical withdrawal.



**Figure 17.** Performed game tables for the Dengueside Survival evaluation.



**Figure 18.** Dengueside Survival available at the Tabletop Simulator.

### 3.4.2 The MEEGA+ questionnaire

The Dengueside validation in its physical and digital versions was carried out according to the MEEGA+ Petri et al. (2019) instrument for evaluating educational games. To this end, 30 questions from the instrument related to the player's experience and usability were applied, which are aimed at evaluating items such as: trust, challenge, satisfaction, social interaction, fun, focused attention, relevance, learning perception, aesthetics, usage learning, operability and accessibility. Possible answers are defined based on a 5-level Likert scale, with alternatives ranging from "strongly disagree" to "strongly agree", together with the possibility of applying a neutral response (indifferent). General player feedback was also collected on MEEGA+ in order to seek improvements and bring out the game's strengths. These are three open questions that assess: what aspect the player liked the most about the game, possible improvements that could be applied to the game, and whether he wants to make extra comments about the game.

Data collection was performed using a google form after each game table with several people, such as university students and participants of the Brazilian Games Symposium (SBGames), held in Rio de Janeiro in October 2019. In addition to the validation instrument, a questionnaire was also applied to survey the users profile (e.g. age group, gender) and their familiarity (or not) with the use of digital games. Finally, the obtained results were grouped into tables and graphs that summarize the values for each evaluated items.

As necessary adaptations for the validation instrument, MEEGA+ is used to determine the quality of educational games in certain subjects. In this sense, 2 questions of relevance and 1 question of learning perception were not applied, as they are linked to gains in the discipline that receives support from the evaluated game, which is not the case of the Dengueside project.

## 4 Results & Discussions

Regarding the obtained results with the Dengueside Survival game, it is important to describe the experience reported by the players during game tables, the modeled missions for the final version of the developed game, and the validation results obtained according to the MEEGA+ evaluation instrument.

### 4.1 Experience report

Analyzing the interactions of the players with the developed prototypes, it was possible to observe the feeling of curiosity of the players, since the environment of modern board games is not something common to most people, even for the sample space of the research. It was also possible to observe that players were surprised to see how the mechanics and dynamics of the designed game worked, and even more when they resembled the real information they knew about fighting the mosquito.

Regarding gameplay and interaction in the game, sometimes there were game tables testing the game (**Figure 17**)

without communication among the players, as they were people who did not know each other. As a result, after a few minutes of gameplay, they lost the match, because someone was distant from the group and suffered all the damage alone, compromising the group as a whole. However, the most interesting thing was to see these same people coming together after the match to try to play again, and thus completing the mission and providing a unique moment of connection between them.

Another important aspect that must be reported refers to the entertainment provided by the game. In fact, as evaluating the proposed game as a serious game, it is expected that during the tests it will be possible to notice that the players may be uninterested in it at some point. However, the reception and encouragement provided by Dengueside created a relaxed and very pleasant environment for players, thus exceeding the initial expectations for it.

## 4.2 Validation results

Regarding the interviewees in the process, the profile of the obtained players reflects a majority male audience, aged between 18 and 28 years old, with at least one family experience with board games, and a very frequent exposure to the use of digital games (**Figure 19**) in a total of 33 respondents.

Regarding the MEEGA+ questionnaire, different aspects about the interviewees were also obtained for these 33 responses (**Figure 20** and **Figure 21**), and, when evaluating each of these aspects, it is possible to observe the following conclusions for each of them:

