The Mystery of Pandora: A Serious Games Approach With 360-Degree Videos on Domestic Violence Against Women

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ABSTRACT

Domestic violence against women has been a serious social and public health problem faced by contemporary society. This type of violence has grown in recent years, placing the woman not only as a victim of the aggressor but also of a sexist culture established over time. One of the ways to combat this problem is through prevention based on learning and awareness of its causes and damages. The use of 360-degree videos and immersive virtual reality (IVR) combined with serious games (SG) is a promising field of research in the educational field. They have the potential to provide more realistic and engaging environments, enhancing the engagement of their users, thus favoring more learning opportunities. This study presents The Mystery of Pandora, a SG that uses IVR and 360-degree videos to promote knowledge about domestic violence against women (DVAW). The game assessment results suggest a pedagogical potential for promoting knowledge DVAW. In addition, this work brings discussions about the benefits and techniques for the use of IVR and 360-degree videos in serious games.

KEYWORDS

360-Degree Videos, Cinematic Virtual Reality, Decision Model, Domestic Violence, Educational Serious Games, Game-Based Learning, Immersive Virtual Reality, Violence Against Women

INTRODUCTION

In recent years, domestic violence against women has been a significant social and public health problem faced by Brazilian society, and as such, it needs to be faced due to its severity (Freitas et al., 2013; Pierotti et al., 2018). Unfortunately, it can be observed that this type of violence is still a very rooted problem in Brazil, constituting one of the most common forms of violence suffered by women (Schraiber & d’Oliveira, 2002).

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Violence against women manifests itself in different forms of aggression, from physical violence to moral violence, such as slander and defamation. This type of violence needs to be fought, as it can cause severe damage to its victims and even lead to death. Many combat actions are still focused on treating the consequences of violence, particularly physical and psychological damage, making it difficult to approach the problem beyond the scope of health (Souza et al., 2016).

For Sousa et al. (2016), it is necessary to think about improvements not only in the effects of violence, but in the expansion of health promotion and prevention actions, that is, actions that can positively contribute to eliminating violence and still be followed by a cultural change. New pedagogical strategies must be developed to combat domestic violence against women, promoting knowledge about the causes, its forms of manifestation, and postures for its effective eradication.

Technologies with educational purposes can be a guiding thread for many of these actions, acting mainly in health education to transform knowledge. Among these, digital games with educational purposes are presented as a viable possibility to use in this context.

In the literature, it is possible to find several terms used to describe such games, but in this work, the term Serious Educational Games (SEG) will refer to all digital games with educational purposes. Serious Games (SG) have been standing out in this context. They can be used as pedagogical tools in the teaching-learning process and raising awareness (Almeida et al., 2018). They propose to transmit pedagogical content while the player plays, stimulating and encouraging it to progress and develop its skills or knowledge in a specific content (Dörner et al., 2016).

Recently, Immersive Virtual Reality (IVR) experiences, in particular 360-degree video, have become popular when it comes to engaging educational experiences (Rupp et al., 2019). The use of 360-degree videos can provide the user with a greater sense of immersion and presence, enabling more immersive experiences and enhancing player engagement. For Pirker et al. (2020), immersion is seen as an essential factor for learning in many studies. For example, Argyriou et al. (2016) and Ivkovic et al. (2018) show in their findings that immersion had a positive impact, allowing users to be more interested in learning more about the content presented in immersive 360-degree videos.

Therefore, the present study seeks to combine the benefits and potential of SGs in the teaching-learning process with the immersive potential of 360-degree videos to develop more realistic and engaging experiences. Such a combination can provide an immersive and interactive SG capable of strengthening the players’ affective aspects, allowing a greater understanding and reflection on the topic addressed and a greater awareness and learning. According to Bloom et al. (Bloom et al., 1976), all learning has an affective component, and that emotions and feelings can impact the willingness to interact and experience new experiences. Therefore, it is intended to enhance such components to favor the learning process.

This study presents the development and assessment of the serious game “The Mystery of Pandora”. The game was developed to enhance the affective aspects of the players to provide more significant learning and awareness about Domestic Violence Against Women (DVAV). The work aims to present a tool that can be used as a pedagogical resource in the educational sphere and to stimulate and promote a change in attitude and behavior in adolescents, young people, and adults regarding DVAV.

SERIOUS GAMES

Digital games have been used not only to entertain but for educational purposes. In the literature, it is possible to see that games with these characteristics are gaining more and more space and importance and are often treated as Serious Games (Felix et al., 2020). According to Dörner et al. (2016), a serious game is a digital game that was developed with the intention of entertaining and achieving at least one specific objective. Machado et al. (2018) understand this “specific objective” as a purpose that must exist in the game beyond entertainment, taking as an example assistance in educational processes, physical rehabilitation in patients, treatment of phobias, and awareness of themes, among others.
Conceptually, SGs seek to achieve a purpose beyond fun and entertainment. However, this does not mean they cannot be fun (DÖRNER et al., 2016). According to the author, it is important that Game designers, programmers, artists and domain specialists (e.g. educators) work together throughout the SG development process and, with that, can produce an engaging game that has a balance between playful aspects and education in a way that enhances player engagement.

The task of trying to balance playful and educational aspects in an SG is not simple. It requires understanding how these games can be designed in order to enhance the player’s experience and positively support the learning process. The first step is to think about the fundamental points in the construction of a game, regardless of being an SG, and in this sense, Schell (2014) presents the elementary tetrad or the four basic elements of the design process of a game, which according to the author, they are fundamental for its conception, they are: mechanics, it consists of the procedures and rules of the game, specifies the objectives of the game, as well as, actions necessary to reach it; narrative, symbolizes the sequence of events that occur in the game world (story); aesthetics, concerns the stimulation of the senses (sight, hearing and touch) provided by the game, such as the appearance, sounds and sensations of the game; and technology, with respect to software and hardware artifacts that make the game possible, such as the game engine, controls, among others. Regardless of the game that will be developed, each of the four elements has its due importance, none is more important than the others (Schell, 2014).

