

Mundo Bit Byte - A digital mobile game to disseminate female personalities that made history in Computing

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Abstract

There are great female personalities in the history of computing who have played an important role in the historical achievements of this area. However, their contributions are often poorly publicized and/or credit for those contributions is denied to the true authors. Thus, this paper proposes a game called *Mundo Bit Byte*, created by a team of female undergraduates and high school girls. The story is based on five prominent female personalities in the field of Computing. Each phase of the game is inspired by the life of one of these women, showing, in a playful and fun way, their achievements and other relevant aspects of their lives. A demo version of the game containing two phases was evaluated by 511 people. In the first test, 234 responses were obtained, and in the second test, 277. Most respondents (97.4% in first test and 98.2% in second one) reported that they would like to meet other important women in computing after playing *Mundo Bit Byte*. The results indicated that games like this can be powerful tools to reduce stereotypes in the Computing area.

Keywords: Digital mobile game, Computer history, Female personalities, Platform game, Mundo Bit Byte

1 Introduction

According to INEP (Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira), in 2019, the percentage of females who completed graduation in the area of Computing and Information and Communication Technologies (ICT) was only 13.6% (INEP (2020)). This shows the huge gap between the number of men and women who work professionally in this area. Among the facts that influence the interest of girls and women in the area of STEM (Science, Technology, Engineering and Mathematics) are: contact, presentation, breaking stereotypes and female examples working in the area (UNESCO (2018)).

Unfortunately, it is common knowledge that girls and women who have tastes outside the imposed standard of the “female universe” experience hostility from all walks of life. Thus, carrying out a historical review is, in addition to valuing important figures, a way of showing that the world of digital games is also a female universe. The reality is that for as long as there have been electronic games, some women have been interested in them. However, this is not always known, possibly because the women themselves conceal it for fear of suffering prejudice. It can also happen due to society’s bias in maintaining false stereotypes. Ochsner (2019) analyses accounts of women working on game industry and presents

some interesting findings about this reality.

Thus, when looking at the history of the game universe, it can be observed that there has always been an important female participation, which contributed, and continues to contribute, to the evolution of games in terms of definition, technological development, creative thinking and experience as female game users. Women like Grace Hopper and Ada Lovelace contributed to the development of algorithms and programming languages that made the digital age a reality. Carol Shaw and Roberta Williams were the women who took the first step in implementing video games. Another important fact that supports the claim that the digital game universe is also female is the record that Rebecca Ann Heineman, in 1980, was the first person in the world to win the Space Invaders championship (Ross et al. (1982)).

Due to this reality, a group of women conceived and developed a digital mobile game entitled *Mundo Bit Byte*. The game is gender neutral and aims to spread historical information about female personalities in the world of Computing. The innovation lies in its main purpose which is to disseminate, in a creative and metaphorical way, the characteristics and achievements of five great female personalities who left an important legacy in the area of Computer Science. Thus, each level of the game represents one of these women. The level metaphor, including the objects, phrases and thoughts of

each character are all based on their respective personalities according to research done on them. Likewise, the colors, sounds, enemies and achievements of the phase also follow a pattern related to the female personality being presented.

The development team for the game *Mundo Bit Byte* was initially set up by six beginners in programming, five of them undergraduates from Universidade de Brasília (UnB) and one from high school, who, in 2022, joined the Software Engineering course at UnB. During the development of the game, the team gained another programmer graduated from the University of Vale do Ijaraí. Five of these seven girls were part of the extension project *Meninas.comp* at UnB Holanda et al. (2016a), Holanda et al. (2016b), Araujo and Holanda (2021), which aims to promote the area of Computing among girls.

This article is an extended and revised version of the original article (Briceño et al. (2021)), published in WIT 2021, with only the first phase of the game *Mundo Bit Byte*. To present the game *Mundo Bit Byte* (phases 1 and 2 for Android and iOS platforms) and demonstrate that the universe of games also belongs to girls, this article is composed, in addition to this section, of four more sections. Section 2 presents an analysis of related works. Section 3 provides a detailed description of the game, presenting its phases and main features. Next, Section 4 presents the preliminary game evaluation results for the first and second phases. Finally, Section 5 presents some conclusions and future work.

2 Related Work

This section presents some related works regarding games and female representation and contributions in Computer Science. Also, the design of games and its relation to gender is mentioned.

In Santos and da Silva Figueiredo (2016) a card game called *Computasseia* was proposed as a tool for supporting the learning of the history of computing. The card game was employed in experiments described in Alencar et al. (2019) to emphasize female influence in the history of computing. The experiment was carried out with 45 students from schools (public and private) and universities. However, it is important to emphasize that the players had to initially take part in a brief class on the history of Computing, because during the game this information was necessary and most of the evaluators had no knowledge of the subject.

In Angeli et al. (2020) the authors showed a proposal to build a game with Elementary School II students from a public school through Participatory Design. The game's function is to address the contributions of women to Science, with the aim of providing discussions on this subject and bringing a new perception in young people to the world of technology. However, the game had not yet been developed and the article consisted of a description of the methodology based on Participatory Design and its application to the game design and development.