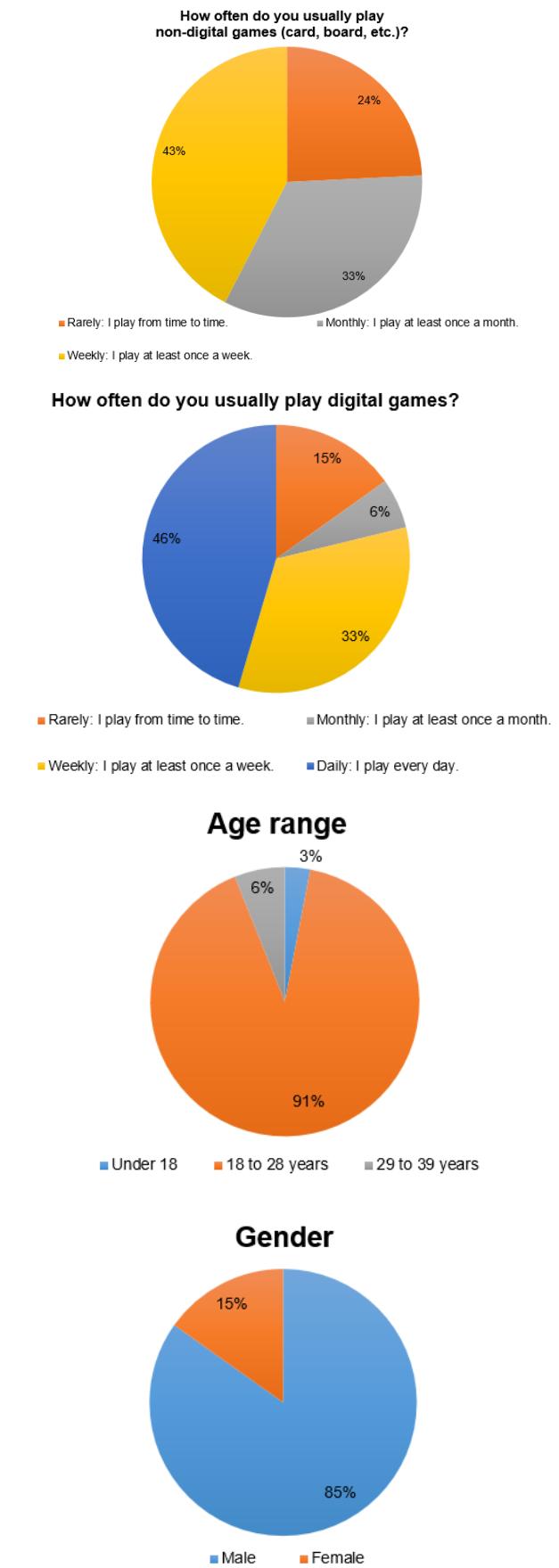
**Trust:** The organization of the game is essential for players to feel secure in their actions and have greater commitment during the game. In this sense, a summary of the game's execution cycle was provided, which was always available to the player for the proper understanding of the game. As a result, the game obtained positive responses from the players in this regard, showing that they had a confident experience in its gameplay.

**Challenge:** In the case of a cooperative game, the challenge factor is of great importance, since it is not an individual challenge, but a stimulus to teamwork. With the positive reception about this issue, it is possible to verify that the balance of the game reached the planned expectations for the same.

**Satisfaction:** There was a notable difference in the responses of this aspect to the first question, something that can be explained by the fact that the game needs to be played cooperatively, where thinking individually does not help players to progress during the game. The reception of the players according to the other questions was very positive, indicating that the objectives and rewards to be achieved in the game were well developed.

**Social Interaction:** When dealing with the primordial aspect of the game, social interaction had the best evaluation since players could easily lose if they did not interact with each other. Furthermore, in the observed matches, it was possible to notice that the victory was only achieved when there was some interaction between the other participating players.

**Fun:** Providing a pleasant experience was also one of the pillars in the game's development. The idea of serious games



