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Research Paper

A Digital Game to Motivate and Empower Women in Learning Algorithms for Computer Science

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Abstract. *Background:* High dropout and failure rates in introductory Computer Science courses, such as Algorithms, represent a challenge, with dropout rates particularly high among female students. Traditional teaching methods do not always maintain engagement, highlighting the need for innovative approaches that promote motivation and learning. *Purpose:* This study proposes the development of ProgramADAs, a digital educational game to support female undergraduate students in Computer Science and related fields. The goal of the game is to stimulate interest in the Algorithms course by providing an engaging learning experience and contributing to the reduction of dropout and failure rates. *Methods:* ProgramADAs was developed by students who have previously taken Algorithms, allowing their experiences to shape the creation of an educational game aligned with the challenges faced by female students. The game is customizable and incorporates game elements to promote engagement. To evaluate its effectiveness, the authors conducted two studies: the first analyzed the game's potential as a motivational strategy, and the second assessed its usability and player experience. *Results:* The results indicate that ProgramADAs has significant potential as a motivational teaching tool. The usability evaluation yielded positive scores, suggesting that the game is educationally relevant and effective in supporting the teaching and learning of Algorithms. *Conclusion:* The results suggest that ProgramADAs has the potential to increase female students' engagement in Algorithms. Its interactive and customizable features make it a valuable resource for improving the learning experience and addressing challenges of motivation and retention in Computer Science.

Keywords: Digital Educational Game, Algorithms, Gender Equality.

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1 Introduction

Recent research highlights a notable trend in female participation in the technology field. In 2023, while women accounted for 57% of bachelor's degree graduates[1], this majority drops drastically when considering the field of Computing and Information Systems, where women represented only 23% [Santos and Marczak, 2023]. Several factors may contribute to this decline, including low female representation, frustration with the perceived difficulty of courses, and lack of encouragement to pursue a professional career in the field, among others. At the same time, the demand for women in the technology job market is increasing, with various companies offering specialized training and recruitment programs for women, such as Nubank's *Yes, She Codes* program[2]. In this context, a key approach to mitigating gender imbalances in Science, Technology, Engineering, and Mathematics (STEM) fields lies in the proactive promotion of self-efficacy among women from the early stages of their education [Cunha *et al*., 2022].

The development of algorithms is one of the first topics covered in Computer Science and related areas. Proficiency in this subject is essential for these programs, as it provides the foundational technical skills and fosters critical and creative approaches to solving problems [Raabe *et al*., 2020]. This competency plays a central role in reducing student retention in the early stages of the program, enabling them to overcome initial challenges. Furthermore, for women entering higher education, mastering introductory courses can be crucial, as failing a course early on is one of the factors associated with female student dropout rates [Santos and Marczak, 2023].

Creating an immersive and engaging learning environment for teaching Algorithms and Programming Logic can be achieved through approaches based on Computational Thinking [Gomes *et al*., 2014; Schoeffel *et al*., 2015]. The Computational Thinking enhances creative, critical, and strategic skills by applying computing principles to identify and solve problems across various fields of knowledge [Bell *et al*., 2009]. The intersection of these elements, as highlighted in the guidelines outlined in the Reference Curriculum in Technology and Computing [Raabe *et al*., 2020] from the Innovation Center for Brazilian Education (CIEB)[3], underscores the urgency of prioritizing the teaching of Algorithms for developing both interpersonal and technical competencies.

Initiatives that strengthen self-confidence and present successful women role models in STEM fields increase female students' sense of competence and belonging, stimulating their continued interest in those areas [Marini *et al*., 2023;

[1] Available at: `https://tinyurl.com/nsttd8u2` (accessed on 24 December 2025).
[2] Available at: `https://tinyurl.com/4kwan6zy` (accessed on 24 December 2025).
[3] Available at: `https://curriculo.cieb.net.br/` (accessed on 24 December 2025).

Salinas, 2021]. Among these initiatives, Digital Educational Games (DEGs) stand out, as they enable a playful and motivating teaching and learning process [Kalmpourtzis, 2018]. DEGs make the classroom more engaging, increasing student involvement and facilitating learning [Macena *et al.*, 2022; Nepomuceno and Souza, 2022; Queiroz *et al.*, 2019].

Given this context, the objective of this work is to present the game *ProgramADAs*, developed by female students who have already completed the Algorithms course, with the aim of enhancing the motivation of other female students to study Programming Logic. This work is an extension of the one presented by Yamashita *et al*. [2024a], with additional game features and a much more comprehensive evaluation of the game. The game is set at the Federal University of Juiz de Fora (UFJF) to provide familiarity and includes characters inspired by female professors from the institution, presenting female role models to the students who act as mentors to the main character, thus promoting the sense of belonging previously mentioned. The proposal is a game with playful elements, easy to customize, that can be used throughout the semester to motivate students and, at the same time, enrich the knowledge they acquire early in the course. By introducing the proposed game within the first semester, it is expected to reduce dropout rates among students in the early stages of their courses, as well as decrease the failure rate in the Algorithms discipline. Moreover, recruiting students to develop the game forms a sense of purpose and community that also reinforces their sense of belonging to the field.

The rest of the paper is organized as follows: Section 2 presents the theoretical background, including topics related to the development of educational games. Section 3 discusses initiatives related to this work. Section 4 outlines the methodological aspects for conducting this study. Section 5 provides a description of the proposed game to motivate women to learn Algorithms and Programming Logic. Section 6 presents the evaluation conducted to assess the game's effectiveness. For this purpose, two studies were conducted: the first to evaluate the students' motivation, and the second to assess the usability and experience of the players. Section 7 presents a discussion of the results, highlighting the main findings. Finally, Section 8 presents the concluding remarks of this work.

2 Background

The effective use of technology in education can enrich teaching, making it more interactive, accessible, collaborative, and adaptable to students' individual needs [Pereira and Araújo, 2020]. Technology has a significant impact on education, transforming the way people learn, teach, and interact within educational environments. In this context, game-based learning is recognized as an innovative approach to enhancing students' interest in education through gameplay. It involves leveraging games as educational tools or strategies to promote learning and engagement. This method integrates educational content into a game format, encouraging players to actively participate and interact with game mechanics to acquire knowledge or develop skills [Videnovik *et al.*, 2023].

By definition, initiatives that integrate video games with education are classified as game-based learning. Within this broad scope, effective educational game design must strike a balance between entertainment and educational value [Prensky, 2003]. As stated by Aslan and Balci [2015], developing a DEG for game-based learning poses significant technical challenges for educators, researchers, game designers, and software engineers. Identifying pedagogical requirements is a crucial step in designing effective educational games. Moreno-Ger *et al*. [2008] emphasizes the importance of aligning game mechanics with instructional goals, ensuring that games not only engage learners but also support meaningful learning outcomes. Key requirements include adaptation to individual learning needs and embedded assessment mechanisms. These elements contribute to a structured learning experience that goes beyond simple entertainment, fostering active participation and skill development.

The choice of game genre plays a fundamental role in educational game design, as it defines the overall experience and determines the types of interactions players will engage with. A genre categorizes games based on shared gameplay characteristics, mechanics, and objectives, influencing both the structure and the cognitive demands placed on learners. Different genres, such as action, adventure, role-playing (RPG), or strategy, offer varying levels of immersion and challenge, which can significantly impact educational outcomes. Heintz and Law [2018] highlight that genres like mini-games, action, and RPGs present different cognitive demands and engagement levels, emphasizing the need to align the genre with specific learning objectives and the target audience to maximize educational benefits.

Beyond genre selection, game elements serve as the building blocks that shape the player's experience and influence engagement [Toda *et al.*, 2019]. These elements (such as challenges, rules, rewards, missions, avatars, and narrative) play a critical role in motivating learners and structuring gameplay to reinforce educational content. Missions and objectives guide players through meaningful tasks, fostering a sense of accomplishment and continuity. Scoring systems provide feedback and reinforce achievements, rewarding players for completing challenges. Fantasy and narrative elements, often introduced through engaging storylines and avatars, enhance immersion by allowing players to assume roles within the game world. Levels, as a structuring component, define progression and ensure that learning unfolds in a paced manner. By carefully designing these elements, educational games can create compelling and effective learning experiences that sustain motivation while fostering skill acquisition and knowledge retention [Santos *et al.*, 2018].

As noted by Mozelius and Humble [2023], research on educational game design for girls reveals several key themes that inform the development of games tailored for this audience. Girls tend to express a preference for games that encourage creativity, such as those with features that allow them to modify game characters and elements. Many girls also appreciate the functionality in games that enables them to customize aspects of the game world. In general, girls tend to prefer games with minimal violence or punitive feedback, opting for exploration and collaboration over aggression. Additionally, girls seek gameplay that is rich in narrative, offers diverse activities and characters, and provides opportunities for social interaction. Studies have also shown that girls are more inclined to build games that incorporate social interac-

tion. Furthermore, inspiring female role models is essential, as games with female protagonists have been shown to increase girls' interest in technical subjects. These insights highlight the importance of creating games for girls that foster creativity, social engagement, and exposure to empowering female figures, which will guide the development of our proposed game aimed at motivating women to learn Algorithms.

3 Related Work

Teaching Computer Science is challenging due to its complex concepts and high level of abstraction, which can create significant difficulties for students, especially in learning Programming Logic [Franzoia *et al*., 2019]. In this context, DEGs have proven to be effective tools for motivating students and enhancing the teaching and learning process [Segura *et al*., 2020; Silva and Dantas, 2014; Silva *et al*., 2021, 2022, 2023]. However, as pointed out by Mozelius and Humble [2023], differences in game design preferences between boys and girls suggest that Programming Logic education strategies should adopt more inclusive approaches to ensure greater engagement from both groups.