In Oliveira et al. (2019), the game *Personalities* was described. This game aims to promote important, but little known, personalities in the area of Computing. It is worth noting that some relevant women who appear in the game

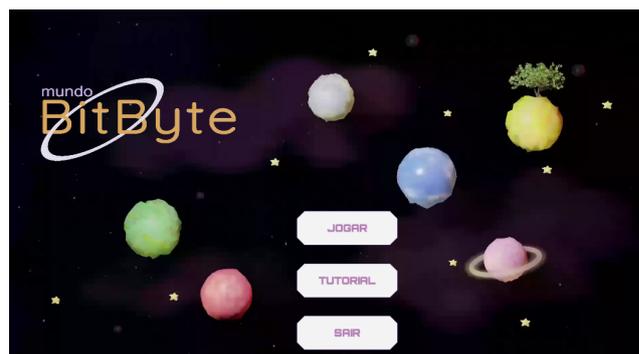


Figure 1. Start screen of the Game *Mundo Bit Byte*.

Personalities were also included in *Mundo Bit Byte*, such as Ada Lovelance and Hedy Lamarr.

A website that provides three mini-games created with the purpose of promoting female characters in Computing and Science was presented in Milson et al. (2020). This website, aimed at high school students, is one of the products of the *Bytes & Elas* Project, and was developed by high school students from the integrated technical course. Among the three mini-games, one called “Ajudando Marie” has as its main character Marie Curie, one of the scientists best known for her contribution to radioactivity. Another game is called “Quem Sou Eu”, and its focus is to make players develop their knowledge of women who played a big role in Science. Finally, a Memory Game was implemented, with the goal of providing players with knowledge about six important women in computing.

The article Rode (2011) shows that to address the disparity of women in Science and Engineering, it is necessary to develop gender-sensitive technologies. Furthermore, it states that although games are considered to be neutral, as most are made only by men, they tend to bring masculine experiences. In this way, female demands are forgotten among the features implemented in the games.

Regarding the game interface, the work in Samantha Breslin (2014) addresses the theme of gender in the design of technologies, stereotypes such as color, styles of games aimed at women and female characters. In addition, it is mentioned that technology is seen as a masculine symbol and also that, unfortunately, female usability tends to have little visibility.

To the best of our knowledge, no other game was published that aims to be neutral gender as well as presenting female personalities in computing history, and developed by a female team. Thus, *Mundo Bit Byte* aims to be a game developed by women for all genders. For this, it was implemented with an intuitive design, and a color palette inspired by the great female personalities. The *Mundo Bit Byte* is a game that features five female personalities in Computing, each in a different stage of the game. In this way, players get to know these women who made history in Computing, without having any prior knowledge. The game *Mundo Bit Byte* is available on both mobile platforms, Android and iOS, and can be played even in offline mode.



Figure 2. The story scene.

3 The Game *Mundo Bit Byte*

Mundo Bit Byte is a game developed for mobile platforms, with the aim of disseminating knowledge about important female personalities in Computer Science. Thus, as a consequence, it is intended to encourage players to consider the area of Computing as a possible professional alternative. As it is a game developed by women and that addresses the female personalities of Computing, it is expected that girls who have contact with the game will notice that there is female representation in the area, and that they may feel more motivated to pursue a career in the ICT area.

The game was created by a team made up of undergraduate and high school female students, and developed using the Unity game engine ¹ and the C# language. The source code is available on GitHub Mundo Bit Byte ². The objective of the game is to go through five phases that aim to show, in a comical and metaphorical way, the characteristics and achievements of great female personalities in the world of Computing. Each level was created with goals, phrases and thoughts of these personalities, including colors, sounds, enemies and achievements, according to the *Game Design Document* ³. Figure 1 shows the initial screen of the game *Mundo Bit Byte*.

3.1 The Game Development Methodology

The team created a GDD (Game Design Document) and improved it continually through a series of decision meetings. One of the decisions was to choose the color palette based on historical facts or photographs of the female personalities portrayed in the game. For example, in phase two, the colors were chosen according to the River Raid game created by Carol Shaw. First phase colors were based on the Ada

Lovelace's outfit in some colored pictures. Grace Hopper's stage colors are related to the US Navy, and so on.

The game's mechanics were inspired by the 1983 Mario Bros game, of which several versions were released and which are very successful to this day. Most of the developers of *Mundo Bit Byte* game had good childhood memories of the Mario game and for this reason it was chosen for the game mechanics. The character in each phase was created by a single developer, so that the developer could insert bits of her personality into the character: in this way, each character reflects one of the team developers. The elements of the phase were also researched according to some aspects of the life of the female personality portrayed. In the second phase, for example, the night is the enemy, because Carol Shaw was afraid of the dark, as she had to return home late at night by bike. The first phase has horses as the enemies, because Ada lost a lot of money on horse racing. The methodology used was weekly meetings lasting 2 hours and interspersed with game research and development.