Machado et al. (2018) also emphasize that in SG it is important that the purpose and pedagogical aspects are related to the tetrad of the four elements, while the game provides the development of the skills and competencies expected for the player. According to Machado et al. (2018), understanding the specific content (the purpose) is the central point and starts to play a fundamental role in the SG design process.

SERIOUS GAMES IN THE COMBAT DOMESTIC VIOLENCE AGAINST WOMEN

DVAW is usually referred to as acts of physical violence, sexual violence, emotional abuse, and behavior control, which are usually practiced by an intimate partner (Brazil. Law No. 11.340, of August 7, 2006. Maria da Penha Law. Brasília., 2006). It is a problem that affects women regardless of age, ethnicity, or social status (Hasse & Vieira, 2014). As previously mentioned, innovative educational strategies can be used to promote knowledge and awareness, minimizing the internalization of the patriarchal culture rooted over time. New technologies such as Serious Games can encourage empathy and change attitudes that contribute to facing and combating DVAW (2018; Felix et al., 2020).

Although SGs are used efficiently in the most varied areas of concentration, there is still a shortage of games that address the problematic domestic violence against women (Almeida et al., 2018; Felix et al., 2020). For example, Almeida et al. (2018) present the serious game “Pandora’s Box.” The game was developed to run on a personal computer with the objective of training health professionals both in the identification of women in situation of domestic violence and in the construction of new knowledge to guide changes in practices. In addition, the game makes it possible to disseminate concepts related to DVAW, as well as to promote greater reflection on the subject. The game features scenes with passages from the life of the character Marta. The story unfolds in three levels according to the character’s life stage: childhood, adulthood with a partner and children, and adulthood as a victim of partner violence. Figure 1 presents one of the screens that make up a game scene.

In Felix et al. (2020), the SG Pandora’s Box Mobile was developed. The game is the redesign of Almeida et al. (2018), adapting it to run on mobile platforms that use the Android operating system. In this version, the target audience has been expanded to individuals over 13 years of age. According to the authors, the motivation to migrate the original game to a mobile platform was due to the understanding that: 1) there is still a great lack of tools that address this issue; 2) because it can expand access and acquisition of knowledge, both for health professionals, students and society in general; and 3) for making the application available through mobile technology whose access can occur anywhere and at any time. Figure 2 illustrates an example of an interface worked on in the game’s challenges.
The game was validated with a sample (n=60) of high school students. For Felix et al. (2020), the statistical results suggest the game’s potential to promote knowledge. Figure 3 illustrates one of the validation moments with the students.

Smith et al. (2017) presents the game Jesse. The game is intended to make its users aware of domestic violence’s impact on all involved. Jesse was designed to offer a simple mouse-controlled interface where players can point and click to move around the scenarios and interact with objects, allowing users inexperienced with computer games to use it. The game has five levels. Each level takes place in a different environment in which the player takes control of a new story-related character each
time. Level 1 introduces the characters and basic game mechanics (Figure 4). In level 2, the player takes on the role of a nurse and takes place in the hospital where Jesse’s mother was admitted after suffering physical violence from her partner. At level 3, the player takes on the role of Jesse’s teacher and takes place at his school. Level 4 takes place in a pool hall with a dialogue between Jesse’s mom’s husband and his best friend. Finally, at level 5, players (in the role of Jesse’s mother) have the option to determine the outcome of the story based on the information they have gathered in previous levels.

Despite the scarcity, it is possible to observe that these works tend to address the problem of domestic violence in an increasingly younger audience. While in Almeida et al. (2018), the focus is on attention and care for the consequences of DVAV, in Felix et al. (2020) and Smith et al. (2017), the approach is carried out in an increasingly younger target audience. These works follow the path of education and awareness as important elements to challenge the norms of acceptance of domestic violence before adolescents, pre-adolescents, and young people internalize them. It is essential to identify and avoid violent attitudes and behaviors that can perpetuate the sexist and patriarchal culture present in abusive relationships that trigger violence. Targeting children and youth in such games seems crucial to transforming societies and creating a more lasting change in the situation of women and men, thus contributing to the elimination of this serious social and public health problem.

Figure 3. Validation of Pandora’s Box mobile

Figure 4. Jesse at Level 1
SERIOUS EDUCATIONAL GAMES BASED ON 360-DEGREE VIDEOS

Given the interest of people of the most varied age groups (children, young people, adults, and the elderly) in digital games and research indicating their potential in the teaching and learning process, it is essential to explore new resources that can increasingly strengthen this process. Among these resources, technologies associated with virtual reality are becoming popular and arousing interest in the sense of combining their potential with serious educational games. One of these is 360-degree videos. Interest in the use of 360-degree videos has emerged along with the advancement of low-cost technologies and increased video content on online platforms (e.g., YouTube) (Snelson & Hsu, 2019).

It allows users to explore their content in all directions, similar to what happens with human vision, thus enabling a greater sense of immersion and presence and, consequently, more engaging experiences. In addition, they can promote cognitive learning, as presented in studies by Araiza-Alba et al. (2021) and Gold and Windscheid (2020).

