Educational Games for Teaching the Essentials of Exact Sciences in Brazil: A Ten-Year Systematic Mapping Study

Matheus Campos Sousa, Rodrigo Duarte Seabra, Phyllipe Lima

Institute of Mathematics and Computing – Federal University of Itajubá (UNIFEI)
Post Office Box 50 – 37.500-903 – Itajubá – MG – Brazil

campos98matheus@gmail.com,{rodrigo,phyllipe}@unifei.edu.br

Abstract. Introduction: *Exact science subjects are constantly labeled difficult and are known for causing difficulties for students during the learning process. Educational games are an alternative to complement and improve the teaching process, combining entertainment and pedagogical purposes.* ***Objective:*** *This research presents a ten-year systematic mapping study of scientific articles published in specialized events and journals in Brazil, aiming to identify educational games for teaching the essential bases of exact sciences.* ***Methodology or Steps:*** *The study started with an extensive search of scientific databases, identifying 537 initial publications. After applying selection and exclusion criteria, the final dataset was narrowed down to 86 publications.* ***Results:*** *The main results showed that the content covered is related to teaching mathematics; its availability to the general public is limited, and the predominant genre of games is quizzes using gamification.*
Keywords*: Educational Games, Systematic Mapping Study, Exact Sciences.*

1. Introduction

Exact sciences play an essential role in the foundation of education. Mathematics, for example, is taught to children from the earliest years of life and is considered a fundamental educational requirement, as it allows them to build cognitive skills that are relevant to various other areas, such as engineering, physics, chemistry, technology, and finance [Kacmaz and Dubé 2022]. In the Brazilian context, chemistry and physics subjects are covered in high school [MEC 2018] and are essential for engineering and technology. However, teaching these subjects faces challenges, and some students usually have difficulties while learning, which can lead to frustration and lack of interest [de Lima and Gitirana 2021]. Given this reality, games can be used as educational resources.

When applied to a pedagogical context, the term ‘serious game’ can be used, as the aim is to extract from these games the entertainment they provide, and that something is taught. Serious games engage and motivate students, providing an interactive and rewarding learning experience. In addition, they allow complex concepts to be explored practically and entertainingly, stimulating logical reasoning, problem-solving, and critical thinking [Victal *et al*. 2015]. Pedagogical games have helped students develop the skills and abilities required by the National Common Core Curriculum [MEC 2018], helping to reduce the anxiety related to studying mathematics and other subjects in exact sciences [Rocha and Dondio 2021].

To identify the presence of educational games in the research of the Brazilian scientific community, this paper presents the result of a ten-year systematic mapping study on educational games developed for teaching the essential bases of exact sciences,

which is its main contribution. The study aims to contribute to future researchers, teachers, and students searching for tools to help teach the subject through educational games. On this occasion, the areas of mathematics, physics, and chemistry for primary and secondary education in Brazil were considered.

This research expands the study by Damaceno Júnior *et al*. [2023] for different reasons. Firstly, the study above searched for references published only from 2020 to 2022; our article, in contrast, covers a study spanning 10 years. Secondly, the study cited investigated articles dealing only with approaches in mathematics; our research encompasses work in three disciplines: mathematics, chemistry, and physics. Thirdly, our approach considers the availability and platforms on which the games were developed.

The article is structured as follows: Section 2 presents the background; Section 3 reports on the research methodology used, as well as the research questions, stages, and processes carried out; Section 4 explains the results and discusses the research questions defined in Section 3; and finally, Section 5 provides the final considerations.

2. Background

Education experts established and investigated a relationship between the practice of games and the learning process at the beginning of the 21st century [Prensky 2003], arousing interest in using and implementing educational games in the context of teaching and learning. According to Tarouco *et al*. [2004], games with an educational character, commonly called educational games, are created in a specific way to instruct people on certain subjects, expand concepts, and strengthen the development and understanding of historical or cultural events.

The term ‘serious game’ describes games with objectives beyond mere entertainment [de Vasconcellos *et al*. 2017]. As Raessens and Goldstein [2005] state, serious games are designed and used to address more pressing everyday issues with real-life consequences. In this sense, educational games can bring various benefits to teaching and learning processes [Savi and Ulbricht 2008], for example:

- Motivating effect: Educational games are fun and encourage learning through interactive and dynamic environments, stirring interest and motivation in students. They encompass challenges, curiosity, interaction, and fantasy [Hsiao 2007].
- Facilitating learning: Digital games facilitate learning in various areas of knowledge by putting the student in the role of decision-maker. In addition, they present increasing levels of challenge to enable learning through trial and error [Mitchell and Savill-Smith 2004].
- Development of cognitive skills: Games promote intellectual development and various cognitive skills, such as problem-solving, decision-making, pattern recognition, information processing, creativity, and critical thinking [Balasubramanian and Wilson 2006].
- Discovery learning: Games develop the ability to explore, experiment, and collaborate [Mitchell and Savill-Smith 2004]. Instant feedback and a risk-free environment kindle experimentation and exploration, stimulating curiosity and learning by discovery [Dawes and Dumbleton 2001].
- Motor coordination: Different types of digital games promote the development of motor coordination and special skills [Gros 2003].

The following section presents the research methodology used in this work and the research questions, stages, and processes carried out during the systematic mapping study conducted on this occasion.

3. Research Definition

The study aimed to identify educational games for teaching the essential foundations of exact sciences in Brazil. This research is justified since it explores the national literature in search of applying this game category to the teaching and learning process of subjects labeled as problematic for students in general. In addition, the research presents the main content covered in the games identified, the genre most present in the studies, and how these games are currently made available. The research methodology was based on Petersen *et al*. [2015]. It addresses questions of interest, the search protocol and selection of repositories, the execution, application of inclusion and exclusion criteria, and data extraction.

3.1 Questions of Interest

The primary purpose of the questions of interest is to provide insight into using educational games to teach the essential foundations of exact sciences in Brazil. To this end, three research questions were defined:

Q1: What content from the core foundations of the exact sciences is most often covered in educational games? This question sought to identify which mathematics, chemistry, and physics content is most explored in educational games. The aim is to determine which areas have the highest priority for developers and educators. In addition, we sought to identify areas of deficiency that could be further explored with games as a teaching support tool.

Q2: What genre is most present in the educational games identified? There are a variety of game genres, such as first-person shooter, 2D platformer, strategy, third-person action, and treasure hunt, among others. The question investigated which game genre was most adopted, making it possible to direct future developers of educational games or to ask whether other genres could be better explored.

Q3: How are these games made available? There are various ways of making educational games available, such as Google Play Store or App Store, the game official website or the company responsible for developing it, or via direct download links. The question investigated which platform was most used to run the games: mobile, personal computer, console, or multiplatform.