The plot also includes a city called Labrisaí, which is an anagram of Brasília, the city where the game developers live. The scenario of the Covid 19 pandemic is also portrayed in the plot of the game in the choice of a virus that would destroy the technology.

3.2 The Game Story

The story developed in the game begins in the year 2021 in Labrisaí, a futuristic city with large fields, low suspended buildings, streets that resemble scissors and accesses that resemble needles on the main axis. However, the narrative developed in the game is not tied to that year and scenario. Mysterious aliens arrive on planet Earth (Figure 2), releasing a type of virus that, when it comes into contact with humans sucks all knowledge related to Computing, and when they touch electronic equipment they invalidate these. As a result of the invasion, people forget how to program and all terrestrial electronics are destroyed. Thus, people are left without cell phones, without Internet, and even without any mechanism that allows searches in virtual databases.

Ram, an alien who has become fond of a group of human friends, tries to help them by donating an unconventional time machine, since when traveling in it, the physical aspects of time are unconfigured. This group is made up of five girls with very different experiences, who met through the Internet. They are hackers who are at Computeca (the physical place where people have access to virtual books), where they meet weekly to study, share experiences and develop projects together.

Accompanied by a small invention of theirs, a robot called Turing - which stores a large volume of data, but cannot process it - they travel in the past with the mission of recovering the 5 important pillars for the group (algorithm, fun, simplicity, persistence and communication) before the aliens wipe out humanity. In this scenario, *Mundo Bit Byte* is developed in 5 phases, with each phase presenting a historical personality in the area of Computing. The phases will be described in the next sections.

¹<https://unity.com/en>

²<https://github.com/thamipontes/jogo.git>

³<https://bityli.com/mundobitbyte>



Figure 3. Levels and achievements screenshot.

3.3 The Phases of the Game

Each level in the game represents and is themed around one of the following female personalities in Computing: Ada Lovelace, Carol Shaw, Susan Kare, Grace Hopper, and Hedy Lamarr. They bring a unique visual identity and a specific puzzle. In addition, if the player has gathered all the collectibles for the phase, he/she gets a special object from that stage of the game. To represent the evolution of the knowledge acquired in each phase, the graphical interface becomes more defined. By collecting the objects and winning the puzzle, the player unlocks satellites, which are represented on a game map shown in Figure 3. The game starts with the character, Tati. However, at each phase a different character takes over the story. At the end of the fifth phase, the player completes the entire storyline.

The *Mundo Bit Byte* is a game of the Platform genre (Rabin (2009)), so the gameplay consists of overcoming obstacles such as ramps, moving platforms, holes, spikes, falling bridges, restricted visibility, enemies walking across the stage or that throw objects, among others, with the player able only to jump, move to the sides and attack.

3.3.1 First Phase

This phase was created to honor Ada Lovelace, who is known for having built the first computational algorithm. The setting is in London in the 1840s. The puzzle in this phase is related to mathematics, as Ada had a degree in mathematics, and the collectible objects of this stage are the rings of an abacus. The enemies are represented by racehorses, as Ada liked this sport despite losing money on betting⁴. Another enemy in this phase is the horse with wings, as Ada believed that she could create a mechanism capable of flight, and it would have the form of a winged horse, as shown in Figure 4.

The character in this phase is Tati (Figure 5), with the common impetuosity of young people, she is the first to jump into the time machine. She is creative and dreamy like Ada Lovelace, and as the youngest member of the group was 14 years old when the aliens arrived on earth. Her parents take a dim view of “women in the technological area”, after all, they should dedicate themselves to areas such as health. However, in the home of her grandmother, Elaine (represented in the second phase), she has the freedom to program computers.

3.3.2 Second Phase

This phase was created to honor Carol Shaw who is recognized for being the first female video game developer. The stage takes place in Palo Alto in the 1970s. This puzzle is a tic-tac-toe game that references the 3D Tic-Tac-Toe game created by Carol Shaw⁵. The collectible object is the amount of gasoline, in reference to her most famous game called *River Raid*⁶. The big challenge of the phase is the night environment, in which the player has restricted visibility, relying only on the light of a flashlight for which the player must collect battery charge for its operation (Figure 6). As time passes the light decreases and it is necessary to collect more batteries in order not to lose. Night was chosen as the enemy because Carol Shaw was strict with her work schedules, as she often commuted to work by bicycle and did not like to come home late. The boss is a ghost, still referencing the dark.

The character of this phase is Elaine (Figure 7), a 63-year-old lady who doesn't follow society's standards very much (she has shaved hair, has some tattoos and piercings), seems to be angry and presumptuous but is adorable and in love with flowers. She enters the time machine behind her granddaughter Tati, her biggest fear is heights and because of that a slack line was added as a level obstacle.