According to Fokides et al. (2020), the characteristic of presenting real environments makes 360-degree videos a suitable tool for application areas in which a high degree of realism and safety are required such as in biology, engineering, in sciences of health and education. This characteristic is evident in different scenarios and applications in various studies. For example, in medical training in obstetrics (Arents et al., 2021), At guiding the use of operating rooms (Fukuta et al., 2021), At training nursing students in the treatment of trauma patients (Herault et al., 2018), in developing water safety skills for children aged 10-12 years (Snelson & Hsu, 2019), and in teaching soil and water conservation (Tsai et al., 2020).

With regard to the educational context, all these works have educational purposes in their conception, whether for professional qualification/training or teaching. The results obtained from the tests with users of these applications points to several benefits regarding the use of 360-degree videos, corroborating the findings of (Snelson & Hsu, 2019), such as high levels of immersion and presence, greater interest and involvement, engagement with the learning experience, as well as the perception of increased knowledge.

Therefore, combining SEGs and 360-degree videos seems to be a promising proposal, especially for offering more realistic and attractive experiences (Argyriou et al., 2016), allowing the player to be more actively involved with the story instead of just observing. However, although the educational potential of 360-degree videos is emphasized by several studies (Barsom et al., 2020; Fokides & Arvaniti, 2020; Snelson & Hsu, 2019), there is still little empirical evidence to support this claim (Fokides & Arvaniti, 2020) since these studies are pretty scarce, mainly due to their recent popularity. It is opportune to move forward along this path to expand the development and access to tools that are capable of promoting more effective educational benefits. In this case, the SEGs can contribute positively as, according to Dörner et al. (2016), they are environments capable of creating fun experiences that can motivate and generate greater interest and curiosity in the content covered, thus favoring the educational objectives intended by the game.

Regarding the development of SEGs with 360-degree videos, it is possible to identify that there is still a significant shortage. Most of the works found in the literature are gamified environments; they are environments that only incorporate some game elements, not addressing all the facets that make games important applications to aid teaching and learning. For example, in Barsom et al. (2020), a virtual environment with 360-degree videos was developed for Cardiopulmonary Resuscitation (CPR) training, in Argyriou et al. (2016) a conceptual framework for gamification for VR applications in environments with 360º videos, and Ivkovic et al. (2018), an environment with 360º videos was developed to present the cultural heritage of bridges in the city of Sarajevo, Bosnia.

From the works cited, it was possible to observe that the contents presented in gamified environments with 360º videos suggested the improvement of immersion and engagement of users, as presented in Argyriou et al. (2016), Ivkovic et al. (2018). There was also greater retention of knowledge in such environments when compared to the use of traditional videos (2D), according to the results of Barsom et al. (2020). These results align with the benefits listed by (Fokides & Arvaniti, 2020; Snelson & Hsu, 2019), making these technologies promising resources to act in teaching and learning processes based on digital games.
METHODOLOGY

To achieve the objectives of this study, the methodology contemplates four phases: 1) literature review; 2) construction of assessment instruments; 3) implementation of the SEG; and (4) assessment.

1. **Literature Review:** The objective of this step was to provide a broader view of the problem addressed in this work. As a result of this step, it was possible to observe that there is still a significant lack of games that address the issue of violence against women and that there is a tendency to direct them to an increasingly younger audience. In addition, it was also found that the use of IVR and 360° videos in SEG is still incipient; however, the results found in the literature highlight the potential of these technologies for the SEG universe, especially concerning player involvement.

2. **Construction of assessment instruments:** At this stage, two instruments were built, one to assess player satisfaction and the other to assess the pedagogical potential of the game. Regarding satisfaction, the GameFlow model (Sweetser et al., 2017) was used with some adaptations, especially about factors, presence, and knowledge. For presence, eight questions selected and adapted from the presence questionnaire (QP) of Witmer and Singer (Witmer & Singer, 1998) and the Player Experience of Need Satisfaction – PENS (Rigby & Ryan, 2007) were included. As for the knowledge factor, five questions from the EGameFlow model (Fu et al., 2009) were included and adapted. Regarding the pedagogical potential, the instrument by Almeida et al. (2018).

3. **Development of the SEG:** The development stage took place in seven stages arranged as follows: (a) Scope definition; (b) Development of scenarios; (c) Planning and writing scripts; (d) Production of 360° scenes; (e) Definition and implementation of the intelligent model; (f) Software implementation; and (g) Preliminary tests.

4. **Evaluation:** Finally, in the fourth stage, an evaluation was carried out with 52 users to verify its efficiency in relation to the pedagogical aspects (learning) and the satisfaction (experience) of the participants. The objective was to verify the pedagogical capacity of the SEG after its use. Then, the player’s perceived satisfaction was evaluated from the adapted GameFlow model.

THE MYSTERY OF PANDORA

The Mystery of Pandora was conceived as a Serious Educational Game (SEG) in immersive virtual reality that makes use of 360° videos. The game’s objective is to combine the benefits of SEGs and 360° videos to enhance the affective aspects of the players, favoring the educational and awareness process regarding the problem of domestic violence against women. The game works on three fundamental technological approaches: (1) virtual reality, (2) 360° videos, and (3) immersion.

1. **VR:** All environments and objects that make up the game were simulated in 3D, as illustrated in Figures 7-10. The player will be able to freely navigate and interact in real time with the environments;
2. **360-Degree Videos:** All the game’s challenges were recorded in 360-degree videos. The videos simulate situations of violence against women and are used to address the educational content of the game. Visualizing these situations can provoke feelings and emotions in the player, leading to greater reflection and empathy. The player must immerse and explore the situations staged in the videos to complete the challenges presented in the game.
3. **Immersion:** The player must move within the game’s virtual world and interact with its objects (3D environments and 360-degree videos) using VR glasses. The game was developed to run on a smartphone on an Android platform using glasses for low-cost immersive VR (Figure 5). The objective is to democratize access to the game and expand the reach of knowledge.