3.2 Research Execution

To outline the scope of the research, specific criteria were established to guarantee the reliability and viability of the mapping process. The study was carried out using five databases, namely: Revista Brasileira de Informática na Educação (RBIE), Revista Informática na Educação: Teoria e Prática (IETP), Revista Novas Tecnologias na Educação (RENOTE) and SBC Open Lib – by their respective search engines. A direct search was also carried out in the Proceedings of the Brazilian Symposium on Games and Digital Entertainment (SBGames), representing the fifth database. In this case, the tracks of interest were “Education and Culture” and “Arts and Design”. The criterion for selecting the databases was that they are the primary outlets for publishing scientific

articles in Brazil aimed at the research objective and are recognized from an academic point of view.

The search was restricted to publications obtained exclusively from the selected repositories, and the period considered was from January 1, 2015, to December 31, 2024. The dates were chosen to obtain the most recent publications spanning a decade of study. Note that SBC Open Lib has become a popular base for centralizing work published in national events and journals supported by the Brazilian Computer Society. For example, since 2021, papers published at SBGames have been indexed in this database. In addition, papers published from June 2021 onwards in RBIE have also migrated to this database. However, to include the search starting in 2015, it was necessary to search the SBGames website for papers published before 2021 manually. The RBIE database also had to be searched for documents before 2021. In this process, duplicate articles appeared in both databases and were carefully analyzed to be eliminated. RENOTE and IETP, conversely, are not integrated with SBC Open Lib; the search was thus carried out directly into the database.

The search strings used were eight, namely: "*game*" AND "*math*", "*game*" AND "*chemistry*", "*game*" AND "*physics*", "*game*" AND "*mathematics*", "*game*" AND "*chemistry*", "*game*" AND "*physics*", (*game* OR *jogo*) AND (*mat** OR *química* OR *chemistry* OR *física* OR *physic**) AND (*educ**)."

Using these strings, 537 articles were identified and distributed as follows: SBGames – 58 papers; RBIE (until June 2021) – 6 papers; RENOTE – 71; IETP – 24; SBC Open Lib – 378. Note that this total included duplicates in this first phase, which were eliminated in the second filtering phase. In the second phase, the titles and abstracts of the identified studies were read, and inclusion (IC) and exclusion (EC) criteria were applied, as shown in Table 1. After this filtering, the 91 selected papers were distributed as follows: SBGames – 39 papers; RBIE (until June 2021) – 0; RENOTE – 13; IETP – 2; SBC Open Lib – 37.

Table 1. Set of inclusion (IC) and exclusion (EC) criteria. Source: The authors.

Criteria	Description
IC-01	Games that cover topics related to the essential foundations of the exact sciences: mathematics, chemistry, and physics.
IC-02	Games designed to help Brazilian primary and/or secondary schools.
IC-03	Games published between 2015 and 2024.
IC-04	Papers that describe the development of the game
EC-01	Games that address themes from other subjects in Brazilian primary and/or secondary education.
EC-02	Games that aim to help teaching at other levels.
EC-03	Games published before 2015 or after 2024.
EC-04	Papers that analyzed games developed by a third party

The full texts of the 91 papers were read in the third filtering phase. Five were excluded, leaving 86 articles. The aim was to ensure the articles were relevant and adhered to the established selection criteria. Two research authors completed the identified papers complete reading and data extraction process, and a third author contributed to resolving any discrepancies. The process consisted of the authors' detailed reading of the papers and merging each author's extractions as the final data to be considered. The selected studies are tabulated in Table 2, which contains the references for each work identified.

Table 2. Catalog of studies selected (continued). Source: The authors.

ID	Citation	ID	Citation
S1	Santos, J. V. M. *et al*. (2022)	**S44**	Santos, W. e Alvez, L. (2016)
S2	Alves, A. G. *et al*. (2020)	**S45**	Leite, B. S. (2020)
S3	Minholi, F. S. *et al*. (2022)	**S46**	de Melo Santos, C. E. e Leite, B. S. (2019)
S4	Soares, C. N. e da Nóbrega, G. M. (2021)	**S47**	Vahldick, A. e da Silva, W. T. (2020)
S5	Santiago, J. M. S. *et al*. (2018)	**S48**	Sande, D. *et al*. (2021)
S6	Silva, E. e de Sousa Pires, F. G. (2017)	**S49**	Laurindo, L. E. C. *et al*. (2019)
S7	de Oliveira, A. M. D. *et al*. (2020)	**S50**	Minussi, M. M. e Wyse, A. T. S. (2016)
S8	de Lima Moreira, I. E. *et al*. (2019)	**S51**	Meira, M. C. *et al*. (2019)
S9	de Castro, J. B. *et al*. (2021)	**S52**	Benedetti Filho, E. *et al*. (2019)
S10	de Souza Chagas, J. V. *et al*. (2022)	**S53**	Guimarães Dias, S. *et al.* (2024)
S11	Barros, G. C. *et al*. (2022)	**S54**	Cintra, L. F. R. e Sarinho. V. T. (2024)
S12	Alvez, C. N. H. *et al*. (2019)	**S55**	dos Santos, R. W. P. *et al.* (2023)
S13	Macêdo, P. H. *et al*. (2017)	**S56**	Pinheiro, W. S. *et al.* (2023)
S14	Vogel, B. *et al*. (2020)	**S57**	Silva, I. O. *et al.* (2023)
S15	Stochero, A. D. *et al*. (2018)	**S58**	Pedrosa, C. *et al.* (2024)
S16	Parmegiani, L. C. (2022)	**S59**	Conde, A. *et al.* (2024)
S17	da Silva Araújo, A. *et al*. (2020)	**S60**	Miguel, J. *et al.* (2024)
S18	Vieira, M. *et al*. (2019)	**S61**	Martins, W. *et al.* (2024)
S19	Silva, A. C. S. e Falcão, T. P. (2019)	**S62**	Andreucci, B. *et al.* (2024)
S20	Gomes, W. *et al*. (2018)	**S63**	Brilhante, M. *et al.* (2023)
S21	da Cruz, E. F. Martins e Pereira, R. M. (2020)	**S64**	Alves Júnior, F. *et al.* (2024)
S22	Pereira Junior, C. X. *et al*. (2016)	**S65**	Rolim, I. *et al.* (2023)
S23	Mayer, R. *et al*. (2022)	**S66**	Higa, H. *et al.* (2024)
S24	Tito, J. e Moraes, R. (2022)	**S67**	Cardoso, R. C. *et al.* (2024)
S25	Santos, F. A. O. *et al*. (2018)	**S68**	Moura, T. *et al.* (2024)
S26	da Conceição Silva, F. *et al*. (2020)	**S69**	Lais, R. *et al.* (2024)
S27	Jardim, A. M. e de Paiva, D. C. (2016)	**S70**	de Souza, G. G. e da Mota, R. R. (2023)
S28	Lemes, J. S. e de Paiva, D. C. (2016)	**S71**	Estevam, L. C. *et al.* (2024)
S29	Moraes, I. G. e Colpani, R. (2016)	**S72**	Gripp, C. R. S. *et al.* (2024)
S30	Sobrinho, M. E. *et al*. (2016)	**S73**	Amaral, L. *et al.* (2024)
S31	de Carvalho, M. F. *et al*. (2017)	**S74**	Monteiro, N. *et al.* (2024)
S32	Santos, W. O. *et al*. (2017)	**S75**	Oliveira, M. C. *et al.* (2023)
S33	Martins, T. C. (2017)	**S76**	Ortolan, V. A. e Modesto, F. A. C. (2023)
S34	Corrêa, E. B. *et al*. (2017)	**S77**	Siedler, M. S. *et al.* (2024)
S35	Belli, M. e Alvez, A. G. (2018)	**S78**	Correia, R. R. S. *et al.* (2023)
S36	Rios, L. C. *et al*. (2018)	**S79**	de Carvalho, V. R. *et al.* (2023)
S37	de Barros, A. C. M. *et al*. (2018)	**S80**	Shimohara, C. e Sobreira, E. S. R. (2015)
S38	Cunha, O. A. L. *et al*. (2019)	**S81**	Otsuka, J. L. *et al.* (2015)
S39	Colombini, F. R. e von Lochter, J. (2019)	**S82**	Frade, B. V. *et al.* (2015)
S40	Silva, E. P. *et al*. (2020)	**S83**	Dourado, J. B. *et al.* (2015)
S41	Costa, T. F. *et al*. (2020)	**S84**	Fo, M. R. e da Silva, A. C. (2015)
S42	Alencar, L. *et al*. (2020)	**S85**	de Oliveira, R. G. S. G. *et al.* (2015)
S43	de Melo Fernandes, M. e de Souza Rebouças, A. D. D. (2016)	**S86**	Madeira, C. *et al.* (2015)