3.3.3 Third Phase

Phase 3 honors Susan Kare, the graphic designer responsible for bringing a more friendly aspect to computers. Susan Kare created the graphical interfaces and icons for the Apple Macintosh operating system, the Mac OS, originally from 1984. The setting is New York City in the 1980s. The collectible objects in this level are small dots that can be both black and white, which in the end composes her image, representing the pixels so common to the artist. The puzzle also references the same, being a Nanograma⁷ of a bitten cashew, an allusion to the famous Apple, and which symbolizes a large part of the illustrator's professional career. Enemies are playing cards that shoot arrows or attack with axes, in reference to the first solitaire game on the Windows operating system, created in 1990, for which Susan designed the cards.

The third phase's character is Bell (Figure 9), a very tall 17-year-old girl who is passionate about Japanese culture, movies and coffee. She joined the Bytes group, through her desire to make the computer interface she loved more user-friendly. Bell is very fond of programming and loves to express herself through art, so she was chosen to be the third phase character as she likes to color and just like Susan is very keen on design.

3.3.4 Fourth Phase

This phase was designed to honor Grace Murray Hopper who was the creator of the first compiler. The scenario of this phase takes place on a ship (Figure 8), as she was an admiral and systems analyst for the United States Navy. Therefore, the puzzle in this phase is an enigma to be deciphered, and in it there is a text with highlighted letters from which the player

⁵Wikipedia: 3D tic-tac-toe: https://en.wikipedia.org/wiki/3D_tic-tac-toe

⁶Wikipedia: River Raid: https://en.wikipedia.org/wiki/River_Raid

⁷Wikipedia: Nonogram: <https://en.wikipedia.org/wiki/Nonogram>

⁴Marília Marasciulo: <https://www.bbc.com/portuguese/internacional-54017008>



Figure 4. Screenshot of the first phase of the game.



Figure 5. The character of the first phase - Tati.

must form a sentence. This puzzle alludes to the translation from programming language to machine language performed by compilers. The collectible objects of this phase are diplomas, as Grace Hopper received 40 honorary diplomas⁸. The enemies of this phase are ghosts and insects. The ghosts were adopted to reference her grandfather who inspired her to join the navy. Insects were introduced in acknowledgement of the colloquial software term,, 'bug', which was first used in the computing context by a team in which Grace Hopper participated⁹.

The character of the fourth phase is Durga (Figure 10), an 18-year-old girl of Indian descent, very confident and clumsy. She is a person who takes care of the people around her, a collector of trinkets and bracelets. Durga met the Bytes when she was younger and in high school. Based on the advice of the girls in the group, she decided to do Mechatronics Engineering.

3.3.5 Fifth Phase

The fifth phase of the game *Mundo Bit Byte* was designed to honor Hedy Lamarr, as she is considered the mother of cell phones and Wifi¹⁰. This phase takes place in a movie studio, since in life, she was a great actress. The puzzle is a rhythm game, in which the player has to press the button when a wave is in the correct position, referring to the 88 different frequencies that Hedy Lamarr suggested to dodge the radars during the Second World War. The collectible objects chosen for this stage are stars, making reference to the Hollywood Walk of Fame in which the actress is represented. Enemies are represented by a prince who throws apples, as well as mirrors and frames that break and cause damage. They symbolize the beauty of the actress, and the apples are also a reference to the Disney-produced *Snow White* animation in which the princess's appearance was inspired by Hedy Lamarr.

The character of the fifth phase is Ema (Figure 11), an outgoing and ambitious surfer. Passionate about the universe, she was 22 years old when she started this journey and had just entered the Electrical Engineering course, dividing her reading between scientific research and superstitions to earn good grades.

4 Results

The game underwent two preliminary tests in which a demo version was made available, also popularly called "demo", with the aim of evaluating, among other aspects: gameplay, acceptance and interest in knowing more about important female figures in computing. The first test took place in March 2021, when the game was made available on the Play Store Briceño et al. (2021). This demo had the first phase of the game implemented, whose theme is based on Ada Lovelace. In this version of the game, the public had access to the Stage

⁸Wikipedia: Grace Hopper: https://pt.wikipedia.org/wiki/Grace_Hopper

⁹National Geographic: <https://www.nationalgeographic.org/this-day/sep9/worlds-first-computer-bug/>

