*Journal on Interactive Systems, 2025, 16:1,* doi: 10.5753/jis.2025.4656


# Evaluating a Serious Game for Math: Is it Useful and Fun?

**Diego Fellipe Tondorf** [ **Santa Catarina State University** | ***diegodft@hotmail.com*** ]
**Marcelo da Silva Hounsell** [ **Santa Catarina State University** | ***marcelo.hounsell@udesc.br*** ]
**Vanessa Andrade Pereira** [ **Federal University of São Paulo** | ***vapereira@unifesp.br*** ]

*R. Paulo Malschitzki, 200 - Zona Industrial Norte, Joinville - SC, 89219-710, Brazil*

**Received:** 30 June 2024 • **Accepted:** 02 December 2024 • **Published:** 01 January 2025

**Abstract:** *Background:* Some arguing has been drawn in the literature questioning if a game can be purposeful (such as a Serious Game) and fun at the same time. *Purpose:* A serious game called Matemágica, designed to review basic mathematical operations and procedures, was selected to help delve in depth on this questioning. *Methods:* The evaluation assesses the game's utility to teach mathematics and the fun perceived by its players. An empathic utility questionnaire was answered by 50 mature and experienced teachers, and a perceived fun questionnaire was created and answered by 334 students. *Results:* Girls and boys perceived similar fun and 3rd grade students (the actual target audience) felt just a little bit more fun than 4th and 5th grades. No significant difference was found between students from public and private schools. Overall, the game (Matemágica) was regarded as of high utility (scored 4.39 on a scale from 1 to 5) by the teachers and of high perception of fun (score 4,61 on a scale from 1 to 5) by the students. *Conclusion:* This paper shows that even a casual Serious Game can be useful and fun at the same time.

**Keywords:** Game Design, Game-Based Learning, Education, STEM

## 1 Introduction

A game is a structured system where players exert effort to influence quantifiable outcomes, to which they are emotionally attached, and where consequences are optional and negotiable [Juul, 2011]. Serious Games (SG) are designed for specific purposes, where fun is not the main focus of the game [Michael and Chen, 2005]. They can be used in areas such as health, politics, communication, defense, training, engineering, and education, among others [Zyda, 2005]. Video games provide players with engaging elements like outcomes and feedback, which actively facilitate the learning process within the gaming experience [Prensky, 2001].

The term "serious" in "serious games" could stress the debate over whether such games can combine fun with their intended purpose, as it usually implies a lack of fun. The common sense understanding of seriousness often refers to something boring, rude, authoritative, and funless. While "serious" aims to highlight the educational or purposeful aspect of these games, it may be perceived as inherently opposed to fun. There are other terms used in the literature such as [Michael and Chen, 2005; Ritterfeld *et al*., 2009]: Edutainment; Educational Games; Art Games; Health-Games; Games for Health; Games for Change; Games with a Purpose, among others. Nevertheless, SG is the terminology that stuck in the academy.

We understand that an SG can be designed to be used at different moments of the learning process:

- It can be deployed before students deal with the content/skill, as a boost of interest to the topic;
- It can be deployed to actually present specific content/skill to students, but in a ludic way;
- It can be deployed after acquiring the basics of the content/skill, as a way to exercise or to review that topic;
- It can also serve to more than one of the moments above.

Fun is a highly commented and researched subject in digital game design [Blythe *et al*., 2004; Hunicke *et al*., 2004; Koster, 2013]. Positive results from playing a fun serious digital game include enhanced learning, increased active involvement, and a clear way to achieve goals [Tondorf and Hounsell, 2022]. Fun is considered one of the greatest challenges in game design [Tondorf and Hounsell, 2023]. The perception of fun drives players' motivation to use a game and consequently, obtain benefits from it. If a game is not fun, players may not want to play it.

The utility of the game perceived by professionals (teachers, therapists, and others) who would suggest the game to users/players (students, patients, among others) is important because an SG must be useful for its primary purpose; otherwise, it would likely never be chosen by professionals and thus would not reach users/players.

Games have long been elements of society [Huizinga, 2000] and children and young people, who were born into the digital age, naturally integrate digital technologies into their lives [Prensky, 2001]. Games used in the classroom help develop problem-solving skills, enhance knowledge acquisition, and introduce challenges and complexities [Souza and Silva, 2021]. Mathematics, despite its ancient origins, remains a fundamental yet abstract subject [Soares, 2020]. Thus, using digital serious games (SG) to teach mathematics to children holds significant potential.

Although SG with specific purposes can achieve notable benefits [Michael and Chen, 2005], effectively integrating fun remains a complex task. The debate over whether (SG) can be both fun and useful is central to our research. Some argue that the primary focus of SG, such as educational or therapeutic goals, may conflict with fun, potentially leading to reduced engagement and reduced effectiveness [Gurgel

*et al*., 2006]. Others, suggest that fun is a fundamental aspect of games and that it can coexist with educational objectives [Koster, 2013; Schell, 2020]. This debate suggests that fun and seriousness might be mutually exclusive, implying that if a game becomes too serious, it might diminish its fun element [Blythe *et al*., 2004]. Finding a balance between fun and purpose is a challenge, and while some researchers propose that this balance is necessary [Marsh, 2011], a methodology for achieving it is still to be found. Our research explores if an SG can integrate both aspects effectively.

As digital games become increasingly integral to the education of children, it is important to balance fun with educational value [Tondorf and Hounsell, 2023]. The fun derived from both traditional and digital games is influenced by a complex mix of psychological, physiological, and technological factors. Given the rapid growth of the digital games industry, adopting a multidisciplinary approach that includes evaluation techniques and systematic reviews is important to better understand and enhance the fun aspect of these games [Tondorf and Hounsell, 2021].

Exploring the balance between utility and fun involves obtaining teachers' assessments of a game's utility and students' experiences of fun. Understanding both perspectives is essential for addressing the research question, which seeks to determine whether an SG can effectively balance educational value and fun. A game that is useful but not fun may fail to engage players, while a game that is fun but lacks educational content might not achieve its teaching goals. Therefore, finding this balance is key to the game's effectiveness and acceptance.

This paper investigates the utility and perceived fun of a math educational game designed for students in 3rd to 5th grades, intended to be used after they have learned basic math operations. By focusing on educational games for children, this study contributes to a specific subset within the broader category of Serious Games. Understanding whether the game can achieve these dual objectives is important for ensuring that educational games are both engaging and valuable in the learning process. The central question of this study is: Can an SG be considered both useful by teachers and fun by students?

# 2 Related Work

This section highlights some research that focused on integrating educational content with fun gameplay.

Berg [2021] presented a tool for measuring the cognitive functions of students in the form of a digital game. When assessing player's feedback, seven questions were asked on a 4-point scale ranging from 'not at all', 'a little', 'quite a bit' to 'yes, a lot'. Among those seven questions, one was about fun. The results for enjoyment, fun, excitement, and the reverse of boring were combined, and the enjoyment score was generated. The results indicated that the game developed provides an enjoyable experience for the students.

In the work of Zikos *et al*. [2019], an acceptance evaluation was conducted on a gamification-enabled collaboration and knowledge sharing platform. The evaluation was conducted across five dimensions: usability, knowledge integration, work experience, user acceptance, and overall impact. The results showed a highly positive value for user acceptance, with supervisors' results being close to 80% and workers' feedback being close to 60%.

Ninaus *et al*. [2017] conducted a study to examine the intrinsic motivation in math and acceptance of a game-based math learning tool. The results showed students perceiving the game as useful and easy to use for improving their knowledge, and with high levels of acceptance. Additionally, the results supported the hypothesis that there is a positive association between flow experience, acceptance, and intrinsic motivation.