4. Results and Discussion

We read the papers identified (Table 2) from the systematic mapping to answer the research questions proposed in the article.

Regarding the first research question – ***Q1: What content from the core foundations of exact sciences is most often covered in educational games?*** – it is necessary to reinforce the scope of the work and the understanding of the subjects of the

essential foundations of the following exact sciences: mathematics, chemistry, and physics.

As shown in Figure 1, most educational games focus on teaching mathematics, represented by 67 articles. Physics and chemistry are represented by six and 14 papers, respectively. One RENOTE article deals with a game aimed at teaching chemistry and physics, which justifies the total of 87 documents in terms of subjects. This result suggests that mathematics is highly relevant to teaching and can be seen as an essential subject in exact sciences since it is a prerequisite for physics and chemistry [MEC 2018], promotes the development of thought, and lays a solid foundation for later grades [Alves 2016]. However, mathematics is also considered an arid and challenging subject and is often demotivating [Santos 2015]. For these reasons, the Brazilian community seeks to improve mathematics teaching through educational games. As Araújo *et al*. [2000] argued, educators strive to disseminate and demystify the use of playful activities in teaching mathematics. The aim is for the subject to be increasingly accepted and to overcome its negative characteristics. The results of this study reaffirm this observation.

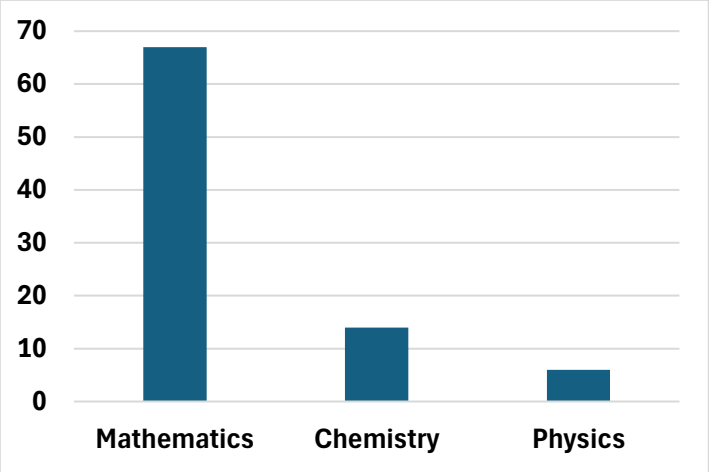

Figure 1. Number of games per subject. Source: The authors.

Still considering the math games shown in Figure 2, the four basic operations (addition, subtraction, multiplication, and division) were the most covered topic, with 40 games standing out.

One example is the game Chocomática, mentioned in S9 (Table 2). This game was developed to help students in the first year of elementary school and learners at other levels who need to understand the concept of basic operations. The game is collaborative, and the aim is to open a chocolate store. To open the store, the players must reach a consensus and organize the space according to the stipulated rules. The gameplay consists of creating sequences of figures with different colors and different amounts of chocolates of the same color. These sequences must follow a progression of one, two, or three units, allowing the formation of four different types of sequences [de Castro *et al*. 2021]. The second most covered theme was geometry, explored in 21 games.

Among the works identified, seven articles on mathematics dealt with two subjects simultaneously: geometry and basic operations (S4, S21, S31, S32, S43, S49, S80 – Table 2). We also identified a single game covering fractions, numbering systems, and matrix (S86 – Table 2).

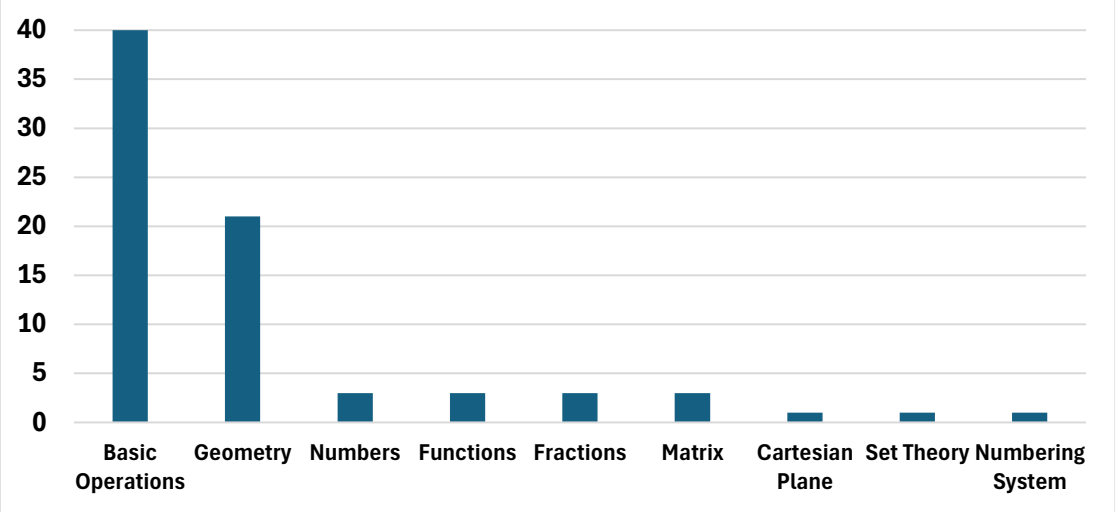

Figure 2. Topics covered in math games. Source: The authors.

