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How can "gamification" help in the teaching of arithmetic operations as a didactic tool and digital technology?

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Abstract

This article is a teaching proposal concerning arithmetic problems of mathematics to help teachers in initial training in mathematics and teaching mathematics in the classroom with the use of Gamification. Thus, the objective of this article is to investigate what contributions didactic engineering and digital technologies using gamification in full-time high school teaching can be *helpful* with the contents of basic operations. The methodology applied with the games was based and structured on the Didactic Engineering research methodology, being exploratory research of a qualitative nature *to* familiarize the mathematical problems with the use of Digital Technologies. The results were categorized based on the phases of preliminary analysis, a priori analysis, experimentation, and a posteriori analysis and validation. Conclusions that the use *of* applied problems brought out the validation of the strategies applied in the classroom. Therefore, the expected results were positive in the teacher's view *of* the way the two games were planned in Google Presentations and in supporting the students in the teaching and learning processes of Mathematics.

Keywords: Didactic Engineering; Digital Technology; Google Presentations; Mathematics.

Introduction

Digital Technologies (DT) have been significantly changing the methods of teaching and learning in the classroom, educational institutions and interactive spaces. (Bzhalava et al., 2022; Inganah et al., 2023; Lazarenko et al., 2020) recurs "for example, an object of knowledge is not teachable if we cannot incorporate it into a teaching progression; if we cannot associate it with exercises for students; if we cannot find ways to assess its mastery." Remarkably, such instruments are launching new interactive platforms and applications that the student establishes with his learning environment (Ahmed & Kumalasari, 2023; Arif et al., 2023; Nasiha et al., 2023), with his peers (Rahman, 2023; Sugianto & Khan, 2023), and with himself (Santiago et al., 2023; Schabas, 2023; Winson et al., 2023).

The changes in DT evolve rapidly, and the alternatives becoming dynamic (Darmayanti et al., 2023; Fikri et al., 2023; Hussain & Xi, 2023; Karim & Zoker, 2023), attractive (König et al., 2019), and opening educational teaching spaces (Meirbekov et al., 2022), previously directed in the traditional class with the use of the whiteboard (Aggleton, 2019), desks, and chairs, currently with the use of digital resources, allowing several ways to make the teaching practice assimilative and inclusive, with attractive methods, to seek the students' attention, increasing the learning opportunities (Bogoslovskiy et al., 2019; Syaifuddin et al., 2022).

The fundamental arithmetic operations cover the calculations used to solve problems, which due to the simple way of solving are important for performing any mathematical calculation in basic education. In this way, we seek to highlight problematizations with the basic operations of mathematics (addition, subtraction, multiplication, division), including the relationship of DTs with the Google Presentations application. Several authors show considerations about the use of these technological tools, among them we highlight the understanding of (Sugianto, Cholily, et al., 2022), "[...] question the ways in which mathematics can be produced in school when using DTs; emphasize the humanity and uncertainty of the subject of mathematics and the use of Digital Technologies in the classroom.

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In this statement, the teaching of mathematics is present in various contexts of students' daily lives, and there are different meanings between the subject taught in educational institutions and the interactive one in everyday life (Darmayanti, Sugianto, et al., 2022; Montiel & Gomez-Zermeño, 2021; Tong et al., 2022). This reality reflects between the contents and the reality provided by the knowledge, representations and conclusions of tasks (Nelson et al., 2021; Zirawaga et al., 2017). Thus, the Brazilian scenario in external evaluations such as the Basic Education Evaluation System (SAEB) points out that students of Brazilian Basic Education, at all levels of education, have difficulties with learning in the subject of Mathematics (Humaidi et al., 2022; Palinussa et al., 2021; Whitton & Langan, 2019).

In this sense, it is observed in the Matrix of Basic Knowledge (MCB), that arithmetic operations are contained in this, and are important content to be worked in the classroom (Khoiriyah et al., 2022; Leton et al., 2019; Sugianto et al., 2017). This practice is a way to reduce the gaps found in this process in the learning process from elementary school to high school.