The relevance of this topic is reinforced by recent systematic literature reviews on the use of DEGs in programming education, particularly those focused on female audiences. Reis *et al*. [2023] conducted a systematic literature review on games with female-oriented themes, presented at two major national events in Brazil: Women in Information Technology (WIT) and the Brazilian Symposium on Games and Digital Entertainment (SBGames). Their study examined whether Goal 5 of the United Nations' Sustainable Development Goals, which aims to achieve gender equality, was being addressed. Based on the analysis of 18 primary studies, the authors identified a total of 20 DEGs, reporting that 75% of them are aligned with Goal 5. Similarly, Yamashita *et al*. [2024b] conducted a systematic review of DEGs designed for programming education and the encouragement of female participation in Computer Science. Their analysis of 12 distinct studies revealed that there are few initiatives specifically aimed at women, highlighting an opportunity for the development of more projects focused on this audience.

Some initiatives focus on engaging girls in Computer Science by allowing them to modify and customize games, providing hands-on experiences that enhance their interest and skills in the field. As an example, Plass *et al*. [2009] developed the game *Peeps* to promote gender equity and bridge the digital divide by providing girls with opportunities to develop programming skills. In *Peeps*, programming is not an end in itself but a means to achieve broader goals, such as digital literacy, by allowing players to design parts of the game while learning to code. Cruz and Barbosa [2020] also explored the use of games to support programming education for high school girls, aiming to encourage them to pursue higher education in Computing. The initiative took place at a public school, where students developed educational games using *Scratch* with a theme of biodiversity and sustainability. Teixeira Júnior *et al*. [2019] conducted game programming workshops for girls from public schools, aiming to spark their interest in the field of game programming. Activities included game testing and modifying code parameters, such as changing colors, speed, and movement. Dlab and Hoic-Bozic [2021] present a European initiative that promotes the acquisition of programming skills through a game development process, with the aim of preparing girls to pursue careers in computing and related fields, and increasing awareness of the relationship between technologies and the real world.

Other initiatives aim to engage girls in Computer Science by designing games where they play as protagonists, exploring narratives that highlight female figures and contributions in the field. Bonner and Dorneich [2016] developed *Sorceress of Seasons*, a game designed to teach fundamental programming concepts while specifically targeting female middle school students. The game was built based on some key requirements aimed at engaging this audience: a relatable female protagonist, an engaging narrative, uncertainty to foster motivation and exploration, social interaction to promote collaboration, and fun to increase engagement. Duarte *et al*. [2021] introduced the game *Sucesso4me*, where players' choices guide the protagonist through different paths, each leading to an ending featuring an important female figure in Computing. The game follows a narrative-driven progression, allowing multiple outcomes that highlight the achievements of influential women in the field. Briceño *et al*. [2021] proposed the game *Bit Byte*, in which each level is inspired by the life of a historical female figure in Computing, showcasing their accomplishments and other significant aspects of their journey in the field.

The strategy presented in this work stands out for combining the teaching of Algorithms with an emphasis on the female audience and active practice through a DEG. The plot is set in the university environment where the game takes place, allowing players to explore and relate to specific elements of this context. In addition to teaching Algorithms, the game provides information about university life, offering incoming students an engaging and educational introduction to their new academic environment.

4 Research Method

The proposed game, detailed in Section 5, was collaboratively conceived as part of an ongoing project at UFJF. This project consists of playing and developing games as a means to provide first-semester female students with the opportunity to engage in the construction of a stimulating application.

Before development began, several DEG initiatives were surveyed, all of them focused on teaching programming, with some specifically targeting women. Information about technologies and tools used in these initiatives was also gathered. Additionally, a mixed-methods research study was conducted with female students of the institution, seeking to identify the characteristics of DEGs that cater to girls and to find the motivations behind their involvement with the subject. The data were collected through a questionnaire, which received 54 valid responses. Among the available options regarding which game genre was preferred, strategy was the most voted, with 34 votes, followed by adventure games with 22 votes [Yamashita *et al*., 2023].

In this context, the proposed game ProgramADAs combines characteristics from both strategy and adventure games, including elements that involve logical reasoning and action.

The game is focused on the reality of first-year undergraduate students, who must attend Algorithms classes already at the first semester of their undergraduate course. The fundamental principle behind the game is to stimulate active involvement of the female students in their own learning process. By immersing themselves in the game, they transcend the abstraction commonly tied to traditional programming drills, which are often simplified and devoid of specific practical application.

The goal of this approach is to integrate the female students into an environment that offers a visual and interactive experience. Since the institution's Algorithms course uses the C++ programming language, so does the game in its challenges. To verify students' motivation for using the game, the evaluation presented in subsection 6.1 was conducted.

A second study was also conducted, using the MEEGA+ questionnaire [Petri *et al.*, 2019] to evaluate the usability and students' experience upon interacting with the game. This study is described in subsection 6.2. In general, the game achieved good results, indicating that it may be a useful tool for encouraging girls to learn content connected to Programming Logic and Algorithms, as well as motivating them to persevere in their Computing degree.

5 The Game ProgramADAs

Considering the challenges women face in undergraduate courses in Computer Science and related fields, the purpose of this work is to use an alternative approach to motivate female students in their Programming Logic and Algorithms studies, hopefully contributing to a reduction in the high dropout and failure rates in the Algorithms course, which is a key subject for these students. ProgramADAs is not intended as an introductory tool for new content or as reinforcement after course completion, but rather as a complementary activity outside the classroom. In particular, it is integrated into mentoring and tutoring sessions dedicated exclusively to female students, in which first-year students play alongside senior students who also contributed to the development of the game. This approach not only encourages academic practice but also fosters a sense of belonging and empowerment by creating a safe and collaborative environment that strengthens female students' confidence and persistence. Besides, the game also aims to contribute to reducing gender disparities in certain indices, such as course completion and labor market insertion.

5.1 Game overview

The game was conceived as a Role-Playing Game (RPG), designed to offer students a fun learning experience. It presents puzzles to be solved or codes to be implemented, with difficulty varying across levels. This means that the students have the opportunity to face challenges that become more and more complex as they progress in their studies.

ProgramADAs was developed with the Unity engine[4] and the C# programming language. The game's source code is publicly available on GitHub[5]. **Figure 1** presents the game architecture, highlighting the main Unity components as well as the modules responsible for the game's logic.

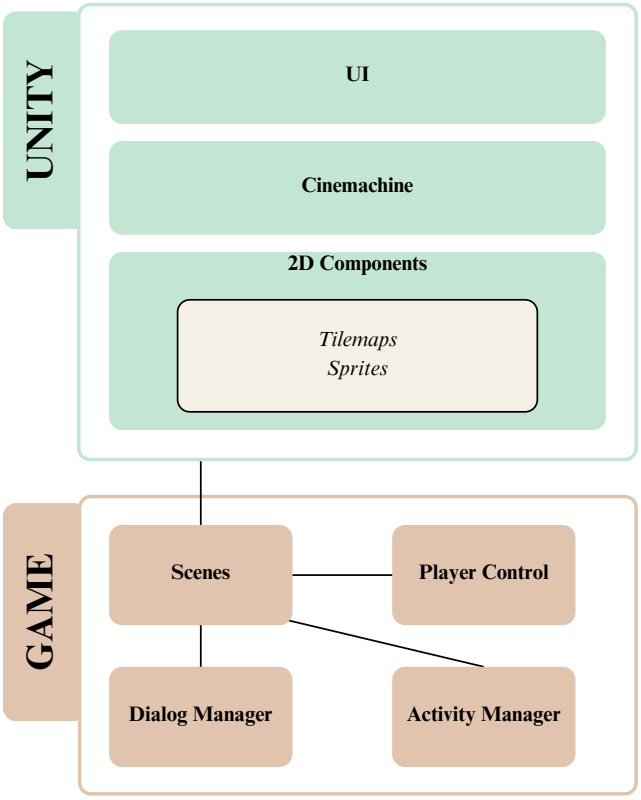


Figure 1. The game architecture.

Figure 2 presents a flowchart describing the possible outcomes of the player's interactions with the game. Upon start, the player sees herself in an exploration area, illustrated in **Figure 3**. This area allows her to access all game levels, which become available individually as the player progresses through the game. Moreover, the player can revisit a level if they want to review specific content.

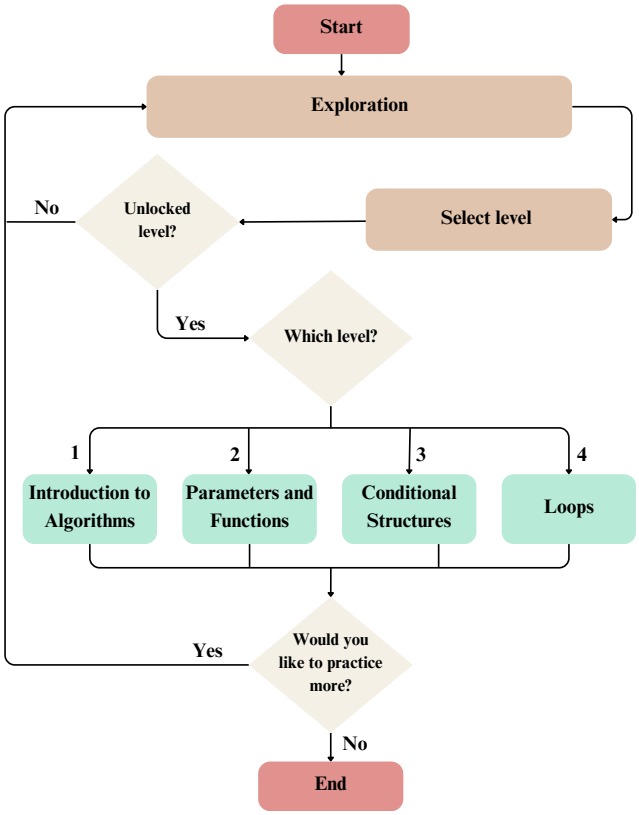


Figure 2. A flowchart of the player's interactions.

[4]Available at: `https://unity.com` (accessed on 24 December 2025).
[5]Available at: `https://github.com/Program-Ada/ProgramADAs` (accessed on 24 December 2025).