An example of research concerning physics teaching is Santos *et al*. [2018], which focuses on learning kinematics. The game is a gamified test in which players control a character who travels along a trail, encountering challenges. To overcome each obstacle, the player must press a button to display a question related to kinematics. By choosing the correct answer and directing the character appropriately, the game progresses to the next stage.

In chemistry, different topics are covered in the games identified. These include Bohr's atomic model, the periodic table, and radioactivity. Of note is the game featured in S50 (Table 2), which offers a broad approach to various aspects of chemistry, exploring topics such as the structure of the atom, changes in the state of matter, and the factors that influence them (such as temperature and pressure). In addition, the game also deals with the names and symbols of the chemical elements, the organization of the periodic table, chemical bonds, biogeochemical cycles, life on Earth, and the relationship between chemistry and pollution, among other relevant subjects.

The second research question – ***Q2: What genre is most present in the educational games identified?*** – involves various game genres, such as strategy, quizzes, puzzles, shooting, RPG (role-playing game), etc. These games can be played on various platforms, such as consoles, personal computers, mobile devices, and browsers. In the context of educational games, this research question sought to identify which genres were most present in the mapped works. It was observed that most games belong to the quiz, puzzle, platform, and point-and-click genres, with 67 games combined (Figure 3).

Games in quiz format are gamified tests. Gamification uses elements traditionally found in games, such as narrative, feedback systems, and rewards [Fardo 2013]. Having a gamified test in the game leads to the idea of a traditional assessment in the question/answer format. If the player gets the answer right, various elements can occur, such as earning points, gaining a new power, a new narrative emerging, and other rewards. If the player gets it wrong, punishment or frustration can arise. Thus, there is no elaborate implementation in terms of game mechanics, and it is mainly presented as a question-and-answer game with gamified elements.

The puzzle genre, found in 14 articles, consists of games whereby the player must solve increasingly complex and intriguing problems, usually with one main

mechanic remaining throughout the game [Frazer *et al*. 2008]. A widely popular example of a puzzle-style game is Tetris. About the mapping conducted, one example found in the searches carried out is S35 – "Tangible interfaces in a digital game: Learning mathematics using logic blocks." This game uses augmented reality to teach geometry, and the player must position the shapes according to the application example image. Other puzzle-style games also follow this idea, in which the problem to be solved is the positioning of elements.

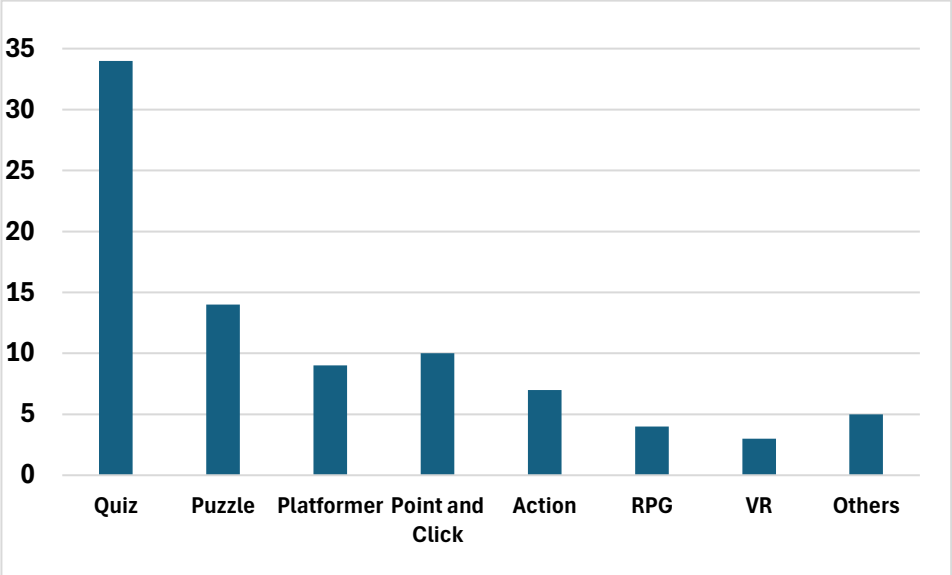

Figure 3. Genres of educational games. Source: The authors.

The platformer genre in nine games refers to 2D games in which a character moves horizontally, continuously or not, in a lateral view. The player only sees part of the scenery, and new areas are revealed as the character moves [El-Habr 2019]. Two popular commercial games in this genre are Mario and Sonic. The Serra Pelada game (S30 – Table 2) is an example of the mapping. The focus is on teaching geometry, in which the player needs to recognize angles and flat figures. The game has ladders and boards, forming angles and figures that the player needs to realize for the character to advance. Note that the game also mixes with the quiz genre in some parts to implement questions.

This is true of several other games that have chosen to differentiate between genres. They have made an additional game design effort, including playfulness in the character's movements and actions or the mechanics implemented. It is insufficient to label them as just a quiz.

Finally, another genre that appeared in 10 games is point-and-click. As the name suggests, these games consist of a mechanic in which movement, character action, or problem-solving is characterized by the player "clicking" in the correct place. Regarding character actions, the player incorporates the character and "clicks" on the screen as if they were the character themselves [Fanni *et al*. 2019]. An example of a game found is Move4Math (S31 – Table 2), in which geometric figures or operation resolutions appear in positions on the screen that players need to point to as if they were a character in the game.

Gamification can aid evaluative activities in the educational environment. Games improve the ability to use logic more efficiently by combining immediate

feedback, sound effects, progress indicators (points and levels), and pedagogical agents. Each activity usually offers an integrated learning and assessment scenario in which the character receives guidance and performs assessment tasks [Menezes and Bortoli 2016].

Nevertheless, there is little exploration of the integration of game mechanics with the content being taught. This means using game mechanics so that learning does not take place as a test or a quiz, but during the actions and decisions that the player can make. In this case, there is a significant challenge in terms of game design, as it is not trivial to map this out. The gamified test or quiz has advantages and benefits [Menezes and Bortoli 2016], but it can create a game in which learning is disconnected from the mechanics of games and actions.

The research by López-Fernández [2023] conducted a study with 45 students to compare the effects of learning a game in the "third-person shooter" genre and another in the "infinite race" genre. The results suggest that the genre made no difference to learning, but the participants preferred "third-person shooters." However, it should be borne in mind that there are dozens of game genres, making it impossible to generalize this observation based on a study that used only two genres. In addition, the participant's personal preferences and the sample may have been insufficient. For this reason, it is understood that game genres should continue to be the subject of investigation in future research, as well as investigating how best to integrate game mechanics with the content to be taught.