In the game, the player is invited to immerse himself in a more realistic virtual world to explore situations of violence against women. The game challenges the player to reflect on DVAW and build
critical thinking about the possible causes and factors that favor such violence. In addition, it seeks to promote greater empathy and behaviors capable of changing attitudes that contribute to the growth of this serious social problem. Figure 6 illustrates the game login screen.

To achieve goals, some requirements had to be established to meet the basic functionalities designed for the game. Table 1 presents a summary of the main requirements.

The educational purpose of the game is to broaden knowledge about concepts that permeate the DVAW and the awareness of this serious social problem in the most varied user profiles (adolescents, young people, adults) and social strata. To approach this theme, the narrative brings as a background the story of a criminal investigator who receives the mission to work on a murder case of a woman, henceforth named Marta. In addition to the clues in the investigator (player) room, called the evidence room, he must look for important information hidden in the police station environment. The player needs to explore the police station in search of this information as it can strengthen their knowledge.

Figure 6. Game login
and critical thinking for the analysis of the case. The Mistery of Pandora design considered a game ambience based in two approaches: a VR environment to set the story and VR 360-degree videos to present Marta’s memories. The VR environment aimed to allow the player to freely explore a police station setting to obtain information about the case and the topic of violence against women. The VR with 360-degree videos, on the other hand, aimed to allow the player to experience the problem of violence in a realistic way in accessing the character’s memories. The videos and tasks associated were based on scenarios designed by Almeida et al. (2018).

Figure 7 shows the interface of the reception/service room of the police station in 3D, where the player will have access to the features of the game, being able to view options such: as 1) Evidence Room, 2) Reports of concepts, and 3) statistics about DVAW, Historical facts, among other options.

Table 1. Functional requirements

<table>
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<tr>
<th>Id</th>
<th>Requirements</th>
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<tbody>
<tr>
<td>R1</td>
<td>Allow the player to view the game first-person;</td>
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<tr>
<td>R2</td>
<td>Allow free exploration of challenges without a fixed navigation route for the player;</td>
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<tr>
<td>R3</td>
<td>The game must present scenarios with 360-degree videos that simulate situations of violence against women on different occasions of their daily lives (environments: home, school);</td>
</tr>
<tr>
<td>R4</td>
<td>Possess an intelligent model capable of evaluating the player according to their attitudes and postures during the execution of the game;</td>
</tr>
<tr>
<td>R5</td>
<td>To be able to set up a pedagogical reinforcement strategy in case the player does not obtain an expected performance and, in this way, promote more significant learning;</td>
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<tr>
<td>R6</td>
<td>Offer an immersion mechanism (adapting scenarios, sounds) in the game world as a function of player interactions (player context);</td>
</tr>
<tr>
<td>R7</td>
<td>Allow player interaction with the scenario from the Gaze interaction concept.</td>
</tr>
</tbody>
</table>

Figure 7 shows the interface of the reception/service room of the police station in 3D, where the player will have access to the features of the game, being able to view options such: as 1) Evidence Room, 2) Reports of concepts, and 3) statistics about DVAW, Historical facts, among other options. Figure 8 shows the same screen (Figure 7) with a stereoscopic vision seen by the player using the VR glasses. To access any options, the player must look at the interaction icon using the Gaze pointer (the location they are looking at) and choose the desired option.
The Pandora Mystery was set in an abstract universe corresponding to the character’s memories. The memoirs address three significant categories of the DVAW theme: (1) Gender, (2) Human Rights, and (3) Health, as pointed out by Almeida et al. (2018). In the evidence room, the player will have access to one or more evidence of the case. On each evidence, the player is immersed in memory. Figure 9 shows the evidence frame that randomly generates a set of evidence that the player should explore. The memory can portray one or more situations of violence (evidence) suffered by the character throughout her life, whether in childhood, adolescence, or adulthood. Figure 10 summarizes case data that can be accessed in the evidence room.

Evidence is a challenge (task) in the game. The evidence is built from 360-degree videos where situations of violence are staged. In each video, 3 DVAW situations are presented, distributed in areas of interest (Figure 11).

The player must explore the zones of interest, analyze each evidence present in the video, and present their point of view by answering a question about the visualized evidence. Figure 12 illustrates a panoramic image of the environment used to stage the evidence (challenges). Each evidence occurs in a zone of interest, zones 1, 2, and 3. The human actors are distributed in the zones of interest so that the player can explore each one of them and experience situations of violence.
For example, Figure 13 illustrates a challenge from zone 1 (Figure 12), which depicts a situation of violence experienced by the character Marta in her childhood. Figure 14 shows a question that contextualizes the evidence presented (Figure 13) and alternatives for the answer. The player must
choose the answer that he thinks is most appropriate, then receive feedback (called reflection) to reflect on his choice. Action should be taken in the light of the evidence presented to facilitate learning about violence against women.

It is intended that the player goes through experiences lived by the game’s character and can perceive and internalize essential values for the fight against violence against women through his experiences. Unlike traditional clues (investigating crime scenes), the game allows the player to immerse and revisit the character’s memories (memories) in order to understand what led her to this tragic end and also discover the big culprit in the story. In the end, the player discovers that the big question is not who but what was responsible for the character’s death (Marta).