The evaluation conducted by Kuindersma *et al*. [2016] compared mandatory gameplay with voluntary gameplay. The questionnaire used in the study had one question about fun, which was considered a part of enjoyment. The results indicate that mandatory gameplay can be just as fun as voluntary gameplay.

In the work of Pyae *et al*. [2017] the Game Experience Questionnaire [IJsselsteijn *et al*., 2013] was used to assess the experience of two groups of elderly players in a Digital Skiing Game. One of the questions in the questionnaire asked about fun, which is part of the positive effect dimension of the questionnaire. The results of the study showed that the positive effects had an average score of 3 (on a scale from 0 to 4). Moreover, some of the players commented that the game was fun and related this to the context of the game, the gameplay, and the user experience. Both groups of players claimed that playing digital games is fun.

The aforementioned works show that SGs have been assessed for fun alongside other dimensions such as acceptance, usability, enjoyment and user experience. They demonstrate that SGs can be fun but it is not usual to find an educational SG to be assessed for both player's fun and teacher's perceived utility.

# 3 Matemágica

Matemágica [Silva and Pereira, 2020] is a casual SG composed of several scenarios and charismatic fairy tale characters in order to entertain and teach. The main objective of the game is to help teach mathematics to 3rd, 4th and 5th graders of elementary school, regarding the four basic mathematical procedures to perform - subtraction, addition, multiplication, and division. The game is available for free using a web browser[1].

**Design and Development:** Matemágica was developed through a collaborative project between CEGI (Centro de Estudos em Games e Internet, a research group at the Federal University of São Paulo) and a public school. CEGI specializes in creating educational digital games in partnership with educators and other collaborators. CEGI is composed of around 25 undergraduate students divided into 4 teams: programming, art, audio and game design. This educational initiative involved a team of computer science students, guided by a faculty member, to create an SG aimed at helping learning through interactive scenarios. Developed with constant

[1] https://cegi.unifesp.br/matemagica

feedback from teachers in order to achieve the educational goal, the project emphasizes the integration of technology into education. Design procedure included online meetings and discussions throughout 2020, with teachers and designers working together on necessary changes.

The production process of an educational SG at CEGI follows these steps: The project starts from a demand for learning content from the teachers, considering the content to be taught. Next, the request is sent to CEGI so the team can develop the initial idea of the game and start the documentation (the Game Design Document, GDD). A first prototype is built and is presented to the teacher, who provide feedback (possibly indicating pedagogical changes and adaptations). The prototype then moves to the finalization stage (including modifications and playability evaluation). Finally, the material is delivered to the partner school and made available on the website.

Matemágica is the result of an interdisciplinary extension project between CEGI and public school teachers. This interdisciplinary approach is one of a most required development process to name the results as a SG. Such understanding can be clearly inferred by Figure 1. The development process, which took a year, included brainstorming, concept development, GDD creation, iterative design, and balancing game mechanics and level design [Rogers, 2010; Schell, 2020].

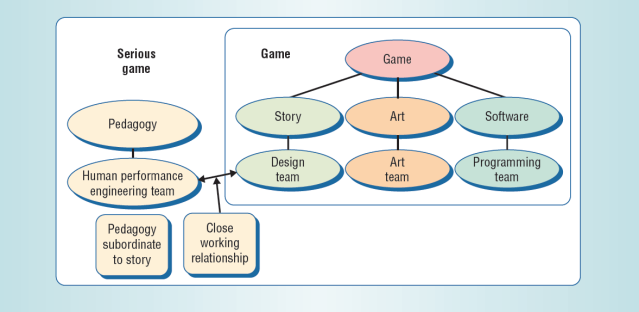


**Figure 1.** From game to serious game. Unlike their entertainment-only counterparts, serious games use pedagogy to infuse specific knowledge into the game play experience [Zyda, 2005].

**Pedagogy and Team Collaboration:** Throughout the development phase, feedback was obtained from three 3rd-grade teachers to enhance the pedagogical aspects of the game. Teachers' recommendations included providing a detailed description of the numbers displayed on the screen, including their full names, and ensuring the game prevents players from making mistakes.

The game was designed as a blended learning [Bonk *et al.*, 2005] approach that combines traditional teaching methodologies with innovative approaches based on digital technologies [Horn and Staker, 2015]. Both the content and the game design aim to engage children and provide an enjoyable learning experience in mathematics.

Teachers are generally enthusiastic about the use of technology in the classroom, believing that it can significantly impact pedagogical practices [Horn and Staker, 2015]. Additionally, teachers were excited with the opportunity to create games for students.

**Purpose and Application** Matemágica serves as an aid in the teaching process of the four basic operations procedures, guiding the student to exercise the knowledge obtained in the classroom. The Matemágica game serves different purposes for different grades:

- For 3rd grade, it functions as an exercise for recently learnt math content. This is the primary function.
- For 4th grade, it serves as a tool for reviewing and reinforcing previously covered content.
- For 5th grade, it provides a rewarding experience for remembering the content.

The variation in purpose to play can be attributed to the specific content of the game. The game does not offer incremental difficulty levels; instead, each activity is designed to focus on a specific mathematical operation and a limited the number of digits involved. The challenge lies in the complexity of the operations, providing a similar level of difficulty to that in typical classroom activities.

**Gameplay and Mechanics:** The game is a casual game, that is, easy to learn, of a short-term use, simple to play, and appealing to a broad audience [Juul, 2010]. In the game, each character was designed to be attractive to children, with sound and environments inspired by the fantastic universe of fairy tales. Players can choose which place to go (see Figure 2 (a)): the Confectioner Dragon's house (subtraction), the Pirate Island (addition), the Tooth Fairy Kitchen (division), or the Witch's house (multiplication). The game does not have incremental difficulties; all challenges are leveled according to the school curriculum, with each mathematical operation having its own specific difficulty.

Matemágica makes explicit some mathematical procedures, such as the "borrow one" (to subtraction), seen at Figure 2 (b) and (c): the numeral that will be borrowed (in this case the centesimal part) appears crossed out (4) and a small number is put over it (3) and this unit join the right value (1 united to 7 = 17) in order to make it a bigger one, capable of being subtracted by the number just below (9). Players must fill out the blank space that appears active on the right, while the others are dimmed and blocked.

The game mechanics were implemented in a way that leads the student to execute the exercise in the correct way. The game prevents the common error of subtraction procedure of doing the calculation from left to right (starting from the decimal part). There is a different narrative for every place and operation (as show in Figure 2).

In the Confectioner Dragon's House (Figure 2 (c)), the objective is for the dragon to bake a cake, which requires a specific quantity of eggs. The player is provided with a number of eggs and must place the correct amount on the scale to match the dragon's requirement. Subsequently, a tally will display the total number of eggs and the number of eggs needed for the recipe.

In the Pirate Island game (Figure 2 (d)), the pirate is lost and needs to add the numbers shown by the parrot by clicking on the correct directional sign. In the Tooth Fairy's Kitchen game (Figure 2 (e)), the fairy needs to divide a certain number of coins equally among a certain number of houses. The

player needs to calculate the number of coins for each house. In the Witch's House game (Figure 2 (f)), the witch needs to make a potion, and for that, she needs certain ingredients. The player chooses a potion and a magic dust. The potion displays the calculation, and the dust displays the result. Each potion and dust are unique, and for each potion (calculation), there is one correct dust (result).