Finally, the third research question – ***Q3: How are these games made available?*** – investigated whether the games in the articles are available to the public and which platform is preferred. The results show that most of the games are not available anywhere. Figure 4 illustrates the availability of the games identified in the systematic mapping. 65 of the 86 games were not available, representing 76% of the games. The search was carried out considering the information available in the articles themselves. Two of the remaining games are available in app stores, and 19 are available on websites.

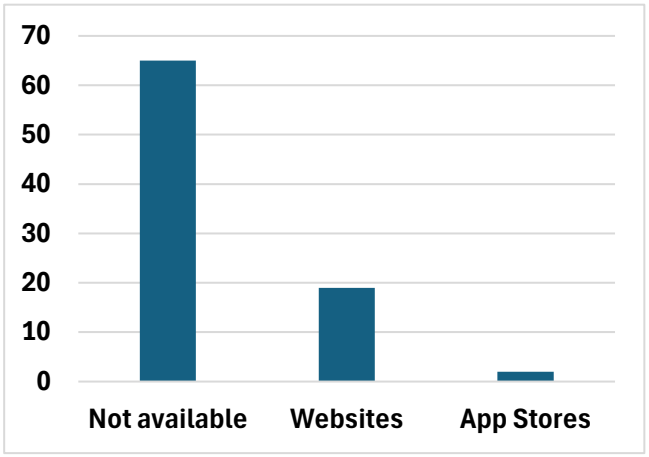

Figure 4. Availability of educational games. Source: The authors.

Making the game available via download and installation limits its reach, as not all users have the necessary knowledge and familiarity with the technology to complete the installation and configuration of the game. A more attractive option would be access by mobile application stores, as they make it easier to install the game. In addition, in recent decades, mobile devices have spread rapidly in society, especially smartphones, so that many potential players would benefit from this practice [Barbosa Neto and

Fonseca 2013]. However, based on the systematic mapping results, only 4% of games are available in app stores.

Another reason educational games are being used effectively on mobile devices is mobile learning (m-learning) advancement. This approach is characterized by innovative smartphone technologies and features, as well as wireless and 4G networks. These tools provide portability, interactivity, adaptability to context, connectivity, and personalization, creating a favorable scenario for educators to explore and implement teaching approaches that integrate these devices effectively in the classroom [Souza *et al*. 2016; Mocbel *et al*. 2020].

5. Final Considerations

The teaching of exact sciences presents constant difficulties for student engagement, which can make the subjects mistakenly be seen as problematic or tedious. Exact sciences form the fundamental basis for developing various areas, and searching for strategies to improve the teaching of this content is crucial. For this reason, educators and researchers are constantly investigating ways of developing digital games as educational artifacts due to their potential for engagement and motivation.

This article systematically mapped the literature to understand the profiles, characteristics, and approaches of educational games developed in recent years to teach exact sciences in Brazil. The target audience was primary and secondary education. The mapping identified 86 publications from repositories considered references in the field to meet the study primary objective.

One of the threats to the study validity is that the research only focused on analyzing work published in Brazilian scientific journals. Considering the games industry, commercial games already used in schools and even gray literature could bring other results, possibly revealing a different reality from the works mapped at this opportunity. Another threat lies in the chosen criteria and selection strategies. Although the searches were well planned and executed, some work related to the topic may not have been included. To mitigate this threat, the three authors of this research reviewed the identified works to resolve possible discrepancies.

Future opportunities include developing new comprehensive and in-depth games for primary and secondary schools. Research into evaluating the impact and effectiveness of these games in student learning is essential, as is ensuring their availability on mobile devices. These initiatives will increasingly contribute to a more dynamic and stimulating education experience, helping to prepare students for future challenges.

References

Alencar, L. *et al*. (2020). “Uma proposta de análise de dados exploratória para um jogo educacional de matemática”, In: Anais do XIX SBGAMES, p. 752-758.

Alves, A. G. *et al*. (2020). “Interface tangível com material dourado em jogo digital de aprendizagem de matemática”, In: Anais do XXXI Simpósio Brasileiro de Informática na Educação, SBC, p. 612-621.

Alves, L. L. (2016). “A importância da matemática nos anos iniciais”, In: EREMATSUL – Encontro Regional de Estudantes de Matemática do Sul, v. 22.

Alves Júnior, F. *et al*. (2024). "Math Mission: Uma proposta de jogo sério com realidade virtual para ensino do conteúdo de frações para alunos do 6º e 7º anos com TDAH". In: Anais do XXIII SBGames, p. 936-947.

Alvez, C. N. H. *et al*. (2019). "Jogos digitais no ensino de física: Estudo do movimento bidimensional através da ferramenta Scratch", In: Anais do IV Congresso sobre Tecnologias na Educação, SBC, p. 637-643.

Amaral, L. *et al*. (2024). "Interactive educational game for chemistry in virtual reality with user gesture interactions via smartwatches", In: Anais do XXVI Symposium on Virtual and Augmented Reality, p. 294-298.

Andreucci, B. *et al*. (2024). "Desenvolvimento de um jogo sério que promova o engajamento na aprendizagem da matemática: Projeto Aurora", In: Anais do XXIII SBGames, p. 297-301.

Araújo, I. R. O. (2000). "A utilização de lúdicos para auxiliar a aprendizagem e desmistificar o ensino da matemática", Dissertação (Mestrado em Engenharia de Produção), Universidade Federal de Santa Catarina.

Balasubramanian, N. and Wilson, B. (2006). "Games and simulations", In: Society for Information Technology and Teacher Education International Conference.

Barbosa Neto, J. F. e Fonseca, F. de S. (2013). "Jogos educativos em dispositivos móveis como auxílio ao ensino da matemática", RENOTE, v. 11, n. 1, 2013.

Barros, G. C. *et al*. (2022). "Jornada Química GeNiAl: Um jogo sério para o ensino da tabela periódica e seus elementos", In: Anais do XXXIII Simpósio Brasileiro de Informática na Educação, SBC, p. 473-484.

Belli, M. e Alvez, A. G. (2018). "Interfaces tangíveis em jogo digital: Aprendizagem de matemática utilizando blocos lógico", In: Anais do XVII SBGAMES, p. 1368-1371.

Benedetti Filho, E. *et al*. (2019). "Desenvolvimento e aplicação de um jogo virtual no ensino de química", Informática na Educação: Teoria e Prática, v. 22, n. 3, p. 144-157.

Brilhante, M. *et al*. (2023). "The Island: Calculated Defense - Praticando operações de adição e subtração", In: Anais do XII Congresso Brasileiro de Informática na Educação, SBC, p. 161-164.

Cardoso, R. C. *et al*. (2024). "Estimulando o aprendizado de matemática no ensino fundamental: Uma abordagem prática integrando jogos digitais e materiais físicos", In: Anais do XXX Workshop de Informática na Escola, SBC, p. 111-121.

Cintra, L. F. R. e Sarinho. V. T. (2024). "Math Run - Um jogo sério para a aprendizagem de expressões matemáticas", In: Anais do XXIII SBGames, p. 110-115.