¹⁰Marília Marasciulo: <https://www.bbc.com/portuguese/internacional-54017008>

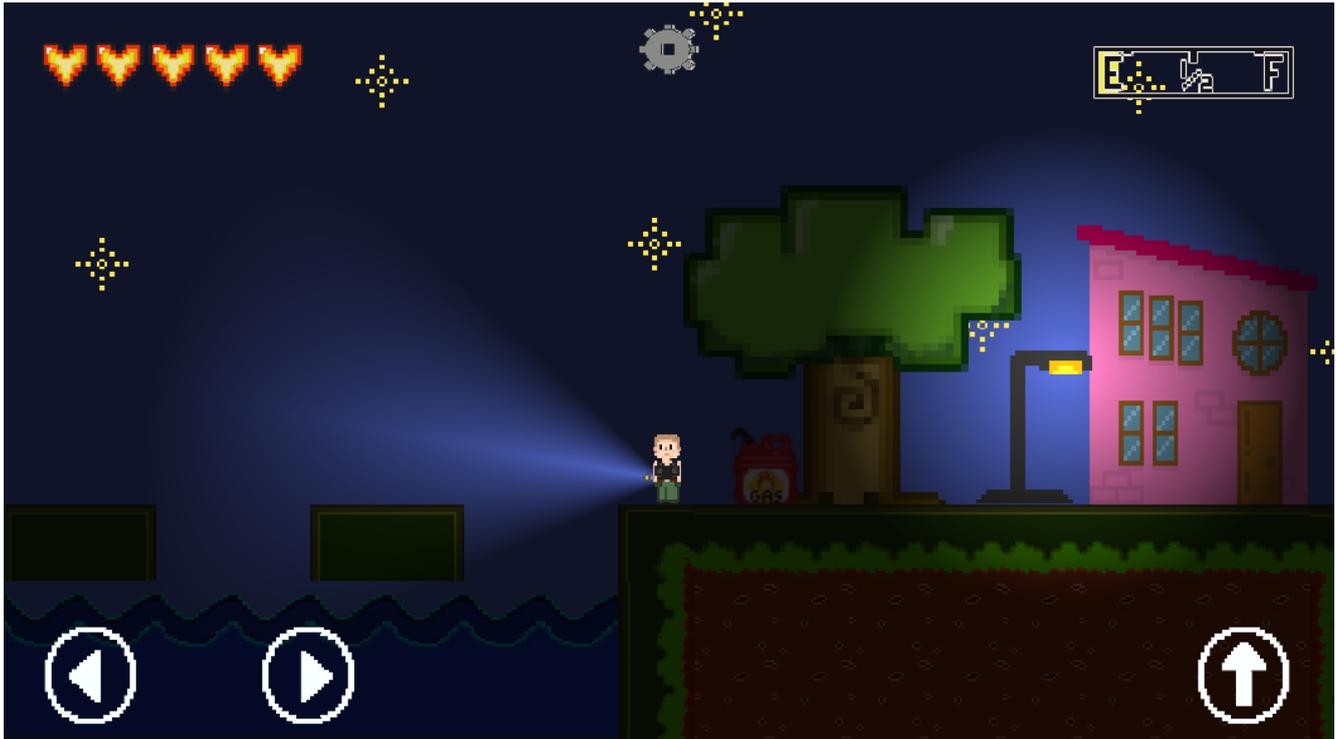


Figure 6. Screenshot of Phase 2.



Figure 7. The character of the second phase - Elaine.

1 scenario and enemies, as well as the lateral and vertical movement controllers. The second test took place in June 2022, when the game was made available on the Play Store and Apple Store, with the second phase also available, whose theme is intended for Carol Shaw. In addition, the boss and a puzzle were added to the first phase.

The evaluation of the players' experience was carried out using a Google form, in which the user had to consent to use the data anonymously. A total of 511 people participated in the survey. In the first test, 234 responses were obtained, among which 39.7% identified themselves as female, 56.8% as male, 3.4% as others. In the second test, 277 responses were obtained, among which 54.2% identified themselves as female, 42.6% as male, 3.2% as others.

In the first test, most respondents are aged between 10 and 25 years (70.5%), as shown in Figure 12. Respondents in the second test follow a similar pattern, with 74.4% belonging to the same age range (Figure 13).

Regarding the players' education, most respondents reported having higher education (complete or incomplete) both in Test 1 (56%, Figure 14) and in Test 2 (61%, Figure 15). When asked about the habit of playing video games, 47.4% of Test 1 participants answered that they play a lot (Figure 16), with 42.2% of Test 2 participants reporting that they occasionally play (Figure 17).

In order to identify the effectiveness of the game with regard to its main objective, which is to promote the dissemination of important female personalities in the history of computing, in both questionnaires it was asked if the player knew, before playing, the main female personality of the available phases of the game *Mundo Bit Byte*. In the first questionnaire 67.5% of all respondents declared not knowing Ada Lovelace (Figure 18), while in the second 68.6% declared not knowing (Figure 19). As for Carol Shaw presented in the