In order to improve the learning process in the game, an intelligent model was implemented that works on three aspects: i) performance evaluation, ii) pedagogical reinforcement, and iii) immersion. Figure 15 shows the basic architecture of the model.
• **TCT Component:** Evaluates the player’s performance during the resolution of challenges based on the Classical Test Theory;

• **Pedagogical Component (PC):** Responsible for reinforcing the player’s knowledge of the concepts used in the game’s challenges; and

• **Immersion Component (IC):** Aims to enhance the player’s immersion in the challenges presented with 360-degree videos to strengthen their engagement. It is responsible for collecting data regarding the player’s experience (e.g., spatial, temporal, and performance context) to favor their involvement and make this data available to the other components of the model. CI uses positive reinforcement strategies to maximize player engagement. The goal is to create stimuli so that he can feel part of the experience as a whole, encompassing all his attention.

When a player does not achieve the expected performance, that is, a score necessary to complete the investigation, it is understood that part of the concepts addressed on the subject of DVAW has not yet been well internalized. Therefore, to provide greater chances of internalizing such concepts, the intelligent model (Figure 15) implements pedagogical reinforcement strategies, mainly verifying the difficulties encountered about the presented contents. The model evaluates the player’s performance and suggests, when necessary, a pedagogical reinforcement to overcome such difficulties.

This reinforcement is given by selecting new challenges that the player must fulfill. Each new challenge is suggested based on previous individual performance. It is intended to suggest challenges with the most significant possible degree of similarity to favor learning in concepts with a greater degree of difficulty. Several techniques are used to determine the calculation of similarity between objects (challenges). However, in this work, the k-Nearest Neighbors-KNN technique was adopted because it is simple and efficient to calculate the similarity as highlighted.
The pedagogical component carries out this assessment. It assesses the player’s level of knowledge not only by its score (produced by the TCT component) but also by analyzing the exploration (produced by the immersion component) of pedagogical elements of the game that are present in the player’s experience. The evaluation is carried out under two prisms. The first is individual performance (score) in the answers to the challenges. The second is the level of exploration of the pedagogical elements that make up the challenge: elements of exploration and player immersion.

Regarding the exploration elements, they were organized and used as follows: 1) time to view the challenge (360º video), 2) time to view the question, and 3) time to view the pedagogical feedback of the challenge. Evaluating the exploration of these elements allows us to verify the player’s behavior in relation to the time spent exploring the scene. For example, not comprehensively viewing the video that presents a particular game challenge can lead to difficulties in understanding the challenge itself (evidence) and the loss of important information for learning. It is possible, for example, to verify if certain areas and elements of exploration in a 360º scene were explored (Figure 16) and, based on this information, make some decisions relevant to the game.

Another exploration element implemented was Audio Adjustment. The game monitors the player’s spatial location and acts on the audio in each zone of interest in the 360-degree scene. Based on the location, the sound volume of the speeches of the human actors is automatically adjusted, varying in intensity according to the exploration of the environment, as illustrated in Figure 16. The objective is to attract attention and keep focused on the challenge and other elements of the area (zone) being explored.

Figure 16. Exploration of areas of interest and exploration elements

Figure 17. Adjusting audios in zones of interest
However, it is observed that the dynamics of temporal exploration can present a high degree of uncertainty. In other words, there are no guarantees (certainty) that the player will always use the ideal time to explore the challenges (viewing the videos, reading the questions and answers, reading feedback, exploring the environment). Such uncertainties may impact the final assessment of the player’s performance and the knowledge obtained. In the pedagogical component, these uncertainties are dealt with by implementing two fuzzy systems, one being responsible for inferring the type of exploration and the other for making the performance evaluation of the player. This evaluation determines if the player needs pedagogical reinforcement, if he managed to unravel the mysteries of the case or if he needs to start over (game over).

Regarding the construction of the design, elements that could enrich the player’s experience with immersive 360-degree videos were considered, among them, some based on the writings of Argyriou et al. (2020):

- **Narrative:** Clear definition of the story. Audiovisual elements were used throughout the game that referred to the problem of DVAW. For example, in the game’s opening, the player is immersed in a sequence of images and sounds that portray situations of domestic violence against women.

- **Scripts:** Planning the scripts and actions of the human actors in the scenario. In addition to the writing of the lines, other elements were added in the composition of the scripts that could attract and direct the player’s attention to some points of interest in the scene. For example, movement of actors between zones of interest and use social cues; that is, the actor speaks and gestures towards another or towards his zone of interest to attract attention to a specific point in the scene. These elements can enhance attention and provide greater immersion and engagement while performing tasks.

- **Layout:** Position and distribution of objects in the scene to create visual guidelines for the player, composing a dynamic field of vision based on their movement. In addition, the use of graphic elements and visual markers can favor the composition of the layout and make the player’s exploration more dynamic. Figure 12 presents a graphic element that allows the player to respond to the task determined in the zone of interest, pause, and visualize the scene again.

- **Camera Location and Positioning:** The position where the player can view the other characters and other elements of the scene. The player’s point of view must be considered, as that is what you will see first. It is essential to define the camera’s location so that the distance between the player’s view and the elements (actors, objects) of the zones of interest can be visible. Therefore, questions of the depth or distance of the actions taking place in the scene must be considered. In this work, the camera was centered with a radius of 2.5 meters. Figure 11 illustrates the strategy used, where the player’s image represents the exact location of the camera.

- **Definition of POIs:** Definition of points of interest. POIs represent specific points that want to direct a player’s attention. POIs can be worked on in the scripts or with audiovisual elements in the scene after recording, that is, in the integration of the video with the game environment using a game engine.

- **Navigation:** Work transition and progression between 360-degree videos. Transition can be performed smoothly, transporting between scenes, for example, using camera movement techniques such as zoom-in and zoom-out.

- **Gamification:** Definition of challenges/tasks, achievements, and level development in the game. This step is important because it makes it possible to add elements to the 360-degree videos that are part of the gaming universe. For example, elements that refer to the execution of tasks (Ex. Figure 14), medal conquests, and feedback on the game progress.