Colombini, F. R. e von Lochter, J. (2019). "Kiduca: Uma plataforma gamificada direcionada ao ensino fundamental", In: Anais do XVIII SBGAMES, p. 1184-1187.

Conde, A. *et al*. (2024). "Aplicação da matemática básica em um serious game", In: Anais do XXII SBGames, p. 302-306.

Corrêa, E. B. *et al*. (2017). "Hexadecimal para binário através de games: Uma proposta de abordagem no ensino fundamental", In: Anais do XVI SBGAMES, p. 1116-1119.

Correia, R. R. S. et al. (2023). “A serious game for students with math learning difficulties: Co-design-based development and user experience evaluation study”, RENOTE, v. 21, n. 2, p. 286-296.

Costa, T. F. *et al*. (2020). “Um projeto de jogo de aplicativo para auxiliar o sexto ano do ensino fundamental”, In: Anais do XIX SBGAMES, p. 735-743.

Cunha, O. A. L. *et al*. (2019). “QuimiCrush: Um tile matching puzzle para aprendizagem de química inorgânica”, In: Anais do XVIII SBGAMES, p. 362-365.

da Conceição Silva, F. *et al*. (2020). “POTENCIALIZA 3D: Jogo para o ensino de atividades matemáticas básicas a discentes com deficiência intelectual”, In: Anais do XXXI Simpósio Brasileiro de Informática na Educação, SBC, p. 431-440.

da Cruz, E. F. Martins e Pereira, R. M. (2020). “AUTISMATH: Aplicativo para auxiliar o ensino e aprendizagem de matemática para crianças com transtorno do espectro autista”, In: Anais do V Congresso sobre Tecnologias na Educação, SBC, p. 627-633.

da Silva Araújo, A. *et al*. (2020). “Operação Ninja: Um jogo educacional digital para auxiliar na aprendizagem das quatro operações básicas da matemática”, In: Anais do V Congresso sobre Tecnologias na Educação, SBC, p. 613-619.

Damaceno Júnior, G. B. *et al*. (2023). “Jogos digitais no ensino da matemática: Uma revisão da literatura”, In: Anais do XXII SBGames, p. 804-813.

Dawes, L. and Dumbleton, T. (2001). “Computer games in education project”. Disponível em: <http://www.becta.org.uk/page_documents/research/cge/report.pdf>. Acessado em: 10 março 2024.

de Barros, A. C. M. *et al*. (2018). “Tobomatics: Desenvolvendo habilidades no aprendizado com as operações matemáticas básicas através do jogo digital educativo”, In: Anais do XVII SBGAMES, p. 1436-1439.

de Carvalho, M. F. *et al*. (2017). “Move4Math: Jogos sérios ativos para alfabetização matemática”, In: Anais do XVI SBGAMES, p. 95-104.

de Carvalho, V. R. *et al*. (2023). “GeoMemory: Jogo digital de memória para o estudo de formas geométricas”, RENOTE, v. 21, n. 2, p. 319-330.

de Castro, J. B. *et al*. (2021). “Chocomática inauguração: Um recurso educacional digital para aprendizagem colaborativa de álgebra nos anos iniciais”, In: Anais do VI Congresso sobre Tecnologias na Educação, SBC, p. 458-464.

de Lima, J. S. e Gitirana, V. (2021). “FrameAGAP: Um *framework* para auxiliar estudantes com dificuldades no estudo das cônicas”, RENOTE, v. 19, n. 2, p. 496-505.

de Lima Moreira, I. E. *et al*. (2019). “Vamos jogar matemática: Utilizando o RPG Maker para produzir um recurso educacional digital para o ensino de matemática”, In: Anais do IV Congresso sobre Tecnologias na Educação, SBC, p. 79-88.

de Melo Fernandes, M. e de Souza Rebouças, A. D. D. (2016). “Math Timer: Um objeto de aprendizagem para apoiar o ensino de Matemática”, RENOTE, v. 14, n. 1.

de Melo Santos, C. E. e Leite, B. S. (2019). “Construção de um jogo educativo em uma plataforma de desenvolvimento de jogos e aplicativos de baixo grau de

complexidade: O caso do Quizmica-Radioatividade", RENOTE, v. 17, n. 1, p. 193-202.

de Oliveira, A. M. D. *et al*. (2020). "Software educativo Desafio da Coleta: Uma ferramenta potencializadora da aprendizagem matemática", In: Anais do V Congresso sobre Tecnologias na Educação, SBC, p. 689-695.

de Oliveira, R. G. S. G. *et al*. (2015). "Uma abordagem lúdica e cultural para o ensino da matemática com jogos customizáveis gerenciados pelo educador", In: Anais do XIV SBGames, p 1025-1031.

de Souza Chagas, J. V. *et al*. (2022). "Um jogo para auxiliar na aprendizagem de química orgânica", In: Anais Estendidos do XXI Simpósio Brasileiro de Jogos e Entretenimento Digital, SBC, p. 1030-1038.

de Souza, G. G. e da Mota, R. R. (2023). "Gamificação para aquisição de habilidades matemáticas estimulação das habilidades geométricas em crianças com distúrbios no desenvolvimento neurológico". In: Anais do XXII SBGames, p. 717-728.

de Vasconcellos, M. S. *et al*. (2017). "As várias faces dos jogos digitais na educação", Informática na Educação: Teoria e Prática, v. 20, n. 4, p. 203-218.

dos Santos, R. W. P. *et al*. (2023). "Um jogo digital: "RabbitLand" para o ensino aprendizagem da matemática", In: Anais do XXII SBGames, p. 1090 – 1095.

Dourado, J. B. *et al*. (2015). "Desenvolvimento e avaliação de um jogo com tecnologia de RA para auxiliar no ensino de matemática", In: Anais do XIV SBGames, p. 846-853.

El-Habr, C. *et al*. (2019). "Runner: A 2D platform game for physical health promotion", SoftwareX, v. 10, p. 100329.

Estevam, L. C. *et al*. (2024). "Realidade virtual e aumentada no ensino de geometria: Um estudo de caso com GeoMeta". In: Anais do XXIII SBGames, p. 1233-1244.

Fanni, F. A. *et al*. (2019). "PAC-PAC: End user development of immersive point and click games", In: Malizia, A., Valtolina, S., Morch, A., Serrano, A., Stratton, A. (eds) End-User Development, IS-EUD 2019, Lecture Notes in Computer Science, v. 11553, Springer, Cham.

Fardo, M. L. (2013). "A gamificação aplicada em ambientes de aprendizagem", RENOTE, v. 11, n. 1.

Fo, M. R. e da Silva, A. C. (2015). "Jogo eletrônico para dispositivos mobile com foco no ensino de geometria para alunos do ensino fundamental", In: Anais do XIV SBGames, p 874-879.

Frade, B. V. *et al*. (2015). "Desenvolvimento de um jogo sério com uso de realidade virtual", In: Anais do XIV SBGames, p. 802-808.