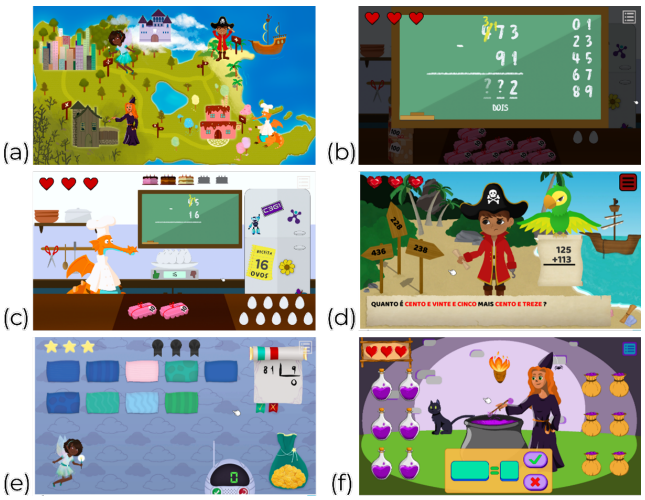


**Figure 2.** Matemágica Screenshots [Silva and Pereira, 2020]: (a) Game's Full Map; (b) Borrow One Procedure; (c) Confectioner Dragon's house; (d) Pirate Island; (e) Tooth Fairy's Kitchen; (f) Witch's House;

# 4 Materials and Methods

Two separate studies were conducted to evaluate Matemágica, one by teachers and other by students. The study with teachers was made on 2022 and the study with the students was made on 2023. Figure 3 shows an overview of the experimental process for both studies. Two different questionnaires were used, one about utility (SEU-Q v2) and other about fun. The entire process was authorized by the Brazilian Research Ethics Committee under CAAE number 57727922.3.0000.0118. All these questionnaires were answered directly in the Google Forms tool.

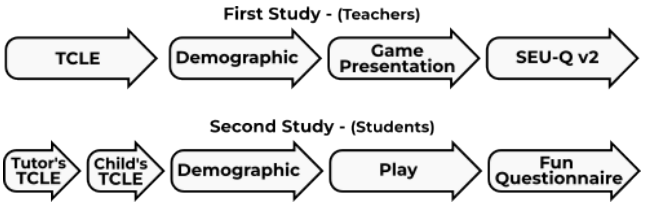


**Figure 3.** Experimental Process Overview.

For the first study, public school teachers were recruited through the research group's social media channels and email invitations. Teachers were presented to the game and its mechanics. Additionally, a link was provided to play the game, which is free and can be played from a browser. Participants completed the questionnaire using their own computers.

In the second study, a collaboration with one public and one private school provided access to teachers and students in their educational settings. Consent was first obtained from the students' tutors, followed by consent from the students themselves through a form. Student information was then collected, and two sessions of gameplay were conducted. After the play sessions, the students completed a questionnaire designed to assess their perceptions of the game's fun.

We have gathered data to analyze how the type of school affects results. In Brazil, municipal elementary schools often have fewer technological resources [INEP, 2023]. We explored how these disparities in investment and technology access might impact fun outcomes.

The two separate studies were conducted to gather distinct perspectives: teachers, who evaluated the game's practical application and utility as a tool, and students, who assessed the game's level of fun. Variations in study contexts and evaluation criteria could result in differing insights into the game's overall performance and effectiveness.

The analysis process started with collecting responses via Google Forms, which provided a structured format. The data was then organized in Excel for efficient management. Finally, Jamovi was used for statistical analysis, offering robust tools to generate informed results and ensure a thorough examination of the collected data.

## 4.1 Is Matemágica Useful?

The SEU-Q v2 questionnaire [Grimes *et al.*, 2019] is an instrument for assessing the utility of an SG that can be applied before, during, or after the development of the game, to any of the stakeholders involved in designing the game. SEU-Q is the only known instrument that allows for an "empathetic" evaluation, i.e. teachers were asked to evaluate from the students' perspective, and from all professionals perspectives (not their own, only). This feature allows the teacher to put themselves in the student's position and think about what their experience with the game would be like.

Those involved are the players (students) and the professionals (teachers) who will use the SG as a tool in their professional activity. However, due to its empathetic characteristic, SEU-Q does not need to be applied to both groups, so, it is possible to make the evaluation only with the professionals who will apply the game.

The age difference between teachers and students can be a significant factor, as it may lead to differing experiences and expectations with the game. However, given that teachers are trained in both pedagogy and child development, they are generally able to give their students' perspectives when evaluating educational tools. The empathic approach makes professionals reflect more deeply regarding the utility of the game despite their own particular perspective.

A previous work [Tondorf *et al.*, 2022], has already been published in Portuguese, with a small sample of 13 answers, where the game achieved an overall average 4.46 (on a 1 to 5 scale) which encouraged us to extend to a bigger sample and include players perspective.

The second version of SEU-Q, emphasize the empathic view; use a more usual and reliable scale; observe the perception of safety regarding the use and acceptance; asks if the Serious Objective is perceptible; reorganize the form to be easier and clearer to fill out; obtain information about the analysis of the game as an instrument, and; broaden the gen-

erality of the instrument. The complete translated SEU-Q v2 can be seen in Appendix A.

Therefore, we used the SEU-Q v2, as it is an objective instrument that is simple and quick to use and focused on the utility of the SG. SEU-Q v2 is divided into groups of questions, separated into 3 sub-groups with 3 questions each. The two main groups are separated so that the respondent would answer questions 1 to 9 from the players' view and questions 10 to 18 from the professionals' view. Besides the objective questions there are 3 discursive questions that seek comments regarding benefits/advantages, difficulties/disadvantages, and suggestions.

An email invitation to participate in this research was sent to mathematics teachers in public schools who teach 3rd to 5th grades. These teachers had no participation in the development of the game. Before beginning the questionnaire, the Informed Consent Form is presented and signed, thus giving full consent to use the data for analysis.

## 4.2 Is Matemágica Fun?

The second study involved the development of a questionnaire designed to evaluate the perception of fun based on a systematic literature mapping [Tondorf and Hounsell, 2022]. The objective of this questionnaire was to assess players willingness to engage in future play and their subjective perception of fun.

Prior to answering the demographic questionnaire parents or guardians of the participants provided their Informed Consent Form. Furthermore, child participants signed a supplementary Consent Form themselves. The first part of the questionnaire is composed of (a) An initial presentation; (b) Presentation of elements of research ethics; (c) Introduction to the SG that defines the context; (d) Questions related to the player's birthday, time of the day and grade. These elements are possible to change the perception of fun when playing. Then the study begins. None of the steps were mandatory, and the child could leave the study at any time without any nor explanation.

As part of the study, teachers were scheduled to take their classes to the computer room to introduce the students to Matemágica and help them get familiar with the game. On the first and second visit the students only played the game. On the third visit, students were allowed to play the game for about 10 minutes before being asked to fill in the second questionnaire regarding fun.

The game session lasted one class (45 minutes), when students played the game accompanied by the teacher and a member of the research group. During the sessions, a senior member of the research group observed the behavior of the students and made notes.

As suggested before [Read and MacFarlane, 2006], the desire to play again is related to fun. As much as common sense accepts this relationship, we have not seen in the literature a specific study that proves these aspects. Therefore, it seemed interesting to also investigate this relationship in particular. The second questionnaire included only 2 questions, the question A (Do you want to play this game AGAIN?), is related to that engagement and the willingness to play again. Question B (How much FUN did you have with the game?) is a direct question about the player's perception of fun. In this case, the answer ranges from "NO fun" (1) to "a LOT of fun" (5).

In order to meet the age range of the children, pictograms were drawn representing faces that vary from a sad expression to a happy expression, and the color blue was used to represent sadness and yellow to represent happiness (see Figure 4). A similar pictogram scheme was used in the Fun Toolkit (FT) [Read and MacFarlane, 2006].