**EXPERIMENT DESIGN**

The assessments of the game The Mystery of Pandora were carried out in person, in which 35 (67.3%) of the respondents were evaluated at the Hospital Juliano Moreira (HJM) located in the city of João
Pessoa-PB, in Brazil, and 17 (32.7%) assessments at the respondents’ homes. We sought to evaluate the game in terms of pedagogical aspects (learning) and the satisfaction (experience) of the participants.

The research participants were health professionals from the HJM, professionals, and students. For each participant, a protocol was adopted with the following steps: a) a dialogic exposition presenting the test team and the research objectives; b) sterilization of equipment and materials used during the evaluation and c) game testing and application of questionnaires. The assessment lasted approximately 45 minutes. Table 2 presents a detail of the procedures adopted in the test protocol. Figure 18 shows moments when the game was tested on the HJM premises.

Two instruments were developed to evaluate the pedagogical and affective aspects and others to analyze the user’s satisfaction with their experience with the game. The pedagogical aspects were

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<th>Procedure</th>
<th>Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposition of the themes and objectives of the evaluation</td>
<td>3</td>
</tr>
<tr>
<td>Sterilization of equipment and materials: glasses and headphones</td>
<td>3</td>
</tr>
<tr>
<td>Application of the questionnaire (pre-test)</td>
<td>5</td>
</tr>
<tr>
<td>Ambience with the game</td>
<td>5</td>
</tr>
<tr>
<td>Play the game</td>
<td>15</td>
</tr>
<tr>
<td>Application of the questionnaire: pedagogical evaluation (Post-test) and satisfaction.</td>
<td>15</td>
</tr>
</tbody>
</table>

Figure 18. Game assessment moment
evaluated by the questionnaire developed by Felix et al. (2020), previously adapted from Almeida et al. (2018). This instrument seeks to verify whether there has been a change in the participants’ behavior in relation to the responses of the pedagogical and affective dimensions. Regarding the participants’ level of satisfaction, a GameFlow questionnaire adapted from Sweetser and Wyeth (2017) was used, which initially consisted of the following factors: concentration, challenge, skills, control, clear objectives, feedback, and immersion. For the application of this questionnaire two new factors were inserted: i) presence and ii) knowledge. These factors can be seen in Table 3.

Each participant tested the game individually using VR goggles, headphones, and a smartphone provided by the testing team. Regarding the application of the instruments, this occurred at two different moments. In the first, an instrument was used to evaluate the pedagogical and affective aspects of the participant in relation to the theme of the game. In a second moment, after playing the game, two more instruments were applied: 1) post-test referring to pedagogical and affective aspects and; 2) the questionnaire to measure satisfaction/experience.

RESULTS AND DISCUSSION

The game was evaluated by a sample of 52 users (N=52, aged between 13-63 years, M=33.55, SD=12.4) composed of professionals from a public health institution (n=35), students, and professionals from various fields (n=17). Table 4 presents a summary of the sample data.

Table 4 shows a predominance of female users (67.3%) aged between 25 and 39 years (30.8%). As for academic training, it can be observed that there was a prevalence of users with incomplete higher education (34.6%). It was also found that the majority (36.5%) are not in the habit of playing games. However, the habit of consuming games has been increasing over the years, as shown by the Game Brazil Survey (2021), which found that about 72% of Brazilians play games. In addition, women are the majority, representing 51.5% of the players.

Table 4 also shows that only 15.4% of users had already had some experience with 3D games or virtual reality glasses. This data is in line with the findings of the Game Brazil Survey (2021),

Table 3. New factors inserted

<table>
<thead>
<tr>
<th>Presence</th>
</tr>
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<tbody>
<tr>
<td>P1. When playing, I feel transported to another time and place.</td>
</tr>
<tr>
<td>P2. The interaction with the game makes me feel like I’m really there.</td>
</tr>
<tr>
<td>P3. When playing the game I feel like I’m part of the story.</td>
</tr>
<tr>
<td>P4. I had reactions to events and characters in the game as if they were real.</td>
</tr>
<tr>
<td>P5. I felt that the visual aspects (images, cutscenes, etc) involved me in the subject matter of the game.</td>
</tr>
<tr>
<td>P6. I felt that the sonic aspects involved me in the subject matter of the game.</td>
</tr>
<tr>
<td>P7. I quickly adapted to the game’s story.</td>
</tr>
<tr>
<td>P8. I felt that the visual aspects of the game distracted me as I played.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>K1. I felt that the game expanded my knowledge on the topic of domestic violence against women.</td>
</tr>
<tr>
<td>K2. I understood what were the basic ideas of the knowledge discussed in the game.</td>
</tr>
<tr>
<td>K3. I realized that I had to apply my knowledge of domestic violence against women to the game.</td>
</tr>
<tr>
<td>K4. I felt motivated to use the knowledge acquired in the game in my daily life, outside the game.</td>
</tr>
<tr>
<td>K5. The game provoked in me the need to learn more about the problems related to the issue of domestic violence against women.</td>
</tr>
</tbody>
</table>
in which it was observed that Brazilians are still a minority (27%) who have played games with VR devices. However, although this percentage is minor, in assessment the SG Mystery of Pandora, no impediments were observed that could compromise the progress of the tests.

**Player Satisfaction**

This evaluation aimed to assess the player’s feelings of satisfaction with their experience with the game. For this purpose, an instrument based on the GameFlow questionnaire was used (Sweetser et al., 2017). In this new instrument, new factors were added, and with this, it was necessary to verify the instrument’s level of reliability or discriminatory power. Because of this, the reliability test was
adopted based on internal consistency analysis through the calculation of Cronbach’s alpha. Table 5 presents the internal consistency analyzed using Cronbach’s Alpha values. This analysis showed significant values (≥0.70) for the adapted GameFlow instrument, that is, $\alpha=0.872$. Thus, it is observed that reliability is acceptable for the instrument’s adequacy for this population.