In view of this, we created the description of a treatment for the theme directed by some elements of Didactic Engineering (DE) to organize the research. In this sense, the importance of DI for the teaching of mathematics included in the classroom that according to (Casey et al., 2017)) is "[...] an experimental scheme that serves as a basis for didactic achievements in the classroom, that is, as the design, realization, observation and analysis of teaching sequences".

This work is based on gamification for teaching mathematics, with the following question: how has the learning of basic mathematics been structured with the use of digital technologies in Basic Education with students of Integral High School? To ground this experience report, we included our study in the considerations of (Cardinot & Fairfield, 2019; Ke & M. Clark, 2020; Qian & Clark, 2016) with Digital Educational Game.

In this sense, we sought to investigate the contributions of Didactic Engineering with the use of the DTs included the active methodology of Gamification in the school environment for Full-Time High School with the contents of the fundamental arithmetic operations. In the following topic, the theoretical basis of the work is presented in detail, subdivided into definitions about Didactic Engineering and Gamification. It also presents the methodological procedures, ending with the expected results and the final conclusions about the theme analyzed.

Literature Review

Didactic Engineering

Classical or first generation didactic engineering emerged in discussions of Mathematics Didactics in the early 1980. In mid 1982, the first to study DE were Guy Brousseau, creator of the Theory of Didactic Situations (TDS) and Frenchman Yves Chevallard (Liu, 2018; Morschheuser, 2018), author of Didactic Transposition (DT), then Michèle Artigue in 1989. This theme emerged as a research methodology capable of elaborating didactic phenomena in situations closer to a traditional classroom.

The term "didactic engineering" was structured on the didactic work compared to the work of an engineer who, in order to start a project, bases himself on scientific knowledge of his area of activity, accepts to insert himself in a scientific type of moment, that is, he is obliged to work with more complex objects than the objects studied in science, therefore, to achieve, with all the supports he has, problems that science does not or cannot apply (Aranda et al., 2019). In view of this, a trinomial relationship arises: teacher, student and knowledge.

(Valiero, 2020), report that French didactics allows that "they allowed to develop didactic research in close interaction between researchers and teachers, as well as in close contact with the reality of classrooms, which is well reflected in the importance given in this tradition to didactic engineering".

Corroborating Artigue description, French mathematician Regine Douady, creator of the so-called Board Game, explains the methodology of DE by comparing the teacher to an engineer. According to the author, DE happens "in the course of exchanges between teacher and students, the project evolves under the students' reactions and according to the teacher's choices and decisions" (Chen & Chi, 2022; Jamaluddin & Faroh, 2020; Kim et al., 2020).

Still, according to (Fjællingsdal & Klöckner, 2020), this methodology has an experimental scheme structured in didactic situations about the conception, execution, observation and analysis of teaching sequences, allowing a validation in the a priori and a posteriori analysis. It goes through the dialectical phases: previous analysis, conception and analysis a priori, experimentation and analysis a posteriori and validation.

In the Previous analysis (preliminary), the important information interact creating the intervention strategy, being able to the epistemological of knowledge, didactic dimension of teaching and cognitive problems of students. (Ezezika et al., 2021), describes the inclusion gives, "[...] epistemological analysis of the current teaching and its effects, of the students' conceptions, difficulties and obstacles, and analysis of the field of constraints and requirements in which the effective didactic realization will be situated".

During a priori Conception and Analysis, we select the tools that can be exposed to the students in order for them to achieve cognitive asymmetry. However, during this phase we can predict the students' conjectures and behaviors during the development of the didactic sequence proposed by the teacher. It is now, that all the directed activities are planned.

[...] the constructivist theory posits the principle of the student's commitment to the construction of his knowledge through interactions with a given environment, the theory of didactic situations that serves as a reference to the methodology of engineering [didactics], had, since its origin, the ambition to constitute itself as a theory of control of the relations between meaning and situations (Cardinot et al., 2022; Han et al., 2018).