**Figure 4.** Our Smileyometer. Based on [Read and MacFarlane, 2006]

# 5 Results

In this section, we present the results of both studies, which aimed to explore the utility of the game from the perspective of teachers and the fun experienced by students.

## 5.1 Ethnographic Data

In order to reveal details of the environment in which the research was conducted, ethnographic notes [Geertz, 2017; Malinowski, 2016] will be presented about the school physical space, the technological artifacts available for pedagogical use, and the actions of students and teachers during the research. The research was conducted in 2023 at a Public and at a Private School, both at Brazilian state of São Paulo. This description will serve to contextualize the social actors involved in the research, their place of action, and relevant considerations for the study based on field observations [Latour, 2007]. Our aim is to investigate the technological differences observed between the schools. This investigation prompts the hypothesis that such distinctions may influence the results within each educational setting.

### 5.1.1 Public School

The study was conducted partially at a public regular elementary school that has a computer room with 15 fully functional computers, each one in a desk with two chairs. Since there are close to 30 students in each class, they usually work in pairs when using the computer room. Computers are equipped with Microsoft Suite, including Word, Excel, and PowerPoint, and run on the Windows 10 operating system. The default browser installed on each computer is Google Chrome.

However, the use of the computer room needs to be scheduled previously. There is a spreadsheet available to schedule the computer room for each class, teachers monitor students during these sessions and provide guidance on the activities to be carried out. Some students lacked the skills to resolve system configuration issues, such as adjusting screen size

and using browser functions. This suggests a limited acquaintance with computers. Additionally, some 3rd-grade students faced challenges in reading and comprehending form questions, which were mitigated by researcher or teacher assistance. Despite difficulties, students expressed gratitude and enthusiasm for the activity, demonstrating positive engagement.

#### 5.1.2 Private School

Another part of the study was conducted at a private regular elementary school with the option of full-time bilingual education. In terms of technology access, the school has a physical Google Room equipped with two large screens for high-quality graphic screening and Chromebooks [2] and Wi-Fi network available to students.

In 2013, the school partnered with Google, adopting products offered by Google for Education to enhance educational support. This program enables the use of various technologies in active classroom dynamics, including virtual reality glasses, tablets, and a virtual assistant sound system (Alexa). From the 4th grade on, each student has their own Chromebook, which they use in their regular classrooms without the need to move around. Therefore, only 3rd grade students had to move from their regular classrooms to participate in the research. In each class, there were approximately 30 students, yet there was no need to share devices. When using the Chromebook for the online questionnaire, students handled the devices individually and showed no difficulty with the system interface or device settings; they use them regularly. Even the 3rd grade students who did not have individual Chromebooks have shown no difficulty in handling the devices. In fact, all the children were familiar with this technological artifact.

The students seemed excited to know they would be using the Chromebooks. However, there was a delay in loading the game website probably due to the excessive use of devices connected to the same website or some inefficiency in the local internet service provider. This delay visibly discouraged those who did not access the game promptly. Nevertheless, many students approached the researcher with smiles and words of gratitude for the game (even suggesting improvements and ideas for new games), actions that showed their excitement.

It can be stated that students from the private school were very well-used to digital technologies in contrast to their public school counterparts.

**Demographic Profile:** The schools are located in a city with 700,000 inhabitants in the countryside area of São Paulo state, Brazil. The city is 91 km from the state capital, São Paulo, which is about a 1.5-hour drive. Regarding the number of students, the public school has 827 students, while the private school has 608 students (data from 2022). The public school includes students who are socially vulnerable, whereas the private school does not.

[2] Devices similar to notebooks, focused on quick and simple tasks, designed to work and store data in the cloud instead of locally with ChromeOS installed

The public school is situated in a low-income housing area, characterized by small homes built through self-construction, inhabited by low-income families. Most of these homes lack space for a car (garage) or a backyard. In contrast, the private school is located in a region of luxury gated communities, with large homes inhabited by high-income families. Most of these houses have garages for multiple cars and large backyards.

### 5.2 Teachers' Perspectives as Players and Professionals on Game Utility

Teachers were asked to fill a demographic survey (See Table 1). Questions 1 to 18 correspond to the SEU-Q questions displayed in Table 2. The questionnaire has also 3 open questions: question 19 is related to the benefits and advantages for the students; question 20 is related to the difficulties and disadvantages for the students, and; question 21 is about suggestions for game improvements.

Emails were sent to 3rd, 4th and 5th grade elementary school teachers obtaining a total of 50 answers (48 respondents were female and 2 were male); ages ranged from 21 to 62 years old, with the average of 43.8 years old (SD = 9.7); as for complete schooling, 1 respondent was a PhD, 32 respondents were post-graduate, 15 respondents were graduate, and 1 respondent was a technician; professional experience ranged from 1 to 40 years, with the average of 16.2 (SD = 9.6).

Regarding the level of experience of the professionals with digital games, the average was 3.08 (on a scale from 1 to 5)(SD = 0.9), which suggests that the respondents have an intermediate level of experience with games (the value obtained was very close to the middle of the scale, 3); the level of experience regarding the use of digital games for education, obtained the average 3.10 (on a scale from 1 to 5)(SD = 0.76).

**Table 1.** SEU-Q v2 Demographic Data

| | |
|---|---|
| Q | I. What is your sex? |
| *A* | *female; male; I prefer not to say* |
| Q | II. What is your age? |
| *A* | *Integer response (years)* |
| Q | III. What is your complete educational level? |
| *A* | *From Elementary School to PhD* |
| Q | IV. What is your professional experience? |
| *A* | *Integer response (year)* |
| Q | V. What is your level of knowledge/use in Digital Games/Virtual/Augmented Reality? |
| *A* | *From 1 (low) to 5 (high)* |
| Q | VI. What is your level of knowledge/use of Digital Games/RVA in EDUCATION? |
| *A* | *From 1 (low) to 5 (high)* |

Q - Question / A - Answer

None of the questions were mandatory. Table 2 shows the results for each question. The color scheme used is to highlight the best result (green) and the worst result (red). Using BoxPlot (Figure 5 and Figure 6), we illustrate the distribution and variability of the experimental results, provid-

ing a concise visual summary of the data's central tendency, spread, and any potential outliers. The figures illustrate favorable results, demonstrating a consistent pattern of positive outcomes. Both distributions skew towards higher values, indicating a significant trend in the utility of the game. In question 19 and 20 there were 48 answers and in question 21 there were 46 answers.

**Table 2.** SEU-Q v2 Player and Professional Perspectives on Utility

| | Anwser scale was were betweem 1 to 5 | n | Average | SD |
|---|---|---|---|---|
| | **Players Perspective** | | | |
| Interaction | 1)Understand challenges | 50 | 4.14 | 0.83 |
| | 2)Accomplish the challenges | 50 | 4.10 | 0.79 |
| | 3)Ease of use | 50 | 4.48 | 0.68 |
| | Overall Interaction | 50 | 4.24 | 0.77 |
| Feedback | 4)Sound effects | 50 | 4.28 | 1.13 |
| | 5)Enjoy the scenery | 50 | 4.58 | 0.70 |
| | 6)Perceive objects and actions | 50 | 4.34 | 0.82 |
| | Overall Feedback | 50 | 4.40 | 0.88 |
| Motivation | 7)The benefit and relationship | 50 | 4.40 | 0.88 |
| | 8)Interested | 49 | 4.57 | 0.65 |
| | 9)Fun and/or engaging | 49 | 4.59 | 0.54 |
| | Overall Motivation | 49 | 4.52 | 0.69 |
| | Overall Players | 49 | 4.39 | 0.78 |
| | **Professionals Perspective** | | | |
| Purpose | 10)Utility of the game | 49 | 4.61 | 0.53 |
| | 11)Utility of the data | 50 | 4.60 | 0.54 |
| | 12)Utility of control | 50 | 4.44 | 0.76 |
| | Overall Therapeutic | 50 | 4.55 | 0.61 |
| Acceptance | 13)Accept | 50 | 4.36 | 0.80 |
| | 14)Adapt | 50 | 4.20 | 0.99 |
| | 15)Safety | 50 | 4.42 | 0.81 |
| | Overall Acceptance | 50 | 4.32 | 0.87 |
| Motivation | 16)Serious goal | 50 | 4.42 | 0.76 |
| | 17)Adopt the game | 50 | 4.06 | 0.89 |
| | 18)Benefits | 50 | 4.46 | 0.76 |
| | Overall Motivation | 50 | 4.31 | 0.80 |
| | Overall Professionals | 50 | 4.40 | 0.76 |
| | Overall Utility | 50 | 4.39 | 0.77 |