Regarding the evaluation of satisfaction, it is possible to observe in Figure 19 that most of the factors were very well evaluated. In particular, the factor Knowledge with the highest average ($M=4.77$) and other factors was reasonably equivalent.

From the results illustrated in Figure 19, it is possible to verify that the results are satisfactory in most of the analyzed factors. Among the nine factors evaluated, seven present averages higher than 4.0 and 2 factors with averages close to 4.0 on a scale ranging from 1 to 5. These results are promising as, as a rule, high average values in each factor indicate that the game provided the appropriate circumstances to enhance the player’s experience in the game (Kiili et al., 2012).

Regarding the individual assessment of factors, Knowledge presented the best result among the others, with an average of 4.77. This factor analyzes the player’s opinion regarding their perception of learning about the theme presented in the game. The result shows that some strategies implemented in the game may have potentiated this performance, such as monitoring the player’s experience in real-time, motivating him to engage in the presented theme, and elaborating pedagogical reinforcement to increase the chances of learning. Therefore, the result obtained in the Knowledge factor may indicate that such strategies may have favored the perceived satisfaction of learning during the experience with the game.

With regard to Concentration, Sweetser and Wyeth (2017) point out that several game elements can influence concentration levels, such as audiovisual resources, graphic quality, engaging scenes,

Table 5. Cronbach’s alpha for adapted game flow

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Cronbach’s Alpha</th>
<th>CI 95%*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adapted GameFlow</td>
<td>0.872</td>
<td>0.797 - 0.930</td>
</tr>
</tbody>
</table>

*Confidence Interval

Figure 19. Player satisfaction
workload compatible with the players’ skills, among others. The results obtained in this factor show that such elements had positive impacts on the evaluation of the game, allowing it to reach the second-best average with 4.54. The use of 360-degree videos and the mechanics of attracting and targeting the player implemented in the immersion component may have intensified levels of concentration.

The Immersion factor obtained an average of 3.87. GameFlow immersion primarily assesses player engagement in which they feel part of the experience. The good result in this factor corroborates the findings found by Ivkovic et al. (2018), Argyriou et al. (2020), which point out that the use of 360-degree videos can increase immersion levels. However, according to Felix et al. (2020) and Argyriou et al. (2020), it is necessary to minimize obstacles encountered in using this media, especially regarding maintaining the player’s focus. It is essential to create mechanisms to alert about the need to correctly explore some game elements, offer personalized Feedback to facilitate player engagement, and provide greater involvement with the environment.

The Presence factor was evaluated with a mean of 3.79. This factor concerns how much the player feels present and immersed in the game world. The use of 360-degree videos in SEG with VR glasses can favor the feeling of presence. However, it is necessary to develop elements in the design of 360-degree environments that enhance this sensation, such as perception of realism, ease of exploring the environment, control of virtual objects, and emotional or affective responses. Pandora’s Mystery uses 360-degree videos and implements these design elements in its sets. However, it is worth noting that the feeling of realism was one of the points penalized in this evaluation because, for some players, the low quality of the images of the 360-degree videos did not provide the feeling of being present in the scene. This factor can demotivate the player to stay in the game.

The Feedback factor was well evaluated with an average of 4.07. Feedback primarily assesses whether the game provides adequate information about the player’s actions and progress (Fu et al., 2009; Sweetser et al., 2017). The feedback in the decision model was designed with the objective of supporting players in the selection and display of relevant information during the game. The feedback is customized for each player based on their experience using context information perceived by the immersion component, such as spatial, temporal, and performance context. Personalizing feedback can encourage and support a player’s self-assessment so that he feels confident and creates new interactions. This trust can generate new exploration in the game environment, interactions with other virtual objects, and unexplored points of interest, among other interactions.

The Challenges factor assesses whether the game’s challenges are in balance with the player’s skill level (Sweetser et al., 2017). The average achieved in this factor was 4.36. This value indicates that equilibrium has been satisfactorily achieved. The challenges were designed from 360-degree videos with punctual interventions (addition of audiovisual elements) without overloading the player, trying to keep him always involved or engaged in the game. In addition, strategies were implemented by the pedagogical component of the game’s decision model to favor this balance, that is, to recommend new challenges based on the player’s skills. Another aspect to be observed in the evaluation was the Control factor, which obtained an average of 4.49. This factor mainly evaluates the control of the player’s mechanisms to perform their actions in the game (Sweetser et al., 2017). In the game, the player needs to select buttons, access menus, move between scenarios, explore scenarios, and select virtual objects. All these actions are performed/controlled by pointing with the Gaze mechanism. Although most participants (players) had no experience with the technologies presented, especially with VR glasses and interaction by pointing (Gaze), there were no significant problems during the evaluation.

As for the Skills factor, the average was 4.30. This factor works from the player’s perspective to develop their skills while playing. It mainly evaluates elements in the game that can enhance these skills. For example, the existence of help, gameplay, and perception of increased knowledge. It is observed that some elements that address the evolution of the player’s knowledge (m=4.77) and the balance of the challenges (m=4.36) of the game were very well evaluated. In this case, they may have positively impacted the Ability factor.
Regarding the Goals, this factor obtained an excellent evaluation with an average of 4.12. They provide players with a clear understanding of the game’s story and the justification for the player’s actions. The goals were presented during the opening of the game and in the scenario that presents the player’s mission. Therefore, the value obtained in this factor portrays the effort employed in the elements that aim to favor the understanding of the game’s objectives.