(a) The player interacts with an element of the area.

(b) Ada makes a funny remark about the plant.

(c) The player interacts with a notice board.

(d) Ada comments on a Calculus notice on the board.

Figure 3. Exploration section of the game. The game itself is currently only available in Portuguese; however, for the purpose of this article, the screenshots have been translated into English.

5.2 Characterization and plot

Studies show the need to adjust DEG characteristics to attract girls [Machado *et al*., 2022]. Based on the conducted research for defining the game characteristics, the game ProgramADAs combines elements of action, adventure, puzzles, and logic, creating a unique experience for the Algorithms' students by providing involving and stimulating challenges.

To ensure a smooth integration between the game and the fundamental concepts of the course, the activities are segmented so that each one tackles a subset of the topics discussed in the course, aligned with the syllabus. During the game, puzzles and programming-related activities are presented to the player, allowing her to progressively acquire knowledge on the subject.

The plot revolves around the character Ada, named after Ada Lovelace, the first person in history to write a computer algorithm. Ada is a freshman admitted to UFJF and is enrolled in the Algorithms course, already establishing an initial connection between the player and the protagonist. For Ada, everything is new, and the challenges are innumerable. But Ada is not alone, and together with other girls, she will be able to explore the campus and learn how to program in a relaxed and fun way.

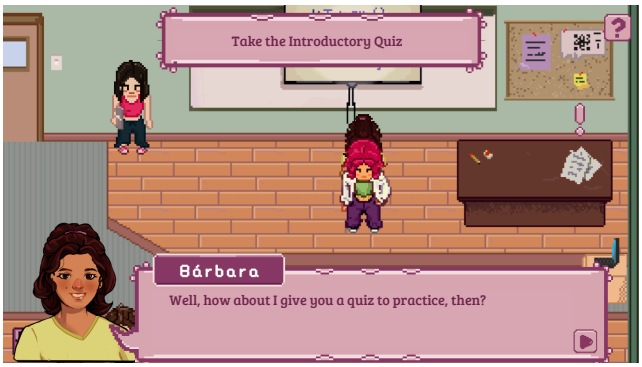
The choices of colors and fonts were guided by principles of clarity, accessibility, and visual coherence, aiming to provide a readable and engaging environment. Our decisions were informed by previous studies on educational games for women, which emphasize the importance of clear visuals, legibility, and consistency to foster engagement (e.g., [Machado *et al*., 2022; Mozelius and Humble, 2023]).

5.3 Cutscene

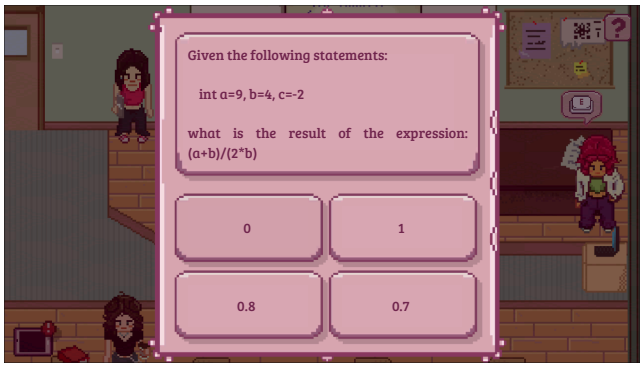
The game opens with a captivating cutscene that introduces Ada, a young woman who has just received life-changing news on her tablet: she has been accepted into the Federal University of Juiz de Fora. The next scene fast-forwards to a few weeks later, capturing her journey on a bus headed to campus. Ada's emotions are through the roof, an intricate mix of anxiety and excitement as she steps into this new chapter of her life, as can be seen in **Figure 4**. Her first interaction at college is with a seasoned student, a friendly veteran who guides her to her first class, setting the tone for the beginning of her academic adventure.

The game features a hall and a street filled with numerous interactive objects, creating an immersive environment that closely mirrors the real-life university. The goal is to provide an engaging and relatable experience that offers another way to assist first-year students in navigating college life.

Figure 4. Cutscene: Ada's thoughts.



(a) Ada talking to professor Barbara.



(b) An example quiz.

Figure 5. Selected scenes from level one.

(a) Professor Alessandreia helping Ada.

(b) Professor Alessandreia correcting a player's mistake.

Figure 6. Selected scenes from level two.

Designed to combine exploration and problem-solving within an RPG format, the game is intended to encourage players to interact with their surroundings, learn about campus life, and overcome challenges in a fun and meaningful way.

5.4 Level one

In the first level, Ada finds herself in her very first Algorithms class, where the setting includes four non-playable characters: the professor and three fellow students. As Ada engages with the professor, she learns about a quiz waiting on the desk nearby. The professor explains that Ada can attempt the quiz at any time, using the notes she has saved on her tablet. The quiz covers the basics of introductory algorithms, presenting a straightforward challenge. To progress to the second level, Ada must demonstrate her knowledge by scoring at least 75% correct answers. **Figure 5** shows the classroom and the quiz.

5.5 Level two

In the second level, Ada participates in a university event called "Café das Minas". This inspiring event features lectures by women in computer science who share their experiences and insights about the job market. After the lectures, a coffee break takes place, during which students often assist with the organization. In this stage, Ada is one of the volunteers helping the professor. As illustrated in **Figure 6**, the gameplay introduces players to the concept of functions and parameters, teaching them the importance of sequence and structure. For example, when a participant orders a grape juice and a strawberry cake, the player must follow the correct order of actions: first clicking on "Take a glass", then on "Put juice of", and finally selecting the desired flavor of the juice. This reinforces the idea that functions must be executed in a logical order, illustrating the importance of proper sequencing in achieving a desired outcome.

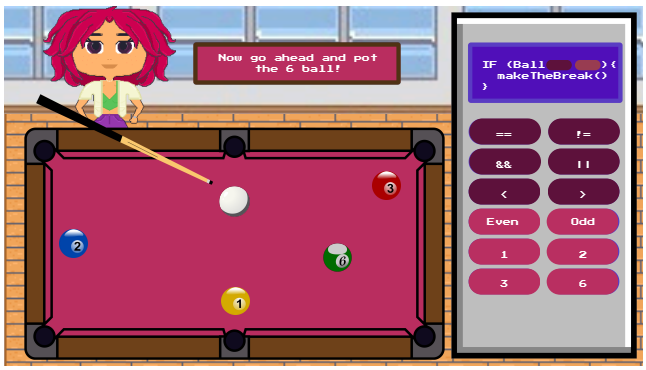


Figure 7. The snooker challenge in level three.

5.6 Level three

The third level takes place in a students' union room, a popular hangout where students gather to play cards and snooker. Ada encounters a veteran student who invites her to join a game of snooker. Ada hesitates, admitting she doesn't know how to play, but the veteran sees an opportunity to teach her through challenges. These tasks are designed to help Ada grasp the game's mechanics while incorporating conditional logic.

As illustrated in **Figure 7**, the challenges involve analyzing the characteristics of the balls on the table. For example,

if the table has four balls numbered 1, 2, 3 and 6, and the veteran instructs Ada to score ball 6, the player must construct a conditional statement to fulfill the task. A possible solution involves creating the condition "ball > 5". Through these logical exercises, players learn to apply conditional statements effectively, bridging gameplay with programming concepts.

5.7 Level four

The fourth and final level is set in a university library, where Ada is searching for a book to assist her studies on repetition structures. **Figure 8** shows the library setting. After completing the book loan procedures, the librarian asks Ada for help organizing some books on the shelves. To accomplish this, the player must use the concept of repetition structures, guiding Ada to place the books in sequence on the designated shelves. The shelves are categorized by subjects (Mathematics, Chemistry, etc.) and each has four tiers. Using predefined sequences of movements, the player must adjust the algorithms so that Ada moves correctly between the shelves and organizes the books, applying the concept of repetition structures by repeating the process for multiple books.

Figure 8. The library setting used in level four.

It is important to note that ProgramADAs is still under development. Future versions will include additional phases and a question bank, allowing female students to face new challenges on each attempt. This design aims to sustain replayability and avoid the novelty effect, allowing the game to be revisited throughout the semester as a complementary practice activity during the Algorithms course.

6 Evaluation

This section presents the evaluation of ProgramADAs, considering two distinct studies. Initially, the students' motivation was assessed while interacting with the game using the Instructional Materials Motivation Survey (IMMS) instrument [Keller, 2009]. The second study applied the Model for Evaluating Educational Games (MEEGA+) in terms of player experience and usability [Petri *et al.*, 2019]. Our choice to employ validated questionnaires such as IMMS and MEEGA+ was motivated by their wide adoption in the evaluation of Digital Educational Games, which ensures reliability, comparability with related studies, and methodological rigor. Both instruments capture central aspects that are directly aligned with the pedagogical goal of ProgramADAs, such as attention, confidence, satisfaction, and perceived relevance—dimensions essential to understanding whether the game effectively supports female students.

6.1 Students' motivation

The first study aimed to assess ProgramADAs from the perspective of female undergraduate students in Computer Science and related fields. The main variable of interest was students' motivation to use the game for learning Algorithms.

6.1.1 Planning

The evaluation process consisted of several steps. First, participants were selected from among female students who had previously completed the Algorithms course in their undergraduate programs (Computer Science, Information Systems, Exact Sciences, or Computational Engineering), as well as first-semester students who had already been exposed to the concepts addressed in the game. All participants possessed prior knowledge of the concepts covered in ProgramADAs.

Next, the evaluation instrument was defined. The IMMS was selected because it is widely used to assess students' motivation toward new educational support approaches. In addition, the IMMS enables the evaluation of technological acceptance and the identification of barriers to the adoption of new technologies, while primarily focusing on users' motivation to engage with a novel tool.

Finally, the instrumentation supporting the evaluation process was established. The instruments used included an Informed Consent Form (ICF)[6], a participant demographic profile questionnaire, a game usage guideline, and the IMMS questionnaire[7].