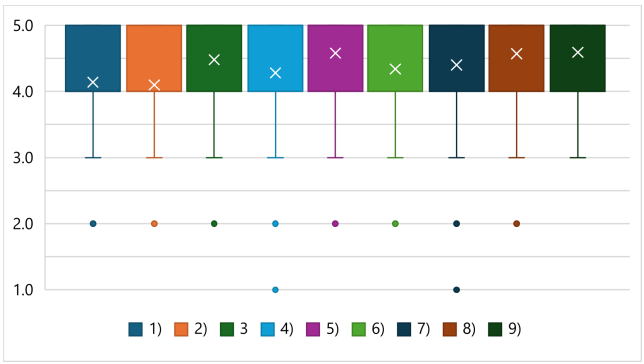


**Figure 5.** SEU-Q v2 Player and Professional Perspectives on Utility - BoxSplots 1-9

The analysis of open questions was influenced by the limited number of participants, and by direct and succinct sentences. Due to this constraint, an analytical approach inspired by Bardin's methodology [2011] was adopted. This decision facilitated a comprehensive examination of the data despite the small sample, allowing for meaningful insights to be drawn.

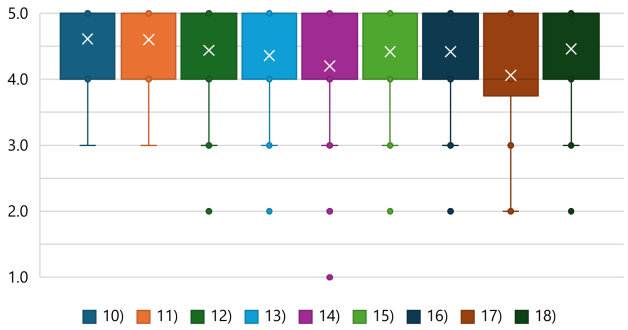


**Figure 6.** SEU-Q v2 Player and Professional Perspectives on Utility - BoxSplots 10-18.

Regarding the benefits and advantages (question 19): 16 participants highlighted the playfulness of the game, indicating its strong appeal to children; 15 respondents emphasized the educational value of play, stating that it enhanced learning by making it more meaningful and facilitating the learning process, 2 of these respondents specifically mentioned the connection between playfulness and learning. A few respondents made additional comments, with each aspect mentioned by less than 4 participants. These comments were vague and direct and covered various aspects.

Regarding the difficulties and disadvantages (question 20), participants provided valuable insights: 15 respondents commented on the limitations of digital resources, highlighting issues such as insufficient or unreliable internet access, limited availability of computers, and challenges related to accessing the game itself; 13 respondents identified personal difficulties of teachers and students, encompassing technological knowledge gaps, a lack of familiarity with the subject matter (learn mathematics), and challenges related to behavior. These challenges included not comprehending how to play the game, being not used to computers, need for adjustments to alternative teaching methods, experiencing difficulties with concentration and commitment, and accepting the activity; 12 respondents explicitly reported no disadvantages or difficulties. Mistakenly, 5 respondents answered advantages of learning through play, emphasizing its ability to engage students, serve as a captivating tool, and foster creativity.

Regarding suggestions for improving the game (question 21), a limited number of respondents (10) provided valuable insights. The suggestions aimed to enhance the gaming experience by addressing specific areas. These included: improving accessibility features for deaf players, offering multiple difficulty levels, refining visual and audio feedback, adding interactive activity prompts, incorporating child-friendly elements, and ensuring compatibility to mobile devices. Furthermore, six respondents provided feedback on potential areas for additional challenges within the game and suggested the development of a similar SG.

Each answer to questionnnaires are displayed on Table 1 and Table 2.

### 5.3 Students' Perspectives on Game Fun

The students of some of the teachers that answered the SEU-Q were contacted to play the game and answer a questionnaire designed to assess their level of perceived fun. The complete questionnaire can be viewed at Appendix B. No question was mandatory.

A total of 334 subjects participated in the study, of which 1 subject answered "No" regarding participation in the research, and 2 did not respond to this question. The data from these 3 respondents were excluded from the results, leaving a total of 331 valid respondents. The FUN questionnaire data can be seen on Table 3.

**Table 3.** FUN Questionnaire Data

| | Public School | Private School | Both |
|---|---|---|---|
| Female | 68 | 100 | 168 |
| Male | 76 | 83 | 159 |
| Did Not Disclose | 1 | 2 | 3 |
| Did Not Answer | - | 1 | 1 |
| Age Range (years old) | 08-11 | 08-11 | 08-11 |
| Mean Age | 9.61 | 8.88 | 9.19 |
| Standard Deviation (SD) | 0.95 | 0.81 | 0.95 |
| 3rd Grade | 45 | 86 | 131 |
| 4th Grade | 52 | 55 | 107 |
| 5th Grade | 48 | 45 | 93 |
| Morning use (07:00-13:00) | 0 | 133 | 133 |
| Afternoon use (13:00-18:00) | 141 | 49 | 190 |
| Night use (18:00-00:00) | 4 | 4 | 8 |
| Total | 146 | 185 | 331 |

Table 4 shows the statistics for each question and also presents the number of answers in each question (n varies according to the question because not all respondents answered all questions). Question A asks about the willingness to play again, while Question B asks about how much FUN the player had.

The majority of the players wanted to play again (question A, Table 4), meaning that the game could give enough reason to be played by the target audience. Also, players strongly agreed that the game was fun (question B), getting a good result and a low standard deviation.

Table 5 shows the results of perceived fun for each group of players, divided by gender and if they take medicine. The color scheme used maintains as used previously.

Students' excitement about going to the computer room was evident, with some of the more outgoing ones shouting "great" and "yeah" upon hearing the news. Overall, everyone showed great satisfaction with using the game.

It is important to note that certain aspects of computer use were observed during the gameplay and questionnaire answering. Most children did not show any difficulties in interacting with the game or its interface. However, some children (only in the public school) faced challenges using the mouse and navigating the questionnaire webpage, particularly with the scroll bar. Additionally, they struggled with basic system configurations such as going into full screen mode or resolving monitor problems like color saturation. These factors suggest that these students may not have extensive familiarity with computers. Several 3rd grade students showed difficulties with reading and comprehending the questions in the questionnaire. However, when the teacher or researcher read the questions aloud to them, they were able to answer more easily due to the use of pictograms (Figure 4).