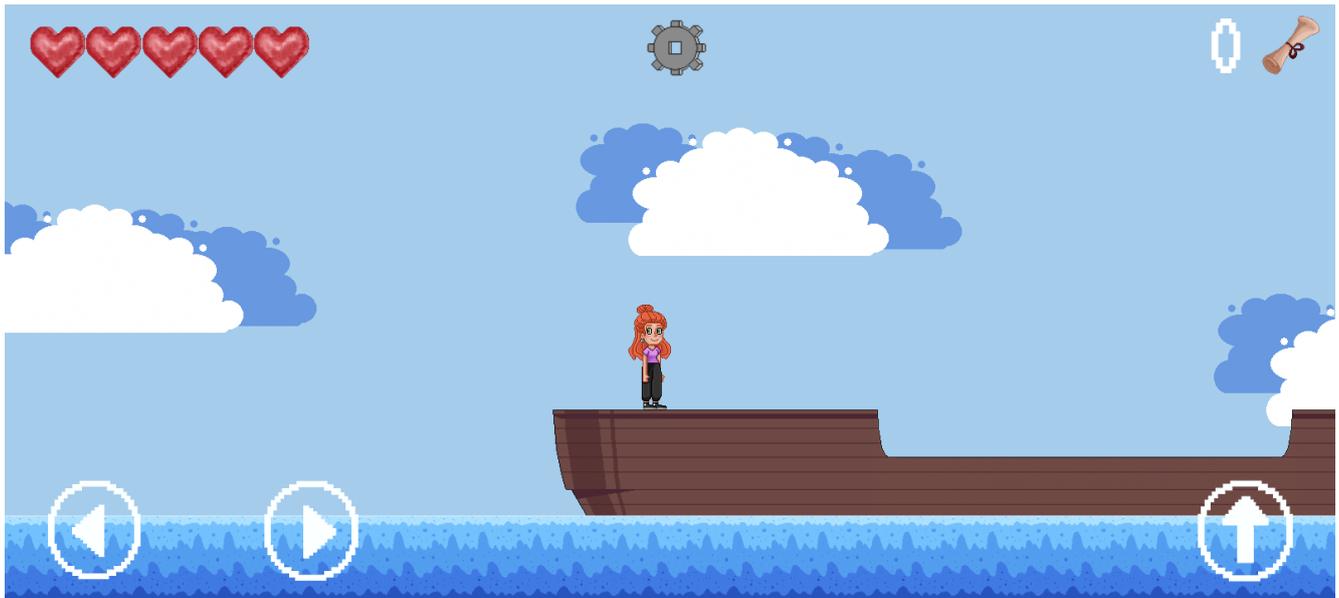


Figure 8. Screenshot of Phase 4.



Figure 9. The character of the third phase - Bell.



Figure 11. The character of the fifth phase - Ema.



Figure 10. The character of the fourth phase - Durga.

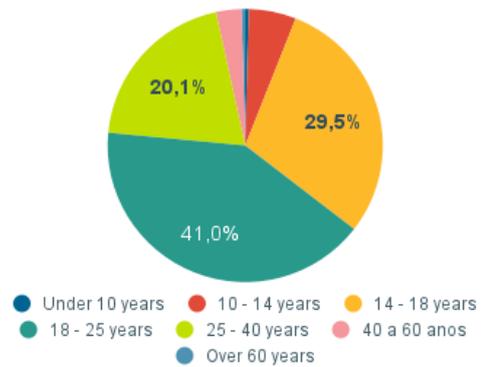


Figure 12. Age group - Test 1.

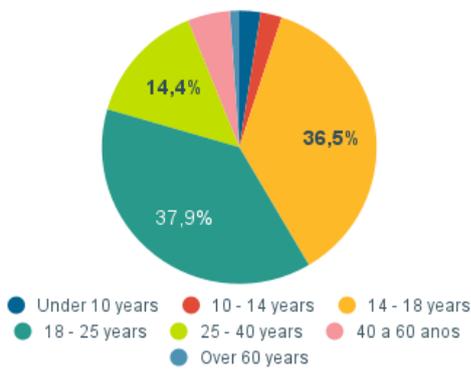


Figure 13. Age group - Test 2.

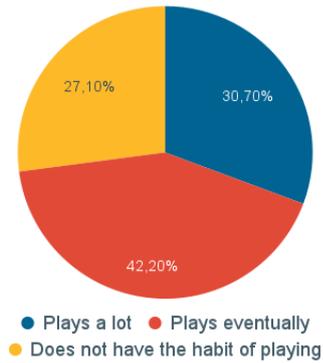


Figure 17. Do you have the habit of playing video games? - Test 2.

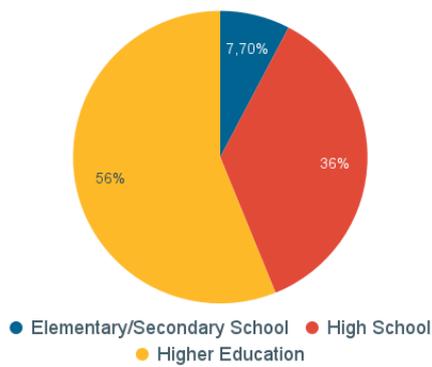


Figure 14. Level of education - Test 1.

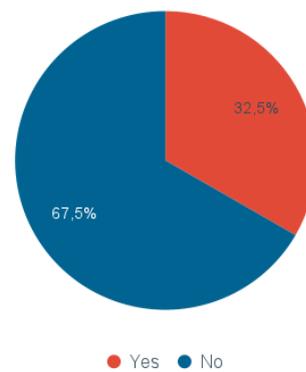


Figure 18. Did you know Ada Lovelace before the game? - Test 1.