The evaluation was conducted in March 2024, when the game comprised two complete levels. Assessing students' motivation at this stage was essential to guide the evolution of the game, resulting in a new version of ProgramADAs that includes additional levels and challenges.

6.1.2 Execution

Among all the invited students, 14 agreed to participate voluntarily. In particular, 5 were Computer Science undergraduate students, 4 Information Systems students, 4 Exact Sciences students, and 1 Computational Engineering student. Initially, the students signed the ICF, which explained the study and informed them that the collected information would be confidential. The participants were also requested to fill in a questionnaire on profile characterization.

All the participants affirmed they enjoyed digital games. The distribution of participants according to their academic program stage is presented in **Table 1**. As for age, the distribution of participants is detailed in **Table 2**, which summarizes the number of students in each specific age.

Table 1. Academic program stage of participants.

Semester	Number of students
1st	3
2nd	5
3rd	1
4th	1
7th	3
11th	1

[6]Available at: `https://tinyurl.com/yc6hk5nv` (accessed on 24 December 2025).

[7]Available at: `https://tinyurl.com/e4kcewhu` (accessed on 24 December 2025).

Table 2. Age distribution of participants.

Age	Number of students
18	2
19	3
20	3
21	2
22	1
23	2
27	1

6.1.3 Results

The IMMS evaluates four dimensions. The first is attention, which involves the ability to capture and maintain the students' interest and curiosity. Next, relevance refers to the connection with the students' personal needs and goals, fostering a positive learning experience. Confidence relates to the students' belief that they have control over their own learning and the certainty that they will achieve success. Ultimately, satisfaction stems from the process or outcome of the learning experience, which may be influenced by internal factors (e.g., a sense of competence) or external factors (e.g., academic certificates), as well as the ongoing desire to learn.

Each student rated 36 questions using a five-point *Likert* scale, with response options ranging from 1 (strongly disagree) to 5 (strongly agree). On this scale, scores closer to 1 indicate strong disagreement with the statements, whereas scores closer to 5 indicate strong agreement. Intermediate values represent varying degrees of agreement or disagreement. Analysis of the results showed that the average scores for the dimensions were 4.3 for attention, 4.2 for relevance, 4.4 for confidence, and 4.7 for satisfaction.

Attention: the average score of 4.3 (standard deviation of 0.51) suggests that the ProgramADAs game effectively captured and maintained the students' interest and curiosity. This result indicates that the majority described the game as engaging and interesting, which is crucial for the learning process. However, the students gave an average score of 2.8 to the statement "*I have learned some things that were surprising or unexpected*", which may have occurred because all of them had already passed the Algorithms course.

Relevance: the average score of 4.2 (standard deviation of 0.61) indicates that students considered the game aligned with their needs. This suggests that the content and challenges of the game were perceived as useful, which may enhance engagement and the perceived utility of the tool. However, the students gave an average score of 3.4 to the statement, "*There are explanations or examples of how people use the knowledge in the teaching approach*", which may be related to the fact that the game is still in the development phase.

Confidence: the average score of 4.4 (standard deviation of 0.23) indicates that the students felt they had control over their learning. This result is highly positive, as self-confidence is a determining factor for persistence and academic success, especially in fields such as Computer Science, where confidence in one's abilities can be a challenge.

Satisfaction: the average score of 4.7 (standard deviation of 0.40) suggests that the students were highly satisfied with the process and outcomes of learning through the game. In fact, this was the highest-rated dimension, with the high level of satisfaction potentially attributed to both intrinsic factors, such as a sense of competence and personal achievement, and extrinsic factors, such as academic recognition. This high level of satisfaction is an important indicator that the game was well-received and appreciated by the students.

The high averages across all dimensions suggest that the game successfully engaged students, demonstrated relevance, strengthened confidence, and provided a satisfying experience. These findings are encouraging and highlight the game's potential as a motivational teaching tool, particularly in contexts where retention and dropout rates are challenging.

6.2 Player Experience and Usability

The second study aimed to evaluate the usability and overall player experience of ProgramADAs among undergraduate students in Computer Science and related fields, including both male and female students. The main variables of interest were the perceived usability of the game and its impact on students' engagement, enjoyment, and learning experience.

6.2.1 Planning

The planning phase of this second evaluation study followed Wohlin *et al*. [2012] recommendations. The MEEGA+ instrument was selected for this study, as it provides a ready-to-use kit for game creators, instructors, and researchers to evaluate the quality of educational games in an effective and efficient way. The questionnaire consists of some initial demographic questions, followed by 32 items that assess usability and player experience across different dimensions. The responses to these items follow a five-point *Likert* scale ranging from strongly disagree to strongly agree. Finally, three open-ended questions solicit feedback on the game's strengths, suggestions for improvement, and any additional comments.

It is important to note that the final items on the MEEGA+ questionnaire are related to the *perceived learning* dimension and must be adapted to the context of the evaluated game. In this study, item 32 was adapted to explicitly address the motivational purpose of ProgramADAs for women in Algorithms courses. This adjustment enabled us to more accurately assess whether the game was achieving its goal of supporting female students. The digital version of the questionnaire was created using Google Forms, which included the ICF[8].

The participants selected for this study were male and female undergraduate students enrolled in the Algorithms course at UFJF. This course is offered in the first semester of the program and delivered in a face-to-face format. The evaluation was planned to take place when students were halfway through the semester. It is worth noting that the participant group was diverse, including students who had previously failed the course, came from different educational backgrounds, and were enrolled in various undergraduate programs. The choice of this class for evaluation was crucial in analyzing the usability and effectiveness of ProgramADAs based on the experiences of students from fields where Computer Science is not the primary focus. The evaluation was planned to be conducted by a researcher and supervised by two Computer Science instructors, who would be responsible for monitoring the participants during the study. The students would be introduced to the game, play it freely, and subsequently complete the MEEGA+ questionnaire.

[8]Available at: `https://tinyurl.com/yfxw8ppa` (accessed on 24 December 2025)

6.2.2 Execution

This evaluation took place in December 2024, when levels three and four were already implemented in ProgramADAs. Initially, time was allocated to present the project, explain the game rules, and describe its components. The students then played the game freely under the supervision of the instructors. At the end of the evaluation, 52 students completed the questionnaire. Since filling out the questionnaire was optional, some participants chose not to respond, without any penalty. The entire experiment lasted approximately 60 minutes.

Among the 52 participants, the gender distribution was perfectly balanced, with 26 female and 26 male students. **Figure 9** shows the undergraduate programs in which these students were enrolled. Approximately 69% of the participants were enrolled in Engineering programs. The class was further complemented by students from the Computer Science program (17.3%) and the Interdisciplinary Bachelor's in Exact Sciences (9.6%). There was also one student from the Information Systems program and one from the Chemistry program among the participants.

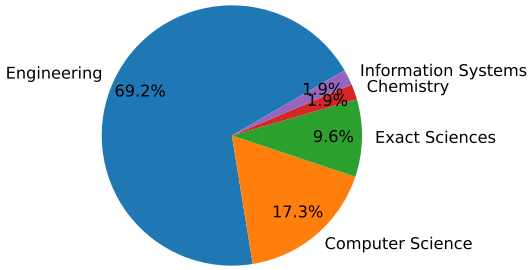


Figure 9. Distribution of participants by academic program.

Regarding age, most participants were young and at the beginning of their university studies, which aligns with the target population of this study. **Figure 10** shows the distribution of students by age group. Specifically, 76.9% of the students were between 18 and 21 years old, while 13.5% were between 22 and 28 years old. Additionally, there was only one person in the 29 to 39 age group and four individuals with 40 years old or older.

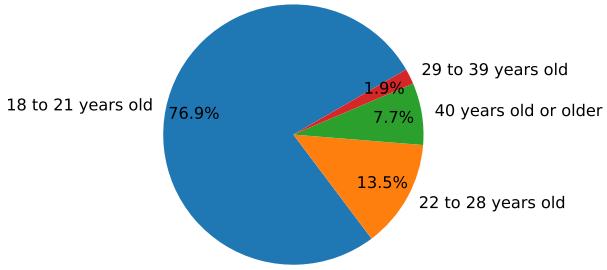


Figure 10. Distribution of participants by age group.

Finally, regarding the frequency with which participants play digital games, **Figure 11** shows the distribution. About 30.8% of students reported playing daily, 21.2% weekly, 17.3% monthly, 25% from time to time, and 5.8% stated that they never play digital games.

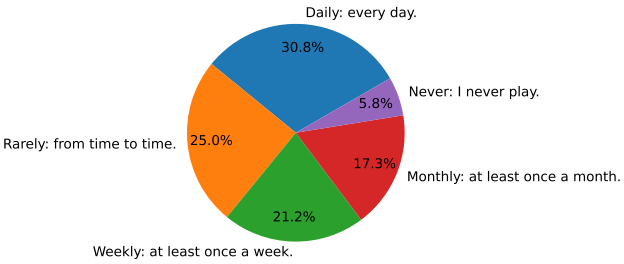


Figure 11. Distribution of participants by frequency of playing digital games

6.2.3 Results

Based on the collected data from all participants, **Figure 12** was created to support initial analysis of the 32 MEEGA+ questionnaire items. We first examine usability, then player experience. Next, aligned with ProgramADAs' goal of supporting female students, we present a gender-based comparison of the results. Finally, a summary of the open-ended responses is provided.

Usability The first quality factor assessed by the MEEGA+ questionnaire was the usability of ProgramADAs, encompassing the visual aspects and perceived interaction principles of the game. The usability statements (items 1 to 9) are grouped into four main dimensions: *aesthetics*, *learnability*, *operability*, and *accessibility*.

Aesthetics (items 1 and 2): the visual appearance of the game received positive evaluations, with approximately 67% of the participants strongly agreed that the design is attractive and about 69% strongly agreed that the fonts and colors are well integrated and consistent.