About the a priori analysis, "[...] the choices made control the students' behaviors and the meaning of these behaviors. For this, it is based on hypotheses; it will be the validation of these hypotheses that will be, in principle, indirectly in play in the confrontation [...]" (Danilovic & de Voogt, 2021; Wu et al., 2021), entering in confrontation with the fourth phase (a posteriori analysis).

At the moment of Experimentation, observation consists in the execution of the didactic sequence, having in mind the assumptions shown, the objectives of the activity and its realization during the research. Thus, it happens "[...] the didactic contract and record the observations made during experimentation" (Dell'Angela et al., 2020; Mercier & Lubart, 2021). In this phase, it is performed the application of the research instrument of the teacher-researcher and the records of the observations of the subjects (students).

In the last stage, the a posteriori analysis and validation is a set of data obtained throughout the third stage (experimentation), as an example, the students' writings, records during observation and audio and video recording, as mentioned above. In this phase, the confrontation between the second phase (a priori analysis) and the a posteriori analysis of the didactic situation takes place.

This research is structured in the four stages of DE, preliminary analysis, a priori analysis and design of the didactic situation, experimentation and a posteriori analysis and validation for an application of teaching the basic operations of mathematics (addition, subtraction, multiplication, division) with the use of Gamification in the classroom.

Gamification

The problem approached in the classroom is challenging, interactive, and shows a universe of fun games, demanding basic knowledge of mathematics from the students' resolutions. However, materials already made by other teachers are generally used, i.e., those evidenced for download on the internet. (Fauza et al., 2022; Lin et al., 2018; Sugianto, Darmayanti, et al., 2022) in the intervention with the "[...] game, it is possible to learn to negotiate in a rules environment and postpone the immediate pleasure. It is possible to work in teams and be collaborative, to make decisions for the best available option."

In this same bias, the teacher and students adapt with Gamification in Google Presentations online version (Hu & Shang, 2018), the starting point will be the alternatives to be selected during the application in the classroom and by which learnings should follow for the resolution. (Gündüz & Akkoyunlu, 2020) reports on attractive teaching materials in the eyes of the subjects, making a major challenge for educational institutions, but also for other professionals in basic education, who need to turn the school environment into learning spaces.

Games provide, in various ways, to advance their stages in education, acquiring rewards as challenges are conquered. (Kaddari et al., 2021), talks about the ways of teaching, inspiration and involvement with a differentiated learning. In this sense, Gamification can increase the number of student participation in front of the enjoyable and fun elements of games in a way adapted to the teaching of mathematics. Therefore, (Mosalanejad et al., 2020) shows that the fact of delivering activities does not characterize gamification, but the means used in the classroom, seeking interaction with everyone, making a pleasant environment for teaching and learning.

(Hu & Shang, 2018), includes "the insertion of games in the context of teaching-learning implies advantages and disadvantages" and worked in the literature specialized in the theme, and should be thought and assumed by teachers, when considering structuring a virtual pedagogical object, with technological games. The author's contributions in the context of the following aspects are evidenced in Figure 1.