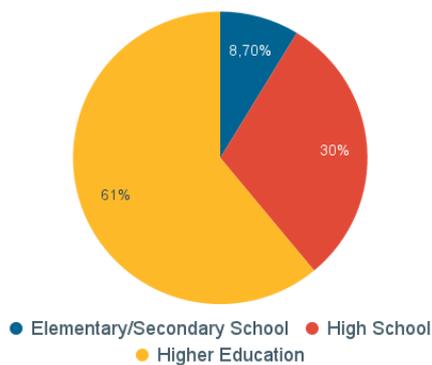


Figure 15. Level of education - Test 2.

second phase, 92.8% of all respondents declared not knowing her (Figure 20). However, most respondents (97.4% in Test 1 and 98.2% in Test 2) reported that they would like to meet other important women in computing after playing *Mundo Bit Byte*.

Therefore, it is concluded that the game *Mundo Bit Byte* seems to meet a demand from respondents to get to know female personalities in computing, whether they belong to the male, female or non-binary audience. This is interesting to note, as it suggests that games like this can be powerful tools to reduce stereotypes about STEM areas. In addition, actions that encourage greater female participation can also be used to arouse the interest of the male audience in the history of

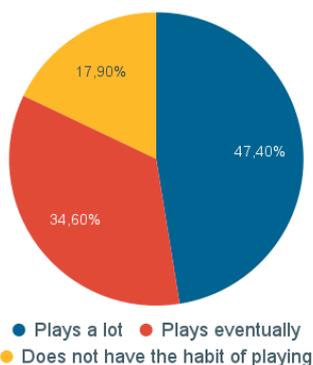


Figure 16. Do you have the habit of playing video games? - Test 1.

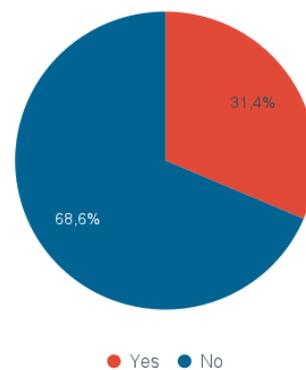


Figure 19. Did you know Ada Lovelace before the game? - Test 2.

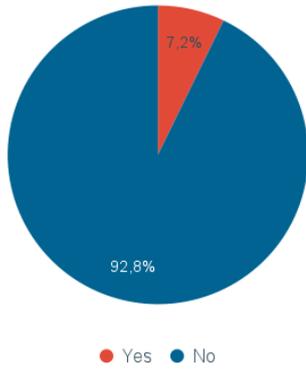


Figure 20. Did you know Carol Shaw before the game? - Test 2.

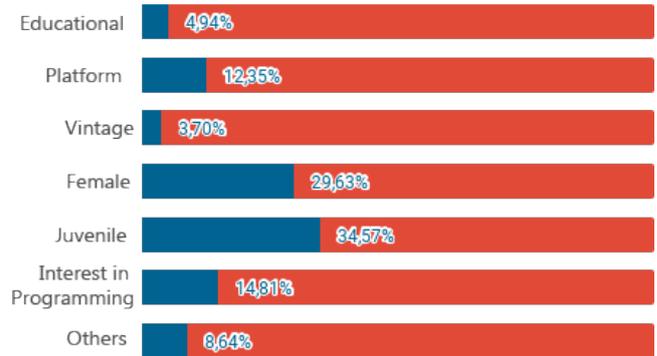


Figure 22. If so, what audience do you think it is intended for? - Test 2.

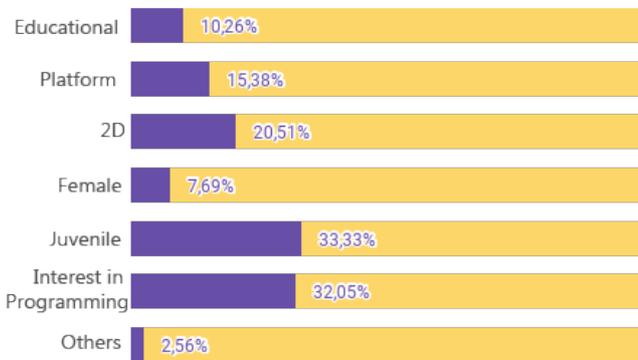


Figure 21. If so, what audience do you think it is intended for? - Test 1.

computing and important actors in the development of the area.

Going a little deeper into the issue of gender stereotypes, the instrument used in the tests sought to verify their impact on the evaluation of specific elements of the game. When asked "if the participant thinks the game is aimed at a specific audience?", in both questionnaires most respondents marked the option "No" (66.7% in Test 1 and 70.8% in Test 2). Those who marked "Yes" were asked which type of group the game would be aimed at, and the answers for Test 1 can be seen in Figure 21. As shown, when only the first phase was made available, only 7.69% of people answered that it is for a female audience. With regard to Test 2, Figure 22, shows that 29.63% of the 81 who answered "Yes" in the previous question said that the game *Mundo Bit Byte* is intended for a female audience. This shows that the theme presented is not limited to this audience.