Learnability (items 3 to 5): the ease of learning the game also received predominantly positive evaluations. Approximately 58% of the participants strongly agreed that they needed to learn a few things before playing. Around 64% strongly agreed that learning to play is easy, and 50% believed that most people would learn quickly. Despite the positive reception, some disagreement or neutrality in item 5 suggests an initial learning curve for some users.

Operability (items 6 and 7): the clarity of the rules and ease of use obtained positive results, as about 62% of the participants strongly agreed that the game was easy to play, while 50% strongly agreed that the rules were clear and easy to understand. The presence of some disagreement in these items suggests that certain players may have experienced challenges with the game's mechanics.

Accessibility (items 8 and 9): this aspect received the highest evaluation among participants. Approximately 79% strongly agreed that the colors used in the game are meaningful, while about 77% strongly agreed that the fonts (size and style) are easy to read. The absence of participants with color blindness or other visual impairments may have influenced this positive perception.

In summary, the usability analysis shows that ProgramADAs achieved positive evaluations across all four assessed dimensions. Aesthetics and accessibility stood out with the highest levels of agreement, indicating that visual design and readability were well received. Learnability and operability also received favorable evaluations, although some disagreement suggests that a few participants faced challenges with the initial learning process and the clarity of the rules. Overall,

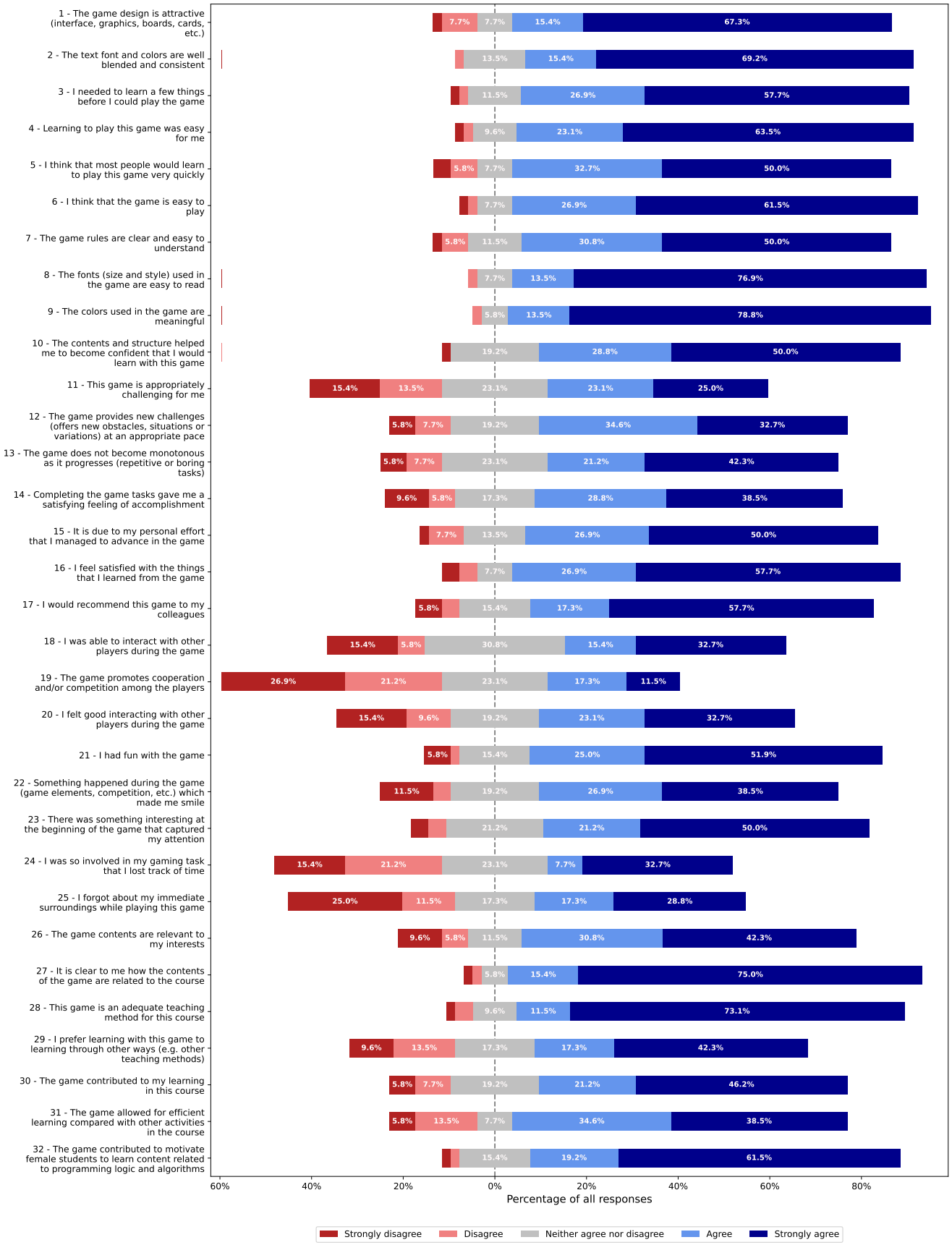


Figure 12. Distribution of Likert-scale responses for all MEEGA+ questionnaire items, considering all participants.

the results indicate that the game offers a usable and accessible experience, while highlighting opportunities for refinement in reducing the learning curve and improving rule clarity.

Players' Experience The second quality factor assessed by the MEEGA+ questionnaire was the players' experience, which encompasses their engagement, enjoyment, and satis-

faction while interacting with the game. The player experience statements (items 10 to 32) are grouped into eight dimensions: *confidence*, *challenge*, *satisfaction*, *social interaction*, *fun*, *focused attention*, *relevance*, and *perceived learning*.

Confidence (item 10): Students' confidence in learning through the game was among the highest-rated aspects. The structure of ProgramADAs appears to have contributed to this perception, with 50% of the participants strongly agreeing that the game helped them feel confident in their learning, and an additional 29% agreeing. These results indicate that the pedagogical design implemented in the game effectively promoted a structured and stimulating learning environment.

Challenge (items 11 to 13): This dimension received a mixed reception. About 25% of participants strongly agreed and 23% agreed that the game presented an appropriate level of challenge, while another 23% remained neutral, and 29% expressed some kind of disagreement. Nevertheless, approximately 42% of participants strongly agreed that the game did not become monotonous, suggesting that despite mixed perceptions of difficulty, the game was able to maintain engagement for a substantial portion of players. These results indicate that the progression of challenges in the game could be adjusted to better accommodate different student profiles, ensuring that the experience remains stimulating without becoming frustrating or overly simplistic.

Satisfaction (items 14 to 17): The data reveal a highly positive scenario. About 67% of participants agreed to some extent that completing the game tasks provided a satisfying feeling of accomplishment, while nearly 58% strongly agreed that they were satisfied with what they learned from the game and would recommend it to their colleagues.

Social interaction (items 18 to 20): This dimension received the lowest ratings among all aspects. About 48% of participants reported some level of engagement with other players, while 21% disagreed. With respect to the perception of collaboration or competition, disagreement reached 48% at any level. These results are not surprising, as ProgramADAs is a single-player game, and participants did not perceive any interaction or competition mechanisms outside the game. Consequently, the potential for social interaction is limited, suggesting that incorporating mechanisms that foster collaboration and healthy competition, such as cooperative challenges or leaderboards, could enhance engagement and social experiences among players.

Fun (items 21 and 22): This dimension stood out in the students' experience. Approximately 52% of participants strongly agreed that they had fun while playing, and an additional 25% reported a positive experience. These results indicate that ProgramADAs created an engaging and playful environment, effectively motivating the participants.

Focused attention (items 23 to 25): The level of immersion in the game received mixed responses. About 50% of participants strongly agreed that the game captured their attention from the beginning. However, higher levels of disagreement were observed regarding sustained attention, with nearly 37% of participants indicating that the game was not engaging enough to lose track of time or feel fully immersed. These results suggest that while ProgramADAs is effective at initially capturing players' attention, there is room for improvement in maintaining immersion throughout the gameplay. Strengthening the narrative and incorporating more engaging game mechanics may improve sustained attention.

Relevance (items 26 to 29): The educational relevance of ProgramADAs was widely recognized by the participants. Approximately 73% strongly agreed that the game represents an appropriate teaching method, while 75% strongly agreed that its contents are closely related to the course. These results reinforce the potential of ProgramADAs as an innovative educational resource, particularly in the context of teaching Algorithms and Programming Logic.

Perceived learning (items 30 to 32): This dimension highlights the educational impact of ProgramADAs. Slightly over 46% of participants strongly agreed that the game contributed to their learning, while 61.5% strongly agreed that it helped motivate female students to engage with Programming Logic and Algorithm content. When asked about the game allowing for efficient learning compared with other course activities, about 39% strongly agreed that it was effective, whereas approximately 20% expressed some level of disagreement. These results suggest that ProgramADAs can support learning and motivation, although perceptions of their comparative effectiveness vary among participants.

Given the results of the MEEGA+ questionnaire, ProgramADAs provided a positive experience for students. Participants reported high levels of confidence, satisfaction, fun, and perceived learning, and recognized the game's relevance as an educational tool. Nevertheless, some aspects showed room for improvement, particularly in maintaining focused attention, balancing challenge progression, and promoting social interaction. Addressing these points in future versions could further enhance the game's effectiveness in supporting teaching and learning, while increasing student engagement.

Gender-Based Analysis Given that ProgramADAs is designed to support female students, promoting inclusion and a sense of belonging, examining responses by gender is particularly relevant for evaluating whether the game meets these objectives. **Figure 13** presents the distribution of Likert-scale responses for each MEEGA+ questionnaire item, separated by gender, to examine potential differences in perception between male and female participants.

Although the distributions of responses appear visually similar, statistical tests were conducted to formally determine which differences are significant. **Table 3** presents the results of these analyses for each item of the questionnaire. Two complementary tests were applied: the Mann-Whitney U test, which assesses differences in the central tendency of ordinal responses, and the Chi-square test of independence, which evaluates whether the overall distribution of responses differs between groups. Values in bold indicate statistically significant differences at the 0.05 significance level, highlighting items where males and females tend to respond differently and providing a formal basis for interpreting the patterns observed in the corresponding response distribution graphs.