Frazer, A. *et al*. (2008). "The same, but different: The educational affordances of different gaming genres", In: Eighth IEEE International Conference on Advanced Learning Technologies, Spain, p. 891-893.

Gomes, W. *et al*. (2018). "Desenvolvimento de um jogo voltado para o ensino de matemática nas séries iniciais", In: Anais do XVIII Escola Regional de Computação Bahia, Alagoas e Sergipe, SBC, p. 88-93.

Gripp, C. R. S. *et al*. (2024). “Jogo para auxílio ao aprendizado de operações matemáticas utilizando ábaco e visão computacional”, In: Anais do XXXV SBIE, p. 2713-2720.

Gros, B. (2003). “The impact of digital games in education”, First Monday, v. 8, n. 7, p. 6-26.

Guimarães Dias, S. *et al.* (2024). “MathCity Finances: Jogo digital educativo para praticar operações matemáticas no cotidiano”, In: Anais do XXXV Simpósio Brasileiro de Informática na Educação, SBC, p. 578-590.

Higa, H. *et al*. (2024). “Mar de Cálculos - Aplicação para ensino da matemática”, In: Anais do XXIII SBGames, p. 292-296.

Hsiao, H. C. (2007). “A brief review of digital games and learning”, In: 2007 First IEEE International Workshop on Digital Game and Intelligent Toy Enhanced Learning, p. 124-129.

Jardim, A. M. e de Paiva, D. C. (2016). “Cuidando do Pomar, ensino de numeração e quantidades”, In: Anais do XV SBGAMES, p. 1484-1487.

Kacmaz, G. and Dubé, A. K. (2022). “Examining pedagogical approaches and types of mathematics knowledge in educational games: A meta-analysis and critical review”, Educational Research Review, v. 35, p. 100428.

Lais, R. *et al*. (2024). “Enigma Pirata: Praticando teoria dos conjuntos e desenvolvendo o pensamento computacional”, In: Anais do XXIII SBGames, p. 902-914.

Laurindo, L. E. C. *et al*. (2019). “Um jogo móvel baseado em localização para motivar e acompanhar estudantes no processo de ensino-aprendizagem”, RENOTE, v. 17, n. 3, p. 163-172.

Leite, B. S. (2020). “Elaboração do jogo Memoráveis Nobéis da Química para o ensino de química utilizando o MIT App Inventor”, RENOTE, v. 18, n. 1.

Lemes, J. S. e de Paiva, D. C. (2016). “Adaptação do Bow and Arrow, desafios para fins pedagógicos”, In: Anais do XV SBGAMES, p. 1481-1483.

López-Fernández, D. *et al*. (2023). “Comparing effectiveness of educational video games of different genres in computer science education”, Entertainment Computing, v. 47, p. 100588.

Macêdo, P. H. *et al*. (2017). “Jogo digital como auxílio no estudo da matemática: Um estudo de caso com estudantes do ensino fundamental I”, In: Anais do XXIII Workshop de Informática na Escola, SBC, p. 548-557.

Madeira, C. *et al*. (2015). “Mathmare: Um jogo de plataforma envolvendo desafios matemáticos do ensino médio”, In: Anais do XIV SBGames, p 1042-1049.

Martins, T. C. (2017). “Eletrostática e Zumbis: Um jogo educativo para Android”, In: Anais do XVI SBGAMES, p. 991-993.

Martins, W. *et al*. (2024). “Condição Celeste: um jogo para exercitar operações aritméticas e o pensamento computacional”, In: Anais do XXIII SBGames, p. 307-310.

Mayer, R. *et al*. (2022). “Experiências de um jogo educacional digital para auxiliar no processo de ensino aprendizagem de transformações químicas para o ensino médio”, In: Anais do XXVIII Workshop de Informática na Escola, SBC, p. 59-67.

MEC. (2018). Base Nacional Comum Curricular. http://basenacionalcomum.mec.gov.br/.

Meira, M. C. *et al*. (2019). “Proposta de aprendizagem integrada de matemática e programação com abordagens do pensamento computacional no jogo Robocode”, Informática na Educação: Teoria e Prática, v. 22, n. 3.

Menezes, C. C. N. e Bortoli, R. (2016). “A gamificação da avaliação: Instrumento de inovação pedagógica”, In: Proceedings of the 7th International Symposium on Technological Innovation, p. 439-445.

Miguel, J. *et al*. (2024). “Vórtex Numérico: Um jogo educacional para exercitar operações básicas e pensamento computacional”, In: Anais do XXIII SBGames, p. 1082-1093.

Minholi, F. S. *et al*. (2022). “O universo das funções: Um jogo sério para a fixação de conceitos sobre funções e seus gráficos”, In: Anais Estendidos do XXI Simpósio Brasileiro de Jogos e Entretenimento Digital, SBC, p. 1465-1468.

Minussi, M. M. e Wyse, A. T. S. (2016). “Web-Game educacional para ensino e aprendizagem de ciências”, RENOTE, v. 14, n. 1.

Mitchell, A. and Savill-Smith, C. (2004). “The use of computer and video games for learning: A review of the literature”, London: Learning and Skills Development Agency (LSDA).

Mocbel, M. A. R. *et al*. (2020). “Um framework para desenvolvimento de softwares de suporte ao ensino para plataformas móveis”, RENOTE, v. 18, n. 1.

Monteiro, N. *et al*. (2024). “Science Kingdom: Jogo digital como ferramenta de apoio no ensino de química”, In: Anais do XXXV Simpósio Brasileiro de Informática na Educação, SBC, p. 566-577.

Moraes, I. G. e Colpani, R. (2016). “Desenvolvimento de um serious game com realidade aumentada para auxiliar no processo de ensino-aprendizagem de matemática básica”, In: Anais do XV SBGAMES, p. 242-245.

Moura, T. *et al*. (2024). “IsoPuzzle: Conectando educação e cultura por meio de jogos interdisciplinares”, In: Anais do XXIII SBGames, p.608-619.

Oliveira, M. C. *et al*. (2023). “Elementetris: Um jogo digital de apoio à aprendizagem de química”, In: Anais do XXII SBGames, p. 1483-1488.

Ortolan, V. A. e Modesto, F. A. C. (2023). “Desenvolvimento de jogo sério como ferramenta de apoio ao aprendizado de geometria no ensino médio”, In: Anais do XXII SBGames, p. 1029 – 1034.

Otsuka, J. L. *et al*. (2015). “LABTECA: Experiência lúdica em um laboratório 3D de química”, RENOTE, v. 13, n. 2, p. 1-10.

Parmegiani, L. C. (2022). “Jogo sério para matemática sobre geometria euclidiana plan”, In: Anais do XXI SBGAMES, p. 744-753.