Pedagogical Analysis

In order to verify if there was a change in the behavior of the participants in relation to the responses of the pedagogical and affective dimensions presented in the two different moments of the tests (pre and post-test), an analysis of the performance of the participants was carried out considering the average of the global scores achieved in both tests. In the pre-test, the average was 6.73, while in the post-test, the average was 7.01. To better observe the behavior of this performance, the same methodology used by Almeida et al. (2018), in which the overall scores are classified according to the following criteria: Insufficient (up to 5.0), Regular (5.01 to 7.5), Good (7.51 to 8.5) and Excellent (8.51 to 10.0). Figure 20 shows the participants’ performance before and after the game play experience.

Although the results (Figure 20) point to an improvement in the participants’ performance, it is not possible to draw more significant conclusions, regarding the comparison of scores obtained in the two moments (pre and post-test) and to state whether there was statistical significance. Thus, the Wilcoxon test was applied. The Wilcoxon test was adopted because the sample data did not follow normal distribution. The test analyzed the following hypotheses:

- $H_0$: The medians of the global scores are equal before and after the participants’ contact with the game;
- $H_1$: The medians of the global scores are different before and after the participants’ contact with the game.

The statistical results of the Wilcoxon test showed a p-value less than 0.05. Therefore, $H_0$ was rejected and concluded that there is a significant difference between the medians of the global scores before and after the experience with the game corroborating the results found by Almeida et al.
Consequently, it is possible to affirm that the statistical results show that there were changes in the participants’ responses. With that, it can be concluded that the game acted positively on the pedagogical experience of the player.

In addition, it was also possible to verify the capacity of the game as a pedagogical tool. The questions were presented to the users: Q1) Realized that my knowledge increased with my progress, Q2) I felt that the game expanded my knowledge about DVAW, and Q3) I felt motivated to use the knowledge acquired in the game.

The results presented in Figure 21 suggest the pedagogical potential of the game. It is observed that the majority (73.08%) of users believe that knowledge on the topic of violence against women was increased during the game; that is, the user learned while playing. For 80.77% of users, the game expands knowledge about the presented theme. Figure 21 also shows that 90.38% of users fully agree that the knowledge acquired about DVAW will be used in the real world, outside the virtual environment.

A powerful result when it comes to environments with educational purposes is to know if the content presented will have relevance or impact on their daily lives; that is, if it will be used in the learner’s daily life. It is worth mentioning that this result becomes even more imperative when knowledge can bring more respect and less violence to women.

Prevention is essential, but it is necessary to use knowledge to face and combat the problems that DVAW brings with it. The results presented here indicate that users have increased their knowledge regarding the educational content, suggesting that the use of 360-degree videos, immersive virtual reality, and SEG was successful from an educational point of view.

CONCLUSION

The use of 360-degree videos and IVR in the context of SEGs is currently presented as a promising field of research in the educational field. It seeks to provide its users with an environment where they
can experience more realistic and engaging experiences with the contents. In this approach, users can feel the sensation of being part of this story.

The possibilities of use in the educational context are the most varied, from environments to training in the health area, such as the works of Barsom et al. (2020) and González et al. (2015), to cultural preservation environments, such as the studies by Ivkovic et al. (2018) and Argyriou et al. (2020). However, if, on the one hand, it is possible to see the benefits of SEGs with 360-degree videos and IVR, on the other hand, there is still a need to advance in discussions and scientific studies that corroborate the strengthening and development of these environments. Despite the benefits, it is possible to verify that there is still a lack of such research in the literature.

Similarly, SEGs applied to learning, and awareness about DVAW are also scarce in the literature. Although the topic has great relevance from a social and public health point of view, there are almost no games for this purpose, leaving a gap that needs to be filled due to its importance.

This work sought to minimize this gap and presents SG The Mystery of Pandora to face and combat the problem of DVAW, bringing with it the provocation of the importance of reflection on DVAW and the discussion of the benefits of immersive 360-degree videos in educational games. The game was developed with the ambition of uniting the potential of IVR, 360-degree videos, and SEGs, to provide a more realistic virtual environment where the player could immerse and awaken feelings and emotions capable of making him reflect on his postures and behavior in relation to DVAW, and consequently, minimize or even eradicate the negative impacts that this problem imposes on women and all contemporary society.

The evaluation of the game revealed encouraging results both from the point of view of player satisfaction and learning. The results of measuring satisfaction were satisfactory, with high averages in most of the factors analyzed. Therefore, it suggests that the heuristics in the game’s development were well worked and provided a good experience for the player. However, in summary, it can be observed that satisfaction was well evaluated. It is worth mentioning that when the objective is educational, obtaining satisfaction enhances the use of perceived usefulness; that is, it goes beyond the moment when the user is asked to use the game.

Another important finding was the excellent evaluation that the game obtained in the aspect related to improving the players’ knowledge regarding the educational content. This data is relevant and suggests the pedagogical potential of the game, indicating that it can be used as a pedagogical tool to promote knowledge and awareness of the problem of DVAW. In addition, another significant finding was the players’ willingness to use the knowledge acquired in their daily lives. This data further strengthens the good expectations of the game to act positively in the context of DVAW.

In addition to the quantitative results presented regarding satisfaction and pedagogical analysis, it was possible to perceive during the application of the tests that the game provoked motivation and a reflection on the need to bring the topic to a broader discussion. Although the use of games is not an everyday activity for most users who have tested the game, it was observed that their willingness and generosity to dive into the world of games to contribute innovative actions that can face and combat this problem during a social phenomenon. These points could be observed and discussed during the application of the tests, indicating that this work follows a promising and very satisfactory path.
REFERENCES


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