**Figure 19.** Demographic information obtained with the validation survey.

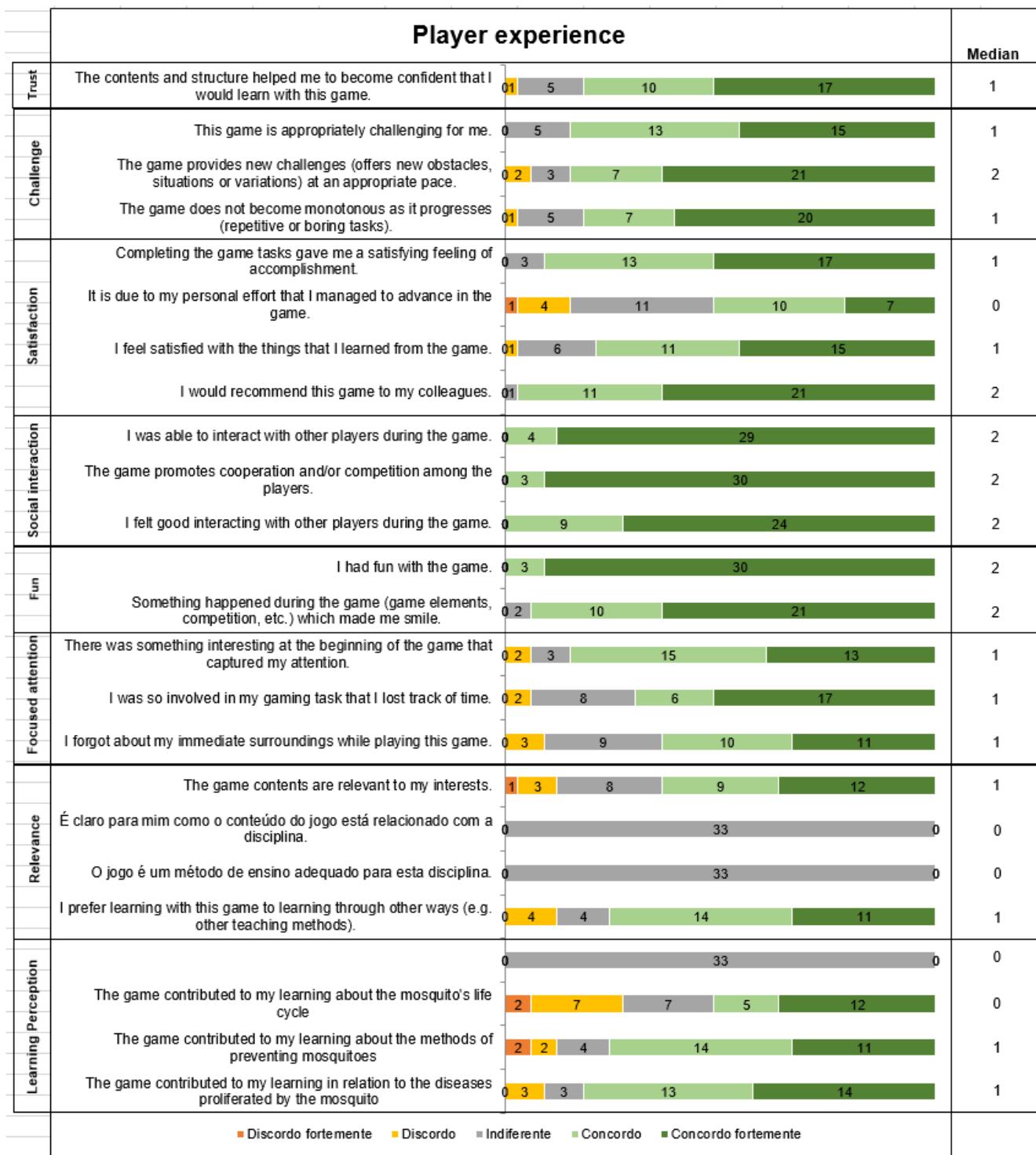


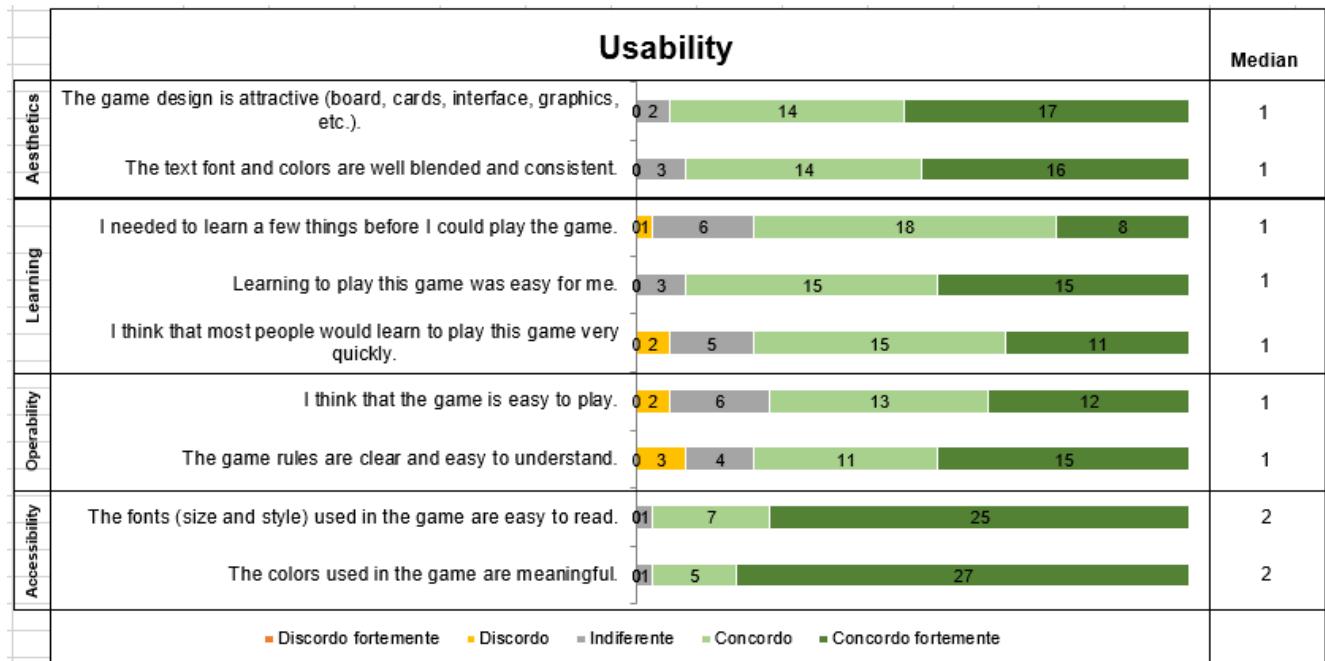
Figure 20. Questionnaire responses regarding the player's experience.

and fun would need to be linked to achieve the game's objective. Thus, the theme of the game was mediated for the players had fun, while learning to deal with the challenges of working as a team in the fight against *Aedes aegypti*, something that was confirmed based on the answers obtained with the questionnaire.

**Focused Attention:** Although the initial retention was not so positive, the immersion provided by the game captured the attention of most players, providing a certain level of unconcern with the time they were playing. However, due to the environment in which the games were tested, in this

case places where players receive different stimuli from several points, there is a relevant impact factor that may have resulted in lower responses than those previously obtained in the questionnaire, in this case with relation to the notion of the environment when playing.

**Relevance:** As the questionnaire is aimed at learning disciplines, and the game does not have a clear discipline linked to it, the questions offered by the questionnaire that address this aspect were not relevant. However, it is possible to notice a well-distributed assessment regarding the players interest in the topic of fighting mosquitoes, concluding that some



**Figure 21.** Questionnaire responses regarding game usability.

players, despite not having an interest in the respective topic, obtained a positive result concerning the questioning of learning obtained with the game.

**Perception of Learning:** Due to the difficulty in raising awareness about the problems that the mosquito brings to our society, some learning points presented some responses with greater disagreement than others, since they demanded information that was not in fact explicit in the game's texts or even embedded in the game's mechanics, such as the mosquito's life cycle. Concerning the question about diseases and their symptoms, this obtained a more positive result when compared to the others, something that can be explained due to the explanation that is made at the beginning of the gameplay about the symptoms that the player may suffer during a match.