**Table 4.** FUN Questionnaire Results

| A. Do you want to play again? | | | | |
|---|---|---|---|---|
| Grade | n | Yes | No | Maybe |
| 3rd | 130 | 90.77% (118) | 0.77% (1) | 8.46% (11) |
| 4th | 107 | 77.57% (83) | 3.74% (4) | 18.69% (20) |
| 5th | 93 | 69.89% (65) | 6.45% (6) | 23.66% (22) |
| all | 330 | 80.61% (261) | 3.33% (11) | 16.06% (53) |
| B. How much FUN did you have? [Scale 1 to 5] | | | | |
| Grade | n | Mean | Mode | SD |
| 3rd | 130 | 4.79 | 5.0 | 0.49 |
| 4th | 103 | 4.44 | 5.0 | 0.82 |
| 5th | 93 | 4.59 | 5.0 | 0.69 |
| all | 326 | 4.62 | 5.0 | 0.68 |

A - Do you want to play again? / B - How much FUN did you have?

**Table 5.** FUN Questionnaire Data - Fun By Gender

| FQ B Fun by | N | Mean | Mode | SD |
|---|---|---|---|---|
| All | 330 | 4,61 | 5 | 0,72 |
| Female | 168 | 4,68 | 5 | 0,61 |
| Male | 158 | 4,56 | 5 | 0,75 |
| Did not disclose the sex | 3 | 3,00 | 1 | 2,00 |

Data from Table 4 suggests that the willingness to play again and perceived fun diminishes along the years for this casual math game whose content and purpose are focused in the 3rd grade. It seems reasonable to consider that the novelty of the content might influence the expectations on the game.

Medicine intake seems to have not affected the perception of fun but the sample was too small to be conclusive. Also, girls showed to have a bit more fun than boys but statistics demonstrated that this was not significant.

## 6 Discussion

The first subsection discuss the first part of the main question, to understand if a Serious Game can be considered useful by the professionals that apply the game. The second subsection discuss about the second part of the main question, to understand if a Serious Game can be considered fun by the players that play the game.

### 6.1 Teachers' View

Teachers that answered the utility questionnaire were mainly mature professionals and well prepared female teachers but

with not much knowledge on computer games.

The highest score of the utility questionnaire was in question 10 (Utility of the game), with an average of 4.61 and SD of 0.53 (Table 2). The majority of the respondents strongly agreed that the game would be useful for professional activities. This can be related to the design procedures used in creating the game. The involvement of teachers and the technical expertise of the game design team helped to build a game that can review math operations and procedures in a useful way. We argue that the involvement of teachers at the game design stage contributed a lot to achieve a better understanding and representation of the math procedures while performing calculations - not just the result of it. This representation became a valuable feature of Matemágica.

It was quite satisfactory to realize that professionals (teachers) (Table 2) valued purpose the most at the same time that they valued motivation the most from the perspective of the players (students) (Table 2).

The lowest average score of 4.06 (SD = 0.89) was obtained in question 17 (Adopt the game) (Table 2), which makes one wander on the game's adoption and integration into daily activities. This question specifically addresses the easiness of incorporating the game into the school setting. This lower score may be related to the disadvantages and difficulties shown in question 20, where public school teachers answered about the limitation of digital resources and also about the personal difficulties that teachers and students may have when using a computer or playing the game. These issues may hinder the adoption of the game on a normal basis.

Nevertheless, all average answers scored above 4.06 (on a scale from 1 to 5), which is well above the center of the scale. This scenario can be qualified as being close to ideal.

From the perspective of the teachers, those who use the game as an auxiliary tool, the game can be considered useful and a dynamic and interesting way to teach the subject. Based on the results obtained from the questionnaire (Section 6) the profile of the teachers can be described as digital migrants [Prensky, 2001]. The average level of experience with digital games was 3.08 (SD = 0.9 scale 1 to 5, Section 6), indicating that the respondents had a mediocre level of familiarity with games. Similarly, the average experience regarding the use of digital games for educational purposes was 3.10 (SD = 0.76). These findings suggest that teachers in this study have had some exposure to digital games, but their experience may be limited if compared to the digital native generation. Therefore, it can be argued that these teachers, although not fully immersed in digital technologies, still recognized the potential benefits of incorporating serious games like Matemágica into their teaching practices. The positive perception of the game's utility and the recognition of its playfulness and educational value indicate that these teachers embraced the opportunity to utilize technology as a dynamic and engaging tool in their classrooms.

The utility of an SG is the ability to comply to its serious objective. In the case of Matemágica, the serious objective is to help in teaching the basic mathematical operations procedures. The data from the first study (Table 2) showed that professionals find the game useful.

Most teachers recognized the advantages of the game, specifically highlighting its playfulness and educational value. However, some challenges were identified, including technological limitations and personal constraints. Teachers also provided valuable suggestions for improving the game.

### 6.2 Students' View

The game was designed to be a short intervention, pretty much as a motivational boost for reviewing the content. However, it came as a surprise that 80.40% (Table 5) of the children declared that they wanted to play it again. It suggests that game features (narrative, aesthetics, mechanics) might have fulfilled their expectations and the content was seemingless incorporated into the game play.

Looking at each grade, it seems that the will to play again diminishes the higher the grade (Table 5). This could be happening because the content in the game was created mainly for 3rd graders. Besides that, the perception of fun does not differ much among grades. Players reported less intention to play again as they became more proficient in the content. This was an expected result because we reckon the content would become too easier for 4th and 5th graders.

Due to the short period of use, we did not assessed learning. The game was designed to aid in the teaching of mathematics as a review activity. We recognize that if it were used as a teaching method for a longer period of time the data might have been different, both for the fun and for the learning.

The overall performance on fun perception (Table 5) was 4.61 (in a scale from 1 to 5) which is very close to the top of the scale. We conclude that the game was considered a lot fun regardless of its intent (motivational, exercise or remembering tool). Some students played the game after 18:00h (outside school hours), which indicates an interest in the game beyond its curricular purpose. This suggests that these students were receptive to this type of activity (Game-based Learning).

Positive student reactions to the game were observed during the study. They were able to enjoy, and have fun with it. These findings were supported not only by the observations made by a member of the research group but also by the results of the questionnaire (Table 4, Table 5), which indicated a positive overall perception of fun and high willingness to play the game again. In general, the players liked the game and the way the math exercise was executed.

Boys' and girls' perceptions of fun were considered close enough although girls seemed to have felt a little bit more fun. Also, results from public and private schools were close enough.

## 7 Conclusions

Serious Games (SG) are becoming an ever more frequent solution for Game-based Learning. A balanced between purpose and fun enables SG to meet the needs of both teachers and students. In this paper we presented and focused on the relationship between game's utility answered by professionals and, game's perceived fun answered by players. An SG must meet the expectations of both the professionals who will apply the game, and the players who will use the game.

**Data Analysis:** The data show that the Matemágica SG can be a useful (general score 4.39 from a 1-5 scale, SD = 0.77) tool for math teachers and, 3rd to 5th grade students have perceived it as fun (4.61 from a 1-5 scale, SD = 0.72), and the majority of the 331 students (80.61%) would like to play the game again.

This work showed that it is possible for a short-term of use (casual) SG aimed at motivating math exercise to be fun for the players (girls and boys elementary students of public and private schools) and useful in the view of the professionals (teachers). It is an argument to put aside the arguing if an SG can be fun and purposeful at the same time. This balance seems to be a matter of managing resources and methodologies.

A useful casual math game proved to be fun but this fades along the school years, regardless the sex of children and type of school. Change in the perception of fun might be related to the type of use of the game (as a motivational exercise or as for remembrance purpose), therefore, such intent may be considered while designing an SG. We conclude that, considering the results of both studies, a casual SG can be considered useful by the professionals and fun by the players.