Pedrosa, C. *et al*. (2024). "Numéria: Um jogo educacional para exercitar as operações matemáticas básicas e pensamento computacional", In: Anais do XIII Congresso Brasileiro de Informática na Educação, SBC, p. 229-232.

Pereira Junior, C. X. *et al*. (2016). "Desenvolvimento de protótipo de game para inserção no ensino de ciências", In: Anais do III Encontro Nacional de Computação dos Institutos Federais, SBC, p. 700-703.

Petersen, K. *et al*. (2015). "Guidelines for conducting systematic mapping studies in software engineering: An update", Information and Software Technology, v. 64, p. 1-18.

Pinheiro, W. S. *et al*. (2023). "Algebird Adventures: Um jogo para o aprendizado de álgebra fundamental", In: Anais do XXIII Escola Regional de Computação Bahia, Alagoas e Sergipe, SBC, p. 114-119.

Prensky, M. (2003). "Digital game-based learning", Computers in Entertainment, v. 1, n. 1, p. 21.

Raessens, J. and Goldstein, J. (2005). "Computer games as participatory media culture", Handbook of Computer Game Studies, p. 373-388.

Rios, L. C. *et al*. (2018). "Geometria em jogo: Uma ferramenta de apoio ao tratamento de disléxicos", In: Anais do XVII SBGAMES, p. 1364-1367.

Rocha, M.; Dondio, P. (2021). "Effects of a videogame in math performance and anxiety in primary school", International Journal of Serious Games, v. 8, n. 3, p. 45-70.

Rolim, I. *et al*. (2023). "Rabbit Code: Um jogo voltado para a aprendizagem de matrizes". In: Anais do XII Congresso Brasileiro de Informática na Educação, SBC, p. 141-144.

Sande, D. *et al*. (2021). "Aprendizagem de física e engajamento através do jogo Nivelamento Online durante a pandemia da COVID-19", RENOTE, v. 19, n. 2, p. 61-70.

Santiago, J. M. S. *et al*. (2018). "MathQuiz: A game app for m-learning", In: Anais Estendidos do XXIV Simpósio Brasileiro de Sistemas Multimídia e Web, SBC, p. 69-72.

Santos, F. A. O. *et al*. (2018). "Um jogo para ensinar física: A cinemática de forma lúdica no ensino médio", In: Anais do V Encontro Nacional de Computação dos Institutos Federais, SBC.

Santos, O. F. (2015). "O desinteresse dos alunos nas aulas de matemática: A desmotivação no estudo de matemática provocada pela metodologia tradicional de ensino", Monografia (Graduação em Matemática Licenciatura), Universidade Federal de Alagoas.

Santos, J. V. M. *et al*. (2022). "Math Dreams: Adaptação de modelo e de boas práticas de ICC em um jogo sério de matemática básica", In: Anais do XXX Workshop sobre Educação em Computação, SBC, p. 274-285.

Santos, W. O. *et al*. (2017). "Desafios das Diagonais: Um jogo para o ensino de matemática", In: Anais do XVI SBGAMES, p. 705-714.

Santos, W. e Alvez, L. (2016). “D.O.M. – Um jogo sobre funções quadráticas: Entre a educação e o entretenimento”, RENOTE, v. 14, n. 2.

Savi, R. e Ulbricht, V. R. (2008). “Jogos digitais educacionais: Benefícios e desafios”, RENOTE, v. 6, n. 1.

Shimohara, C. e Sobreira, E. S. R. (2015). “Criando jogos digitais para a aprendizagem de matemática no ensino fundamental I”, In: Anais do XXI Workshop de Informática na Escola, p. 72-81.

Siedler, M. S. *et al*. (2024). “Aventuras Digitais com Material Dourado: Jogo digital voltado ao aprendizado de matemática”, In: Anais do XXIII SBGames, p. 1453-1464.

Silva, A. C. S. e Falcão, T. P. (2019). “Virtualização de jogos matemáticos: Uma avaliação do Cubra Doze”, In: Anais do IV Congresso sobre Tecnologias na Educação, SBC, p. 50-59.

Silva, E. e de Sousa Pires, F. G. (2017). “O uso do jogo educacional “Eu sei Contar” como auxílio da matemática no ensino infantil”, In: Anais do XXIII Workshop de Informática na Escola, SBC, p. 520-527.

Silva, E. P. *et al*. (2020). “Angels: Uma aplicação gamificada para auxiliar jovens com deficiência intelectual no processo de aprendizagem”, In: Anais do XIX SBGAMES, p. 544-550.

Silva, I. O. *et al*. (2023). “GEOMETRY QUEST: um jogo com foco na geometria”, In: Anais do XXII SBGames, p. 729-738.

Soares, C. N. e da Nóbrega, G. M. (2021). “Ada e a Sociedade Perdida: Um RPG digital para revisão de conceitos da matemática do ensino fundamental”, In: Anais Estendidos do XX Simpósio Brasileiro de Jogos e Entretenimento Digital, SBC, p. 659-662.

Sobrinho, M. E. *et al*. (2016). “Game Serra Pelada: Projeto, implementação e a avaliação de um jogo educativo para o ensino de geometria para alunos do 9º ano do ensino fundamental”, In: Anais do XV SBGAMES, p. 865-872.

Souza, A. L. *et al*. (2016). “Tecnologia ou metodologia: Aplicativos móveis na sala de aula”, In: Anais do Encontro Virtual de Documentação em Software Livre e Congresso Internacional de Linguagem e Tecnologia Online, v. 5, n. 1.

Stochero, A. D. *et al*. (2018). “O processo de desenvolvimento de um jogo matemático com as operações básicas para jovens com espectro autista”, In: Anais do V Encontro Nacional de Computação dos Institutos Federais, SBC.

Tarouco, L. M. R. *et al*. (2004). “Jogos educacionais”, RENOTE, v. 2, n. 1, p. 1-7.

Tito, J. e Moraes, R. (2022). “Realidade virtual para ensino da física: Análise do engajamento e presença de uma experiência imersiva no aprendizado da cinemática”, In: Anais Estendidos do XXIV Simpósio de Realidade Virtual e Aumentada, SBC, p. 1-5.

Vahldick, A. e da Silva, W. T. (2020). “Um jogo sério para suportar o aprendizado do modelo atômico de Bohr”, RENOTE, v. 18, n. 1.

Vieira, M. et al. (2019). “Orangotango: Jogo digital para aprendizagem de matemática e noções sobre meio ambiente”, In: Anais da XIX Escola Regional de Computação Bahia, Alagoas e Sergipe, SBC, p. 48-53.

Victal, E. et al. (2015). “Aprendendo sobre o uso de jogos digitais na educação”, In: Anais do Workshop de Informática na Escola, p. 444-453.

Vogel, B. *et al*. (2020). “Corrida Matemática: Um jogo digital sério desenvolvido para a aprendizagem de operações matemáticas básicas”, In: Anais da XX Escola Regional de Computação Bahia, Alagoas e Sergipe, SBC, p. 173-178.