**Aesthetics:** Considering the design, the ease of reading and the understanding of the game's information, they provided a very positive and consistent reaction according to the obtained responses, confirming as a result that the aesthetics of the game was pleasant to the evaluated players.

**Learning:** A very important point for a game to be considered good for the public is the simplicity of teaching and learning it. In this sense, when assessing how the players dealt with the amount of information they needed to understand (possible actions, game cycle, turn order, equipment effects), it is clear that the players acceptance for the Dengueside Survival rules were quite positive, although it is a game of moderate complexity, when compared to other modern and classic board games.

**Operability:** The operability requirements seek to determine how easy it is to play the evaluated game, as well as how simple and clear the rules are. Thus, working together with the "ease of learning the game", this issue also received a very positive feedback from the evaluated players.

**Accessibility:** Accessibility requirements assess whether the reading of the game components is clear and whether the

colors are clearly distinguishable. The game got a very positive response in this regard, although it was not played by any person with special needs during its evaluation.

Regarding the general comments made in the questionnaire by the players who tested the game, many indicated as strengths: the mechanics, the cooperation between players without making individual entertainment impossible, the unpredictability of the game, the individualities of each character to be played, the difficulty, the art, the possibilities of map variations bringing a high replayability factor, and the idea/design of the game itself as a whole.