**Process Observations:** Our study involved both public and private school settings, where participants interacted in different contexts, including paired and individual play. Despite these variations, our results revealed similar outcomes. While we recognize that the experience of solitary versus collaborative playing may impact overall experience, this paper did not explore these distinction. We emphasize that our main objective centered on assessing and contrasting the utility and fun derived from the SG.

# 8 Future Work

It was not in the scope of this research to analyze the degree of learning obtained and how effective the activity was. A research with a broader scope and a longer experimental period, with two test groups, one using the game for exercising and the other without the game, may answer this question. The novelty of introducing a game into the classroom may have influenced the students' enthusiasm. A study with a broader scope and more sessions could examine how this enthusiasm changes over time. It was also not within the scope of this research to analyze fun between school types.

The level of fun along several game sessions was not analyzed. A small taste of this phenomena might have happened with students of sequential grades (see Table 5). The game is an auxiliary tool, and it is possible that as the player plays and improves his results he may lose interest in the game. Besides the fact that the game loses its novelty and this is another factor that would decrease the interest. A longer survey can help answer these questions. Also, if run together with the utility survey, it can help analyze the relationship among utility, fun and time of use.

Fieldwork revealed varying levels of technology use among different schools. However, the analysis lacked student profiling. Incorporating student profiles could offer a more nuanced understanding of how technological access affects outcomes. This gap underscores the need for a more comprehensive evaluation of the impact of technological resources.

Children enrolled in this study were not screened on how they use computers or smartphones. Therefore, it is not clear how the use of these technology per se would have influenced the perception of fun. A better screening of the children regarding technology acquaintance should be included in future researches in order to answer this issue.

# Declarations

## Acknowledgements

In this study, AI tools were employed to help writing, reviewing and grammar error-checking.

## Funding

This study partially was financed by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001. The authors also would like to thank the UNIEDU/FUMDES Postgraduate Program; to the National Council for Scientific and Technological Development (CNPq-Brazil) for the DT2 productivity grant, process 306613/2022-0, and; to the Foundation for Research and Innovation Support of the State of Santa Catarina (FAPESC-Brazil) for partial funding to the LARVA laboratory, T.O.No.: 2023TR284.

## Authors' Contributions

All authors contributed to the conception of this study. VP conducted the data collection. All authors analysed, wrote, read and approved the final manuscript.

## Competing interests

The authors declare they have no competing interests.

## Availability of data and materials

The datasets generated and/or analyzed during the current study are available in `https://shorter.me/53CN-` (SEU-Q)[3] and `https://shorter.me/Ri4Dn` (FUN)[4].

## Citation Diversity Statement

In this work, our references were selected based solely on the quality and relevance of the publications. The identity of the authors, including their sex, country, or any other characteristics, was not considered in the selection process. By focusing on the merit of the work, we aim to promote a fair and unbiased scholarly environment.

[3] `https://udesc-my.sharepoint.com/:x:/g/personal/26862115200_udesc_br/EZmKnkLrOrlKsXaCufIrydIBurgjQshxSIvA9WiTL7cTHA?e=0kL2Dc`

[4] `https://udesc-my.sharepoint.com/:x:/g/personal/26862115200_udesc_br/EbdjK1y5itRIsCj0CiAuw9IBbcpIcGABudYhyB1iq0BCFQ?rtime=btimgGzI3Eg`

# References


Bardin, L. (2011). *Análise de Conteúdo*. Almedina, 1 edition.

Berg, V. (2021). A Game-Based Online Tool to Measure Cognitive Functions in Students. *International Journal of Serious Games*, 8(1):71–87. DOI: https://doi.org/10.17083/ijsg.v8i1.410.

Blythe, M. A., Overbeeke, K., Monk F., A., and Wright C., P. (2004). *Funology From Usability to Enjoyment*. Kluwer Academic Publishers, New York, Boston, Dordrecht, London, Moscow, 3 edition.

Bonk, C. J., Charles R Graham, Jay Cross, and Michael G Moore (2005). *The Handbook of Blended Learning: Global Perspectives, Local Designs*. Pfeiffer, San Francisco.

Geertz, C. (2017). *The Interpretation of Cultures*. Basic Books, New York.

Grimes, R. H., Schroeder, R. B., and Hounsel, M. da. S. (2019). Potencial de Utilidade de Jogos Sérios: Melhorando um Instrumento de Avaliação. (In Portuguese) - Potential Utility of Serious Games: Improving an Evaluation Instrument. url = `https://www.researchgate.net/publication/330812148_Grimes_Schroeder_e_Hounsell_2019_-_SEUQ2_Avalia_Utilidade_de_SG/link/5c54c63aa6fdccd6b5dad524/download`.

Gurgel, I., Arcoverde, R. L., Almeida, E. W. M., Sultanum, N. B., and Tedesco, P. (2006). A Importância de Avaliar a Usabilidade dos Jogos: A Experiência do Virtual Team. In *Simpósio Brasileiro de Jogos e Entretenimento Digital*, pages 22–99. (In Portuguese) - The Importance of Evaluating the Usability of Games: The Experience of the Virtual Team.

Horn, M. and Staker, H. (2015). *Blended: usando a inovação disruptiva para aprimorar a educação*. Penso, Porto Alegre.

Huizinga, J. (2000). *Homo Ludens*. Editora Perspectiva S.A., São Paulo, 4 edition.

Hunicke, R., Leblanc, M., and Zubek, R. (2004). MDA: A formal approach to game design and game research. *AAAI Workshop - Technical Report*, WS-04-04(August):1–5.

IJsselsteijn, W. A., de Kort, Y. A. W., and Poels, K. (2013). *The Game Experience Questionnaire*. Technische Universiteit Eindhoven.

INEP, B. (2023). Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira. Censo Escolar da Educação Básica 2022: Resumo Técnico. Acesso em: 04 de maio de 2023.

Juul, J. (2010). *A Casual Revolution: Reinventing Video Games and Their Players*. MIT Press, Cambridge, MA.

Juul, J. (2011). *Half-Real: Video Games Between Real Rules and Fictional Worlds*. Mit Press.

Koster, R. (2013). *Theory of Fun for Game Design*. O'Reilly Media, Inc, Sebastopol.

Kuindersma, E., Van der Pal, J., Van den Herik, J., and Plaat, A. (2016). Comparing Voluntary and Mandatory Gameplay. *International Journal of Serious Games*, 3(3). DOI: https://doi.org/10.17083/ijsg.v3i3.133.

Latour, B. (2007). *Reassembling the Social*. Oxford Press, New York.

Malinowski, B. (2016). *Argonauts of Western Pacific*. Oxford City Press, Oxford.

Marsh, T. (2011). Serious games continuum: Between games for purpose and experiential environments for purpose. *Entertainment Computing*, 2(2):61–68. Serious Games Development and Applications. DOI: https://doi.org/10.1016/j.entcom.2010.12.004.

Michael, D. R. and Chen, S. L. (2005). *Serious games: Games that educate, train, and inform*. Cengage Learning, Bostom, MA.

Ninaus, M., Moeller, K., McMullen, J., and Kiili, K. (2017). Acceptance of Game-Based Learning and Intrinsic Motivation as Predictors for Learning Success and Flow Experience. *International Journal of Serious Games*, 4(3). DOI: https://doi.org/10.17083/ijsg.v4i3.176.

Prensky, M. (2001). Fun, Play and Games: What Makes Games Engaging. In *Digital Game-Based Learning*, pages 1–31.

Pyae, A., Joelsson, T., Saarenpää, T., Mika, L., Kattimeri, C., Pitkäkangas, P., Granholm, P., and Smed, J. (2017). Lessons Learned from Two Usability Studies of Digital Skiing Game with Elderly People in Finland and Japan. *International Journal of Serious Games*, 4(4). DOI: https://doi.org/10.17083/ijsg.v4i4.183.