VANTAGENS	DESVANTAGENS
- **fixação de conceitos** já aprendidos de uma forma motivadora para o aluno; - **introdução e desenvolvimento de conceitos** de difícil compreensão; - desenvolvimento de **estratégias de resolução de problemas** (desafio dos jogos); - aprender a **tomar decisões** e saber **avaliá-las**; - **significação** para conceitos aparentemente incompreensíveis; - propicia o relacionamento das diferentes disciplinas (**interdisciplinaridade**); - o jogo requer a **participação ativa do aluno** na **construção** do seu próprio **conhecimento**; - o jogo favorece a **socialização** entre os alunos e a conscientização do **trabalho em equipe**; - a utilização dos jogos é um fator de **motivação** para os alunos; - dentre outras coisas, o jogo favorece o desenvolvimento da **criatividade**, de **senso crítico**, da **participação**, da **competição** "sadia", da **observação**, das várias formas de uso da linguagem e do resgate do **prazer em aprender**; - as atividades com jogos podem ser utilizadas para reforçar ou recuperar habilidades de que os alunos necessitem. Útil no trabalho com alunos de diferentes níveis; - as atividades com jogos permitem ao professor identificar, diagnosticar alguns erros de aprendizagem, as atitudes e as dificuldades dos alunos.	- quando os jogos são mal utilizados, existe o perigo de dar ao jogo um **caráter puramente aleatório**, tornando-se um **"apêndice" em sala de aula**. Os alunos jogam e se sentem motivados apenas pelo jogo, **sem saber porque jogam**; - o **tempo gasto** com as atividades de jogo em sala de aula **é maior** e, se o professor não estiver preparado, pode existir um sacrifício de outros conteúdos pela falta de tempo; - as **falsas concepções** de que se devem **ensinar todos os conceitos através de jogos**. Então as aulas, em geral, transformam-se em verdadeiros cassinos, também sem sentido algum para o aluno; - a **perda da "ludicidade" do jogo** pela interferência constante do professor, destruindo a essência do jogo; - a **coerção do professor**, exigindo que o aluno jogue, mesmo que ele não queira, **destruindo a voluntariedade** pertencente à natureza do jogo; - a dificuldade de acesso e disponibilidade de material sobre o uso de jogos no ensino, que possam vir a subsidiar o trabalho docente.

Figure 1. *Advantages and disadvantages of games in teaching and learning (Grando, 2000)*

These considerations above delineate necessary and important aspects in the inclusion of games in the context of teaching and learning, proposing to the teacher a reflective thought with the methodological assumptions, planned in his school pedagogical planning, observing a coherent conception, present in the action of applicator in the classroom. (Tsai et al., 2020; Wen et al., 2020) discussed about "digital games favor the response to user activity, making it more immediate and instantaneous. There are simulation situations in which a game can direct the learning of skills needed for its improvement, opening space to be used in education."

Understand the economic, social and historical relationships between these dimensions of social practice, through the course understand concepts as relational systems of concrete totalities intended to explain, understand and (Azizah et al., 2021; Gulo, 2020).

Essentially, gamification is a way of using the form and reasoning of games to motivate, engage and facilitate learning, in this way gamification can be applied in two ways: with or without digital technology; the mechanism does not necessarily depend on technical or digital means (Barbosa, Pontes & Castro, 2020). From these exposed elements, it can be noted that gamification is not defined simply by the creation or use of games, but assimilates a global culture that creates challenges that allow students to reason, integrate and engage, as well as engage and motivate to achieve goals.

Based on the theoretical and methodological aspects explained above, the next topic discusses the methodological approach taken in the research.

Research Methode

The methodological path carried out in the complete work that was realized by the phases of the DE (preliminary analyses, a priori analysis and design, experiment and a posteriori analysis and validation), however, only some results will be included for exposition in the text. In the first phase of Preliminary Analysis, a study was created based on two aspects: I) a brief epistemological explanation about the teaching of the four basic operations of mathematics and; II) analyses of textbooks on the content of basic operations to choose questions about the content exposed in Gamification to be addressed in the research.

In aspect I, the basis was in authors such as (Holanda, Freitas & Rodrigues, 2020) and (Jacomelli-Alves & Sabel, 2022) when they work on the teaching of basic operations and the difficulties encountered in the four basic operations, as well as their approach in observing the behavior of students during the application of the questionnaire, realized that one of the important factors in

mathematical problems is the lack of interest and discouragement in the face of insufficient results acquired after the resolution, the basic operations were exposed in an insufficient manner or not included during the school year studied in previous years to the current ones, which is added to the context where the DT is a reality that can no longer be excluded from teaching and learning.