Regarding the game's weak points, several comments about the lack of variety in some aspects of the game, such as enemies, maps and characters, were raised. Other players commented that there could be: a difficulty setting, specific rules for when a character dies in the game, and some discrepancies between the characters' art and their respective items. But the most pertinent commentary indicated that the game mechanics could better explain and address the mosquito's life cycle, since this topic is not so clear to those who do not have a prior knowledge on this subject. In addition, some people pointed out that "there were no weaknesses" in the proposed game.

Finally, after the acquisition of the players evaluation, a calculation was made for the quantitative evaluation of the quality of the game as a serious game. For this, an exploratory factor analysis was used with the Kaiser-Meyer-Olkin index and the Bartlett sphericity test, according to the R language script provided by MEEGA+ for this purpose. As a result, a score of 59.69 was obtained for the game Dengueside Survival, thus reaching the Good Quality level (for scores between 42.5 and 65) according to indicated criteria by the validation model applied.

## 5 Conclusions and Future Work

This paper presented the conception, design, construction and validation of Dengueside Survival, a serious board game aimed at raising awareness of the fight against the *Aedes aegypti* mosquito. It is a game that addresses the problem of awareness about fighting the mosquito in a playful and succinct way, so that players need to make continuous decisions with the health agents team to prevent the number of mosquitoes from growing indiscriminately.

Dengueside also integrates reliable elements into the game context of fighting against the mosquito, both in terms of the scenario itself, as well as the existence of people who do not believe in the problems that the mosquito offers to society as a whole. Furthermore, the game not only represents the difficulty that the behavior of non-collaborators brings to the prevention and combat of the mosquito, but it also shows how the diseases caused by the mosquito can affect the players themselves in different ways and with similar symptoms.

Regarding the proposed game missions, as the idea of the game is to make players aware of the fight against mosquitoes, Dengueside puts the player in the role of a health agent, causing him to understand, execute and perhaps create the practice of daily combating against the mosquito. There are also missions in the game where the residents avoid the access of health agents, increasing as a result the mosquito proliferation. This is a very common reality in Brazil, where “the refusal rates in these areas are very high, resulting in true islands of difficult intervention that not only remain infested but also avoid the elimination of the vector in surrounding areas” Teixeira et al. (1999). Moreover, as the game missions show the action of mosquito infestation in different social organized scenarios, Dengueside becomes an educational tool able to present the environmental contrasts of modern urban spaces that act in favor of the proliferation of mosquitoes that transmit dengue and related diseases Teixeira et al. (1999).

Regarding the validation data obtained from the questionnaires applied after the gaming sessions, it was possible to observe that the game obtained a high level of satisfaction and entertainment among the players evaluated. In addition, when assessing the quality of the game as a serious game, according to the proposed MEEGA+ model for evaluating digital and non-digital games, Degueside Survival obtained a score of approximately 59 points, classifying it as a Good Quality level game. something obtained by its awareness proposal that was able to meet the expectations in terms of fun provided by it.

However, some weaknesses pointed out by players still need to be corrected, such as the mosquito life cycle that must be followed before adding new mosquitoes to the game map. In fact, as the mosquito spreads according to the environment around it, its life cycle is varied and can go through up to four stages: egg, larva, pupa and adult form. According to environmental conditions, the phases from egg to adult form can occur from 7 to 13 days Beserra et al. (2009), indicating that the mosquito foci must be eliminated at least once a week to interrupt the mosquito's life cycle. In this sense, both in the game and in real life, this is an important knowledge for the population in the fight against mosquitoes that needs to be introduced in future versions of the proposed game.

As future work, it is expected to produce a complete digital version of the proposed game, with all rules and restrictions being defined and processed by it. The availability of an online repository for collecting gameplay data is also under development, as well as an online builder for future phases for it. A new name should also be applied to the game in a future version, in order to emphasize the fight against *Aedes aegypti* instead of highlighting just the name of one of the diseases transmitted by it. Finally, to complete the validation of Dengueside Survival, it is necessary to expand the target audience for the evaluation of the proposed game, especially with elementary school children and high school adolescents, who are more difficult to maintain attention and concentration over a long period of time.

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## Notes

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