Another aspect that is often related to gender is the color palette. Therefore, it was asked in the form about the perception of the color palette, and the results were that 73.7% of the respondents of Test 1 (Figure 23) and 82.3% of Test 2 (Figure 24) did not see any relationship with gender, which indicates a neutral evaluation of the game and that it is intended for all genders. This result is regarded as positive, as it suggests that such an assessment was not influenced by gender stereotypes.

Finally, the score that the respondents gave to the game was good, the average score being 8.15 for the game, when applied for the first time (Figure 25), and 8.92 when the second questionnaire was applied (Figure 26). Student's t-test

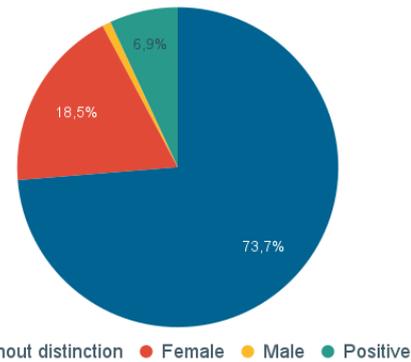


Figure 23. What did you think of the color palette? - Test 1.

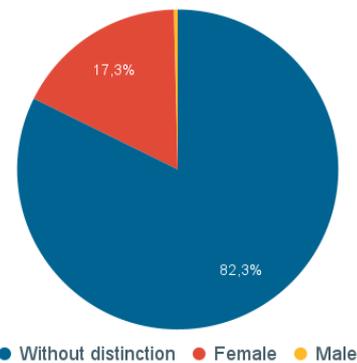


Figure 24. What did you think of the color palette? - Test 2.

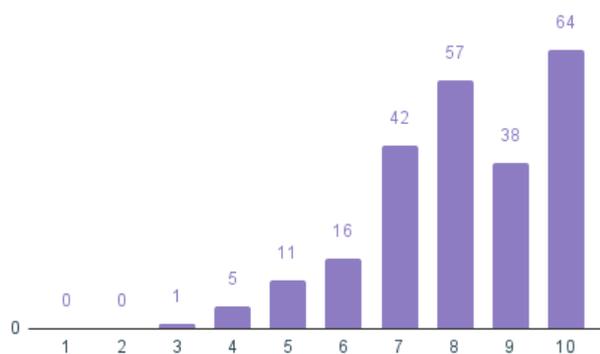


Figure 25. From 0 to 10 how would you rate the game? - Test 1.

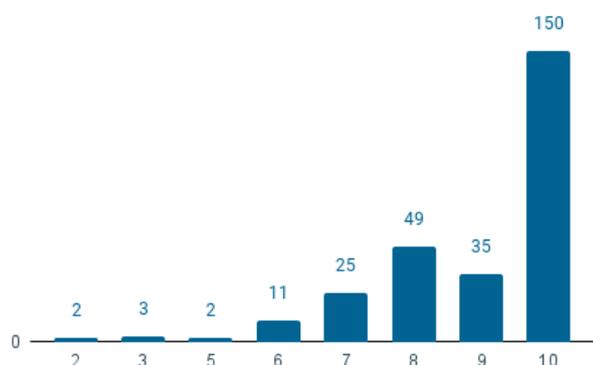


Figure 26. From 0 to 10 how would you rate the game? - Test 2.

analysis supports the interpretation of a slightly higher assessment in the second test ($t(510) = -5.65, p < 0.001$). A possible explanation for this increase is the expansion of game content in Test 2, as this may have allowed more game time and greater contact with enjoyable aspects of the game. The grade given to the game is also positively correlated with the HUD (*Heads - UpDisplay*) rating ($r = 0.58$) and the gameplay rating ($r = 0.48$) of the game.

Finally, when we analyze a comparative analysis between the evaluations of men and women, ANOVA's results suggest that the female audience tended to give slightly more positive scores than the male audience for both the game itself ($F(3) = 15.01, p < 0.001$) and for the game's HUD ($F(3) = 9.10, p < 0.001$), with the difference between the averages being 0.92 and 0.79 points, respectively.

5 Conclusion

This article presented the game *Mundo Bit Byte*, which is being built by women, whose objective is to arouse curiosity about female personalities in the computing area. However, this game, so far, is not perceived as specific for the female audience, and this was confirmed by the analysis of the results of the tests carried out regarding the first and second phases. This is positive because it shows that the world of digital games is genderless, and that both girls and boys can take part in this area.

The game *Mundo Bit Byte* is an ambitious project, which is under development and which aims to be a tool that facilitates the dissemination of the computing area and a little of its

history, while intending to show society that computing is also done by women. Since the published version of the game is a demo, there are several features that should be added for the final version of this game. As future work, we first intend to improve Phases 1 and 2 based on the comments and contributions received in the evaluation, and then complete the next three remaining phases.

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