Item 1 (“The game design is attractive”) was the only question with a p-value below 0.05 in the Chi-square test, indicating a significant association between gender and the distribution of responses. Inspection of the response frequencies in **Figure 13** shows that more women strongly agreed (73.1%) compared to men (61.5%), while men were more

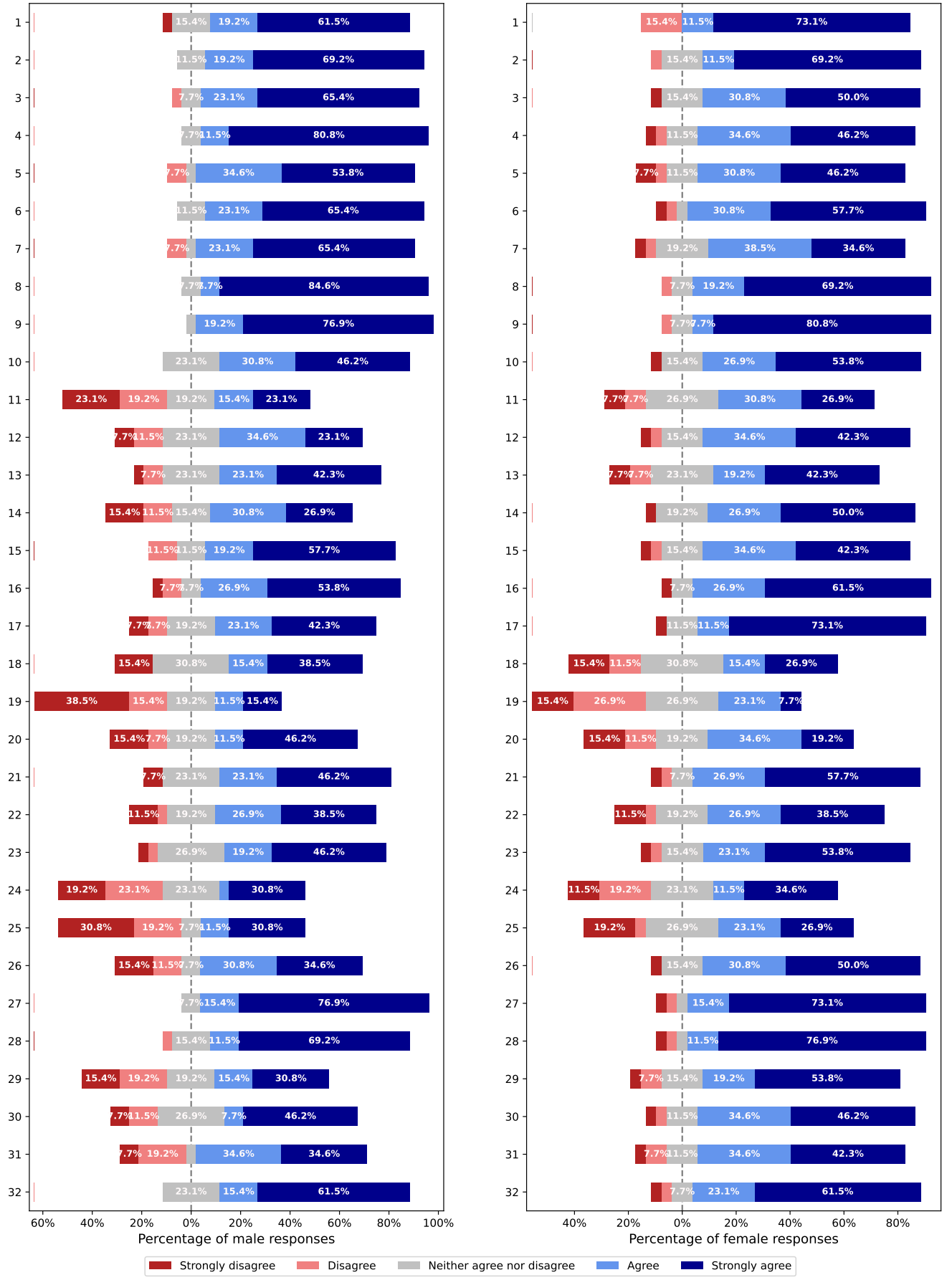


Figure 13. Distribution of Likert-scale responses for all MEEGA+ questionnaire items, comparing male (left) and female (right) participants.

Table 3. Statistical comparison of MEEGA+ questionnaire responses between male and female participants.

Item number	p-values Mann-Whitney U	Chi-square
1	0.509	**0.045**
2	0.840	0.650
3	0.265	0.480
4	**0.012**	0.105
5	0.413	0.471
6	0.589	0.492
7	**0.034**	0.113
8	0.209	0.443
9	0.888	0.450
10	0.640	0.655
11	0.116	0.284
12	0.084	0.524
13	0.832	0.980
14	**0.042**	0.148
15	0.451	0.420
16	0.490	0.711
17	**0.028**	0.202
18	0.338	0.473
19	0.329	0.250
20	0.262	0.193
21	0.304	0.442
22	1.000	1.000
23	0.495	0.900
24	0.411	0.800
25	0.419	0.126
26	0.126	0.185
27	0.690	0.670
28	0.565	0.574
29	**0.034**	0.293
30	0.345	0.117
31	0.407	0.589
32	0.941	0.355

evenly distributed across agree, neutral, and strongly disagree categories. This suggests that female participants perceived the game's design as more visually appealing than male participants, highlighting a gender-related difference in their perception of the game's aesthetic aspects.

Items 4, 7, 14, 17, and 29 showed p-values below 0.05 in the Mann-Whitney U test, indicating significant differences in response tendencies between male and female participants. For items 4 ("Learning to play this game was easy for me") and 7 ("The game rules are clear and easy to understand"), female participants reported lower agreement than males, suggesting slightly greater difficulty with the game's usability. Inspection of the responses and contingency tables for these items revealed that the disagreement came from two female participants who indicated that they rarely play digital games, which may at least partially explain their lower perceived ease of use. Conversely, for items 14 ("Completing the game tasks gave me a satisfying feeling of accomplishment") and 17 ("I would recommend this game to my colleagues"), female participants reported higher agreement than males, indicating greater satisfaction with the gameplay experience. Item 29 ("I prefer learning with this game to learning through other ways") also showed higher agreement among females, suggesting that they found the game more relevant or effective for learning, which aligns with ProgramADAs' goals.

Open-Ended Questions The analysis of the open-ended questions complemented the quantitative results by providing a deeper understanding of participants' perceptions regarding the game. Among the most frequently mentioned positive aspects were the quality of the aesthetics and design, the proximity of the setting to the students' reality, and the integration between playfulness and learning. Participants highlighted the richness of the visual elements (including pixelated graphics, colors, detailed scenarios, and well-developed characters), as well as the resemblance of the environment to the university, which fostered identification, a sense of belonging, and engagement. The combination of narrative, tasks, and algorithm-related questions was also perceived as a dynamic, enjoyable, and effective way of learning. In addition, the initiative was praised for its potential to engage students, particularly women, and the recognition enabled by references to everyday academic life.

Suggestions for improvement were concentrated in four main areas. The first concern was instructions and task clarity, with requests for more explicit objectives, detailed tutorials, and clearer commands (such as running, interacting, or skipping dialogues). The second referred to navigation, with recommendations to include maps, minimaps, or arrows to guide movement and prevent players from getting lost. The third involved game dynamics and progression, with suggestions to gradually increase the difficulty, introduce additional levels and challenges, and reduce the duration of dialogues and cutscenes. Finally, participants highlighted technical and accessibility issues, including bug corrections, improved compatibility with various devices, enhanced performance in the mobile version, and features to support color-blind players.

In summary, the responses revealed enthusiasm for the proposal while also expressing expectations for improvements in clarity, orientation, diversity of challenges, and technical stability. These findings reinforce the quantitative results and provide concrete directions for the continued development of future versions of the game.

7 Discussion

The evaluation of ProgramADAs was conducted through two studies, providing valuable insights into its impact on students' motivation to learn programming content and its usability. In the first study, which aimed to understand the motivation of students based on the IMMS, it was observed that ProgramADAs is effective in capturing students' interest, with an average score of 4.3 in the attention dimension, indicating that the game sparks and maintains curiosity. Relevance was rated at 4.2, suggesting that the content aligns with the students' needs and goals, which may increase their engagement. However, some students were not surprised by the content, possibly because they already had prior knowledge of Algorithms. Confidence (4.4) and satisfaction (4.7) received high scores, indicating that the students felt secure in the teaching-learning process and were satisfied with using the game. This suggests that ProgramADAs is not only well-received but also provides a controllable and rewarding learning environment.

In the second study, which evaluated usability using the MEEGA+ questionnaire, the game was also well-received by students. The accessibility dimension received particularly high ratings, with the game's colors and fonts being particularly praised; this aspect contributes to a positive visual experience. Aesthetics and operability were also well-rated, but learnability showed some variation, indicating an initial

learning curve that could be smoothed out. Regarding the players' experience, the students' confidence was reinforced by ProgramADAs, with most feeling that they learned effectively and with an appropriate level of challenge. However, responses varied in this dimension, suggesting that the difficulty could be adjusted to accommodate different skill levels.

In particular, satisfaction was one of the most highlighted aspects of the experience, reflecting a sense of accomplishment and progress that encouraged continued engagement. However, the social interaction aspect was not strong, with evaluations suggesting that the game could benefit from greater incorporation of elements that promote interactions among students, such as cooperative challenges or friendly competitions. Overall fun was well-rated, with many students reporting that they enjoyed themselves while using the game. However, the level of immersion, although positive, showed that there is still room to improve focused attention and engagement through a richer narrative and more compelling game mechanics. Finally, there are preliminary indications that the game could have educational relevance as a complementary resource for teaching Algorithms within the Computer Science curriculum.