Read, J. C. and MacFarlane, S. (2006). Using the fun toolkit and other survey methods to gather opinions in Child Computer Interaction. *Conference on Interaction Design and Children, IDC '06*, 2006:81–88.

Ritterfeld, U., Cody, M., and Vorderer, P. (2009). *Serious Games: Mechanisms and Effects*. Taylor and Francis e-Library, New York, 1 edition.

Rogers, S. (2010). *Level Up, the guide to great vídeo games design*. John Wiley & Son, New York, 1 edition.

Schell, J. (2020). *The art of game design: a book of lenses*. CRC Press, Boca Raton, Florida ;, 3rd editio edition. Includes bibliographical references and index.

Silva, L. A. and Pereira, V. A. (2020). Matemágica: relato de experiência de um game educativo criado a partir de um projeto de extensão. In *VII Congresso de Pesquisa, Ensino e Extensão*, pages 1, 4. (In Portuguese) - Mathemagic: Experience Report of an Educational Game Created from an Extension Project.

Soares, C. N. (2020). *Um Jogo Digital do tipo RPG para Revisão de Conceitos da Matemática do Ensino Fundamental*. Monografia, Monografia (Graduação - Computação) – Universidade de Brasília Instituto de Ciências Exatas.

Souza, D. C. and Silva, O. S. F. (2021). Formação docente para práticas multiletradas com jogos digitais na Matemática: compreendendo o jogo. *Com a Palavra, O Professor*, 6(16):138–159. (In Portuguese) - Teacher Training for Multiliteracy Practices with Digital Games in Mathematics: Understanding the Game.

Tondorf, D. F. and Hounsell, M. da. S. (2021). De volta ao parquinho: A busca da diversão no jogo digital. In *Simpósio Brasileiro de Jogos e Entretenimento Digital*, number GranDGamesBR: Fórum dos Grandes Desafios de Pesquisa em Jogos e Entretenimento Digital no Brasil, pages 1021–1024, Porto Alegre. Sociedade Brasileira de Computação. (In Portuguese) - Back to the Play-

ground: The Search for Fun in Digital Games. DOI: https://doi.org/10.5753/sbgames_estendido.2021.19751.

Tondorf, D. F. and Hounsell, M. da. S. (2022). Constructs and Outcomes of Fun in Digital Serious Games: The State of the Art. *Journal on Interactive Systems*, 13(1):386–399. DOI: https://doi.org/10.5753/jis.2022.2605.

Tondorf, D. F. and Hounsell, M. da. S. (2023). The Pursuit of Fun in Digital Games: From the Sandpit to the Console and Beyond. In dos Santos, R. P. and Hounsell, M. da. S., editors, *Grand Research Challenges in Games and Entertainment Computing in Brazil GranDGamesBR 2020 2030*, pages 25–46. Springer Nature Switzerland, Cham.

Tondorf, D. F., Hounsell, M. da. S., and Pereira, V. A. (2022). Avaliando a Utilidade do Jogo Sério Matemágica. In *Simpósio Brasileiro de Jogos e Entretenimento Digital*, pages 673–682, Natal (RN). Sociedade Brasileira de Computação. (In Portuguese) - Evaluating the Utility of the Serious Game Mathemagic.

Zikos, S., Tsourma, M., Lithoxoidou, E. E., Drosou, A., Ioannidis, D., and Tzovaras, D. (2019). User Acceptance Evaluation of a Gamified Knowledge Sharing Platform for Use in Industrial Environments. *International Journal of Serious Games*, 6(2):89–108. DOI: https://doi.org/10.17083/ijsg.v6i2.275.

Zyda, M. (2005). From visual simulation to virtual reality to games. *Computer*, 38(9):25–32. DOI: https://doi.org/10.1109/MC.2005.297.

# Appendix A SEU-Questionnaire

To use SEU-Q one has to change the keyword accordingly. Therefore, in the model below, the following changes need to be applied:

PLAYERS -> Students
PROFESSIONALS -> Teachers
GAME -> Matemágica
PROFESSIONAL ACTIVITY -> Teaching Math
SERIOUS PURPOSE -> Learning basic math operations and procedures

**Players View**

Now consider the group of PLAYERS who will be using the GAME (age range, educational level, any difficulties and pathologies) and answer the following by "putting yourself in the perspective of all these PLAYERS".

Consider the following answers:
1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree

Interaction:

1) I, if I were a PLAYER, would easily understand the challenges of the GAME
2) the PLAYERS would easily accomplish the GAME's challenges
3) the PLAYERS would easily use the interaction devices (keyboard, mouse, etc.) with the GAME

Feedback:

4) the PLAYERS would find the sound effects of the GAME useful
5) the PLAYERS would like the aesthetics (scenery, colors, objects, characters, beauty, other visual aspects, ...) of the GAME
6) the PLAYERS would be able to clearly perceive the objects and their actions in the GAME

Motivation:

7) PLAYERS would easily perceive the benefit and relationship of using the GAME for the SERIOUS PURPOSE
8) PLAYERS would feel interested in PROFESSIONAL ACTIVITY if they use the GAME
9) PLAYERS would find the GAME fun and/or engaging

**Professionals' View**

Now, consider that your responses would be representative of the group of ALL PROFESSIONALS who may eventually use the GAME as part of their own PROFESSIONAL ACTIVITY.

Consider the following answers:
1 = Strongly disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree

Purpose:

10) PROFESSIONALS would perceive the utility of the GAME for PROFESSIONAL ACTIVITY with the PLAYERS
11) PROFESSIONALS would perceive the utility of the data provided by the GAME for the PROFESSIONAL ACTIVITY
12) PROFESSIONALS would perceive the utility of the controls (registration, end game, skip level, sound on/off, etc.) provided by the GAME for PROFESSIONAL ACTIVITY

Acceptance:

13) PROFESSIONALS would find that PLAYERS will easily accept the use of the GAME for PROFESSIONAL ACTIVITY
14) PROFESSIONALS would find it easy to adapt their practice and professional environment to include the GAME in their PROFESSIONAL ACTIVITY
15) PROFESSIONALS would see that it is safe (physically and cognitively) for the PLAYER and PROFESSIONAL to use the GAME for their PROFESSIONAL ACTIVITY

Motivation:

16) PROFESSIONALS would clearly see the SERIOUS PURPOSE in the operation of the GAME
17) PROFESSIONALS would find it easy to adopt the GAME into daily PROFESSIONAL ACTIVITY
18) PROFESSIONALS would clearly perceive the benefits of the GAME for PROFESSIONAL ACTIVITY

**Discursive Questions**

19) What are the main benefits or advantages of using the GAME by the PLAYERS for SERIOUS PURPOSE?
20) What are the main difficulties or disadvantages of using the GAME by the PLAYERS for SERIOUS PURPOSE?
21) Do you have any suggestions to improve the SERIOUS PURPOSE of the GAME? Which ones?

# Appendix B FUN Questionnaire

**Players Data**

Q I. What is your sex?

Female
Male
I prefer not to say

Q II. How old are you?

Q III. What grade are you in?

3rd
4th
5th

Q IV. In what period of the day did you play the game?

Morning (07:00 to 12:00)
Afternoon (12:00 to 18:00)
Evening (18:00 to 00:00)

**Players Perceptions**

Q A. Do you want to play this game AGAIN?

Yes
No
Maybe

Q B. How much did you have FUN with the game?

From 1) “I did not have any fun” To 5) “I had a lot of fun”

1 2 3 4 5