Although the current version of ProgramADAs presents a limited number of phases, future releases will incorporate additional scenarios and a question bank to ensure replayability. This evolution is expected to enhance long-term engagement, enabling first-year female students to interact with the game multiple times throughout the semester without encountering repetitive challenges.

Based on these evaluations, it can be concluded that ProgramADAs is a valuable digital game for motivating and teaching Algorithms, particularly for female students, offering a satisfying and enjoyable learning experience. However, to maximize its impact, it would be beneficial to adjust the difficulty level to better accommodate the diverse skills of the students, as well as incorporate more social interaction elements and improve the narrative to enhance immersion in the game. In this way, future versions of the game could become even more effective, increasing engagement and optimizing student learning.

Another important aspect to be discussed is the contextualization of the game scenario. Some visual and narrative elements were inspired by the UFJF campus environment, such as the bus and the university buildings, with the purpose of strengthening the sense of belonging and identification among local students. This choice was intentional and has proven motivating for participants familiar with this context. Nevertheless, these elements are not explicitly labeled as UFJF in the game narrative and can be interpreted more broadly as representations of a generic academic environment. In this sense, while the scenario fosters engagement for UFJF students, it does not compromise the experience of players from other institutions.

7.1 Threats to Validity

Threats to validity represent concerns about whether the results of a study accurately reflect reality or can be attributed to the factors being investigated [Wohlin *et al.*, 2012]. There are different types of threats to validity in research. Among them, the following stand out.

A potential threat to construct validity concerns the representativeness of the measurement instrument used to assess usability and player experience, specifically the MEEGA+ questionnaire. Although MEEGA+ is an instrument developed to evaluate digital educational games in diverse contexts, its application to a specific game like ProgramADAs may not capture all the nuances of students' experiences in learning Algorithms. It is also worth mentioning, still in this context, that our decision to adopt validated questionnaires such as IMMS and MEEGA+ aimed to guarantee methodological rigor, reliability, and comparability with related studies on Digital Educational Games. These instruments assess central aspects, including attention, confidence, satisfaction, and perceived relevance, which are directly aligned with the motivational purpose of ProgramADAs for female students. To mitigate this issue, a careful review of the questionnaire items was conducted to ensure their relevance and appropriateness for the context of the game's use, along with a pilot test with a group of participants that helped refine the questions and increase the instrument's sensitivity. Additionally, future evaluations may benefit from adding gender-specific items to capture more nuanced dimensions of support for women in STEM.

A potential threat to conclusion validity may arise from the generalization of the results obtained with the sample of 52 participants in the evaluation using the MEEGA+ questionnaire. Although the number of participants was increased compared to the first study, it may still not be sufficiently representative to draw generalized conclusions about the impact of ProgramADAs on the engagement and learning of girls in institutions with different contexts. To mitigate this concern, we plan to implement ProgramADAs in various classes and with participants from different courses and teaching modalities in future studies, enabling a more comprehensive and richer data collection.

Finally, potential threats to external validity may include issues related to participant engagement with the game, individual variations in interpreting the MEEGA+ questions, and possible biases in participant selection. Engagement with the game may be influenced by factors such as familiarity with digital games and the students' intrinsic motivation. Additionally, the girls' motivation may be affected by external factors unrelated to the game, such as social pressures or family expectations. To address these issues, strategies were implemented to promote a welcoming and inclusive environment during the game's application, as well as to collect demographic data and information about prior experience with digital games to better understand the participants' profiles and their potential influences on engagement and perception of the tool.

8 Conclusion

This work presented ProgramADAs, a digital educational game developed to support the teaching and learning of Algorithms among female students in Computer Science and related fields at the UFJF, addressing aspects of motivation and belonging. The first evaluation highlighted the high motivation caused by ProgramADAs, with students reporting increased interest, confidence, and satisfaction in the learning process. The second evaluation, using the MEEGA+ questionnaire, reinforced the game's usability and its effectiveness

in enhancing the players' experience, also highlighting the potential of the content and proposed challenges. These results confirm that ProgramADAs, offered as an extracurricular complement to the traditional academic curriculum, create a motivating and inclusive learning environment, strengthening students' confidence in their abilities and encouraging their retention in the field.

In the near future, it is expected to integrate ProgramADAs into the curriculum for first-year students in the Algorithms course, aiming to increase women's involvement and encourage them to remain in the field of Computer Science. With the continued use of the game, it is expected that students will develop a stronger foundation of knowledge and a greater appreciation for the course through a game-based approach. Furthermore, we highlight that although the game scenario was inspired by the UFJF context, this design choice does not restrict its use to this specific setting. For local students, the scenario strengthens motivation and a sense of belonging, while for students from other institutions, it can be understood as a generic school or university environment.

For future work, it is planned to expand the game's reach by applying it to other classes, including students from different courses and teaching modalities, to verify its effectiveness in motivating girls to learn Algorithms. Additionally, an experimental study will be developed to measure the efficacy of the game compared to traditional teaching methods, since the Algorithms course is challenging for everyone. It is also aimed at expanding the content of ProgramADAs to cover subsequent subjects, such as Data Structures, and making the game available to high school students. We believe that by starting their learning journey while identifying with a character in a university setting, more girls will be inspired to pursue careers in Computer Science and related fields.

Declarations

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Authors' Contributions

LV contributed to software development, validation, and writing of the original draft. BQ contributed to conceptualization, validation, writing of the original draft, and funding acquisition. LC contributed to formal analysis, data curation, visualization, writing of the original draft, and review and editing of the manuscript. PV contributed to methodology, investigation, validation, writing of the original draft, and review and editing of the manuscript. AO contributed to conceptualization, methodology, investigation, supervision, project administration, funding acquisition, and participated in writing of the original draft as well as in reviewing and editing the manuscript.

Competing interests

The authors declare that they have no competing interests.

Availability of data and materials

The ProgramADAs' source code is publicly available on GitHub at `https://github.com/Program-Ada/ProgramADAs` (accessed on 24 December 2025). The links to the ICFs and the questionnaires used in the evaluations are provided as footnotes in the corresponding sections of the document.

Further relevant information

The authors declare that OpenAI's ChatGPT was used as an auxiliary tool for translation and for orthographic and grammatical revision during the preparation of this manuscript. All content was reviewed by the authors, who take full responsibility for the final version of the document.

References

Aslan, S. and Balci, O. (2015). GAMED: digital educational game development methodology. *Simulation*, 91(4):307–319. DOI: https://doi.org/10.1177/0037549715572673.

Bell, T., Alexander, J., Freeman, I., and Grimley, M. (2009). Computer science unplugged: school students doing real computing without computers. *New Zealand Journal of Applied Computing and Information Technology*, 13(1):20–29.

Bonner, D. and Dorneich, M. (2016). Developing game-based learning requirements to increase female middle school students interest in computer science. In *Proceedings of the 60th Human Factors and Ergonomics Society annual meeting (HFES)*, pages 380–384. SAGE. DOI: https://doi.org/10.1177/1541931213601086.

Briceño, A. J. L., Silvestre, A. S. S., Castro, B. P., Soares, H. E. F., Oliveira, T. A., Silva, T. P., Araujo, A. P. F., Castanho, C. D., Koike, C. C., Holanda, M., and Oliveira, R. B. (2021). Mundo Bit Byte: um jogo digital para disseminar o conhecimento sobre personalidades femininas na computação. In *Anais do XV Women in Information Technology (WIT)*, pages 121–130. SBC. DOI: https://doi.org/10.5753/wit.2021.15848.

Cruz, F. L. and Barbosa, L. S. d. O. (2020). Computação na escola para mulheres: uso do software scratch com alunas do ensino médio como incentivo as areas de computação. *Brazilian Journal of Development*, 6(3):12841–12854. DOI: https://doi.org/10.34117/bjdv6n3-228.

Cunha, M., Cabral, G., and Fonseca, L. (2022). Pensando computacionalmente com Ana: storytelling sensível ao gênero para favorecer a autoeficácia das estudantes do ensino fundamental I. In *Anais do XXXIII Simpósio Brasileiro de Informática na Educação (SBIE)*, pages 1334–1343. SBC. DOI: https://doi.org/10.5753/sbie.2022.224948.

Dlab, M. H. and Hoic-Bozic, N. (2021). Effectiveness of game development-based learning for acquiring programming skills in lower secondary education in Croatia. *Education and Information Technologies*, 26:4433–4456. DOI: https://doi.org/10.1007/s10639-021-10471-w.

Duarte, S. M., Pinheiro, R. G., Bacchin, C. T., da Consolação Machado, M., and Ishitani, L. (2021). Sucesso4me: projeto de um jogo para atrair mulheres para a área de computação. In *Anais do XX Simpósio Brasileiro de Jogos e Entretenimento Digital (SBGames)*, pages 218–227. SBC. DOI: https://doi.org/10.5753/sbgames_estendido.2021.19642.

Franzoia, F. H., de Sousa Pires, F. G., and Pessoa, M. S. S. (2019). Mentorando meninas iniciantes em programação: um estudo de caso. In *Anais do XIII Women in Information Technology (WIT)*, pages 199–203. SBC. DOI: https://doi.org/10.5753/wit.2019.6737.

Gomes, W. F., Louzada, C. S., Nunes, M. A. S. N., Salgueiro,

E. M., and Andrade, B. T. (2014). Incentivando meninas do ensino médio à área de Ciência da Computação usando o Scratch como ferramenta. In *Anais do XX Workshop de Informática na Escola (WIE)*, pages 223–232. SBC. DOI: https://doi.org/10.5753/cbie.wie.2014.223.

Heintz, S. and Law, E. L.-C. (2018). Digital educational games: Methodologies for evaluating the impact of game type. *ACM Transactions on Computer-Human Interaction*, 25(2):1–49. DOI: https://doi.org/10.1145/3177881.

Kalmpourtzis, G. (2018). *Educational Game Design Fundamentals: A journey to creating intrinsically motivating learning experiences*. A K Peters/CRC Press.

Keller, J. M. (2009). *Motivational design for learning and performance: The ARCS model approach*. Springer.

Macena, J., Pires, F., Pessoa, M., and Melo, R. (2022). Hello Food: um jogo para praticar conceitos de algoritmos para iniciantes na computação. In *Anais estendidos do XXI Simpósio Brasileiro de Jogos e Entretenimento Digital (SBGames)*, pages 1066–1075. SBC. DOI: https://doi.org/10.5753/sbgames_estendido.2022.226172.

Machado, M. d. C., Barretto, Y. C., and Ishitani, L. (2022). Características de jogos digitais para o público feminino: uma revisão sistemática de literatura. *Anais do Computer on the Beach*, 13:111–118. DOI: https://doi.org/10.14210/cotb.v13.p111-118.

Marini, A., Tives, H. A., de Fátima Sarda Muler, I., and Oliveira, G. d. (2023). Promovendo a participação feminina em STEM na Educação Básica: Projeto Meninas! In *Anais do XVII Women in Information Technology (WIT)*, pages 272–281. SBC. DOI: https://doi.org/10.5753/wit.2023.230598.

Moreno-Ger, P., Burgos, D., Martínez-Ortiz, I., Sierra, J. L., and Fernández-Manjón, B. (2008). Educational game design for online education. *Computers in Human Behavior*, 24(6):2530–2540. DOI: https://doi.org/10.1016/j.chb.2008.03.012.

Mozelius, P. and Humble, N. (2023). Design factors for an educational game where girls and boys play together to learn fundamental programming. In *Proceedings of the 11th EAI International Conference on ArtsIT, Interactivity and Game Creation (ArtsIT)*, pages 134–148. Springer. DOI: https://doi.org/10.1007/978-3-031-28993-4_10.

Nepomuceno, J. G. M. B. and Souza, J. F. d. (2022). Enola: Jogo sério para ensino de SQL. In *Anais do XXXIII Simpósio Brasileiro de Informática na Educação (SBIE)*, pages 345–356. SBC. DOI: https://doi.org/10.5753/sbie.2022.224663.

Pereira, N. V. and Araújo, M. S. T. d. (2020). Utilização de recursos tecnológicos na educação: caminhos e perspectivas. *Research, Society and Development*, 9(8):e447985421. DOI: https://doi.org/10.33448/rsd-v9i8.5421.

Petri, G., von Wangenheim, C. G., and Borgatto, A. F. (2019). MEEGA+: Um modelo para a avaliação de jogos educacionais para o ensino de computação. *Revista Brasileira de Informática na Educação*, 27(3):52–81. DOI: https://doi.org/10.5753/rbie.2019.27.03.52.

Plass, J. L., Goldman, R., Flanagan, M., and Perlin, K. (2009). RAPUNSEL: Improving self-efficacy and self-esteem with an educational computer game. In *Proceedings of the 17th International Conference on Computers in Education (ICCE)*, pages 682–689. APSCE.

Prensky, M. (2003). Digital game-based learning. *Computers in entertainment (CIE)*, 1(1):21. DOI: https://doi.org/10.1145/950566.950596.

Queiroz, R. J. d., de Sousa Pinto, F., and Silva, P. C. d. (2019). IslandTest: jogo educativo para apoiar o processo ensino-aprendizagem de testes de software. In *Anais do XXVII Workshop sobre Educação em Computação (WEI)*, pages 533–542. SBC. DOI: https://doi.org/10.5753/wei.2019.6658.

Raabe, A. L. A., Brackmann, C. P., and Campo, F. R. (2020). *Currículo de referência em tecnologia e computação: da educação infantil ao ensino fundamental*. CBIE, São Paulo, SP, 2nd edition.

Reis, R. C. D., Reis, C. D. G., Lyra, K. T., Nascimento, T. M., and Assolari, C. L. (2023). Jogos com temática feminina: Um mapeamento sistemático da literatura. In *Anais Estendidos do XXII Simpósio Brasileiro de Jogos e Entretenimento Digital (SBGames)*, pages 436–448. SBC. DOI: https://doi.org/10.5753/sbgames_estendido.2023.234224.

Salinas, M. N. (2021). A percepção das mulheres sobre a programação — oficinas de programação Django Girls. In *Anais do XV Women in Information Technology (WIT)*, pages 1–10. SBC. DOI: https://doi.org/10.5753/wit.2021.15836.

Santos, A. L. d., Souza, M. R. A., Dayrell, M., and Figueiredo, E. (2018). A systematic mapping study on game elements and serious games for learning programming. In *Proceedings of the 10th International Conference on Computer Supported Education (CSEDU)*, pages 328–356. Springer. DOI: https://doi.org/10.1007/978-3-030-21151-6_17.

Santos, N. D. d. and Marczak, S. (2023). Fatores de atração, evasão e permanência de mulheres nas áreas da computação. In *Anais do XVII Women in Information Technology (WIT)*, pages 136–147. SBC. DOI: https://doi.org/10.5753/wit.2023.230789.

Schoeffel, P., Moser, P., Varela, G., Durigon, L., de Albuquerque, G. C., and Niquelatti, M. (2015). Uma experiência no ensino de pensamento computacional para alunos do ensino fundamental. In *Anais dos Workshops do IV Congresso Brasileiro de Informática na Educação (CBIE)*, pages 1474–1484. SBC. DOI: https://doi.org/10.5753/cbie.wcbie.2015.1474.

Segura, R. J., Pino, F. J. d., Ogáyar, C. J., and Rueda, A. J. (2020). VR-OCKS: A virtual reality game for learning the basic concepts of programming. *Computer Applications in Engineering Education*, 28(1):31–41. DOI: https://doi.org/10.1002/cae.22172.

Silva, A. L., Nascimento, G. S., Pereira, J. G. O., Neto, L. M., Araújo, M. E. C. S., and Oliveira, V. A. P. d. (2022). Codeland: um jogo para o ensino de lógica de programação com Python. In *Anais estendidos do XXI Simpósio Brasileiro de Jogos e Entretenimento Digital (SBGames)*, pages 643–652. SBC. DOI: https://doi.org/10.5753/sbgames_estendido.2022.225460.

Silva, G. L. S. d., de Sá Barreto, G. S., and Nepomuceno, V. S. (2023). Jogos digitais para o ensino de lógica de programação: um mapeamento sistemático. Trabalho de con-

clusão de curso, Instituto Federal de Pernambuco, Campus Recife. Curso de Análise e Desenvolvimento de Sistemas.

Silva, M. A. d. A. and Dantas, A. (2014). KLouro: Um jogo educacional para motivar alunos iniciantes em programação. In *Anais do XXV Simpósio Brasileiro de Informática na Educação (SBIE)*, pages 702–711. SBC. DOI: https://doi.org/10.5753/cbie.sbie.2014.702.

Silva, R. R., Rivero, L., and Santos, R. P. d. (2021). ProgramSE: Um jogo para aprendizagem de conceitos de lógica de programaçao. *Revista Brasileira de Informática na Educação*, 29:301–330. DOI: https://doi.org/10.5753/rbie.2021.29.0.301.

Teixeira Júnior, W., Santos, L., Manzano, A., Ângela Farias, Souza, T., Badji, I., Prietch, S. S., and Resmini, R. (2019). Techno girls: oficinas de programação de jogos para estudantes de escolas públicas. In *Anais do XIII Women in Information Technology (WIT)*, pages 11–20. SBC. DOI: https://doi.org/10.5753/wit.2019.6708.

Toda, A. M., Oliveira, W., Klock, A. C., Palomino, P. T., Pimenta, M., Gasparini, I., Shi, L., Bittencourt, I., Isotani, S., and Cristea, A. I. (2019). A taxonomy of game elements for gamification in educational contexts: Proposal and evaluation. In *Proceedings of the 19th International Conference on Advanced Learning Technologies (ICALT)*, pages 84–88. IEEE. DOI: https://doi.org/10.1109/icalt.2019.00028.

Videnovik, M., Vold, T., Kiønig, L., Madevska Bogdanova, A., and Trajkovik, V. (2023). Game-based learning in computer science education: a scoping literature review. *International Journal of STEM Education*, 10(54). DOI: https://doi.org/10.1186/s40594-023-00447-2.

Wohlin, C., Runeson, P., Höst, M., Ohlsson, M. C., Regnell, B., Wesslén, A., *et al*. (2012). *Experimentation in software engineering*, volume 236. Springer.

Yamashita, V. T., Ferreira, M. R., Vilarinho, L. L. A., Nunes, E., de Melo Quintela, B., and de Oliveira, A. M. (2023). Pensamento computacional e jogos digitais: Possibilidades para despertar a motivação das meninas para o estudo de programação no ensino superior. In *Anais do II Workshop de Pensamento Computacional Inclusão (WPCI)*, pages 117–126. SBC. DOI: https://doi.org/10.5753/wpci.2023.236180.

Yamashita, V. T., Vilarinho, L. L. A., Gonçalves, L. B., Quintela, B. d. M., Renhe, M. C., Chaves, L. J., Valle, P. H. D., and Oliveira, A. M. d. (2024a). Desenvolvimento de um jogo digital para apoiar o ensino-aprendizagem de algoritmos: Estratégias para engajar mulheres no ensino superior em computaçao. In *Anais do XXIII Simpósio Brasileiro de Jogos e Entretenimento Digital (SBGames)*, pages 1281–1292. SBC. DOI: https://doi.org/10.5753/sbgames.2024.241246.

Yamashita, V. T., Vilarinho, L. L. A., Silva, A., Feital, M., Valle, P. H. D., de Melo Quintela, B., and Oliveira, A. M. d. (2024b). Jogos educacionais digitais e a inclusão das mulheres na programação: Um mapeamento sistemático. In *Anais do XXXV Simpósio Brasileiro de Informática na Educação (SBIE)*, pages 1028–1042. SBC. DOI: https://doi.org/10.5753/sbie.2024.242714.