Already in aspect II, it was observed in all books approved in the National Textbook Program (PNLD) 2018, that the contents of the basic operations is little, mostly is found a short explanation. Of the 3 (three) volumes analyzed, only (Balestri, 2016) volume 1 exposes in the initial chapters some problematizations. It was also analyzed how the contents are explained to high school students, following the traditional teaching with some applications of the GeoGebra software, often stimulate the mechanization of learning by repetition. These patterns are considered, according to (AN Vidyastuti et al., 2022; Scott et al., 2022)), exploring the contents about the use of symbology in teaching the proposed activities.

In the a priori Analysis and Design of the didactic situation, an interactive gamification was structured and planned with basic contents of high school to recompose the learning of mathematics. In this case, gamification, as a multimodal approach, should help the mismatch between education and the contemporary world and its digital culture with such a great impact on society, as the dispersion of knowledge and the multiple ways to access it leads to the need to rethink teaching, restructure existing rules and review entrenched and conservative paradigms. Stay focused on your educational goals, free from the extreme effects of distance or proximity to the digital world.

The methodology of the work was exploratory research of a qualitative nature. The inclusion of exploratory research is justified because there are few studies using Gamification for High School outlined in Action Research. (Eriksson et al., 2021; Sah RWA et al., 2022), exploratory research aims to familiarize the problem by trying to make it as explicit as possible for those involved. Qualitative research presents a reality that cannot be treated or quantified with the subjective items of reality with the research (Darmayanti, Baiduri, et al., 2022; MM Effendi et al., 2022). In view of this, it is considerable to analyze the data without the due statistical treatment of the students, because it seeks to understand the reality of the school (Ezezika et al., 2021; Tsai et al., 2019).

In the Experimentation stage, which was applied with two high school classes of the Assis Bezerra Full Time School, 54 students were enrolled and 32 of them were able to participate in the game. The research instrument of this work is composed of the grade of the first period of the subject of Mathematics, following three stages: 1st stage - Bibliographic review of the textbook, school curriculum and matrix of descriptors of SAEB; 2nd stage - Development of games on the Google Presentations platform; and 3rd stage - Application of Gamification with the two classes.

In the first stage, bibliographic research of the textbook on digital platforms that facilitate students' reasoning was surveyed. The second stage included interactive workshops with games in the form of slides. Finally, in the third stage, the digital games created in the Google Presentations platform were applied with the two classes, reporting the rules, the beginning and the end of Gamification in the classroom. In the workshop interactive groups were divided to facilitate the learning of Mathematics content. In this way, digital games were also made to obtain from the students the mathematical thinking and reasoning and apply it in Gamification.

Figure 2. Virtual game in Google presentations, Google (2023)

In the phase of the a posteriori analysis and validation (internal), the analyses of the data obtained in the game resolutions were performed, comparing them with the a priori analysis whose purpose was to reach the objectives and hypotheses present in this work, in addition to analyzing the inclusion of arithmetic problems solved by them and their observations regarding Gamification applied in the classroom.

Research Methode

As a result of this work, two educational games were produced by the mathematics teacher of the classes with the support of the Google Presentations platform. All games had a common goal: to show the Mathematics subject in an interactive and fun way to obtain better results in internal and external evaluations. The application happened with 32 students in the Mathematics subject of the Assis Bezerra Full Time School, located in the city of Quixeramobim - Ceará - Brazil. The application took place during the math teacher's time, with the participation of the students present on the day of the Gamification.

The problems included in the game were taken from the analyzed textbooks referring to the content of basic operations in mathematics. These small problems should emphasize the mathematical calculation of open and interpretative questions that can be presented as students' previous knowledge. Basic Math Museum - is a game that had as a reference the labyrinth and called Labyrinth, aiming to encourage mathematical reasoning, in a playful way and Stop Egypt is a game with a roulette wheel and figures on the side that can be turned to find out which math subject will be answered by students. Game 01 - Presents several mathematical problems with basic operations for students to answer, taking place in various scenes of the virtual environment and passing through random phases during the game. Game 02 - A mathematical logic reasoning game, whose objective is to select a figure displayed on the screen containing 4 by 4, totaling a total of 16 different questions and adding to the left side a choice of any number to solve the question. Right after that, based on the didactic proposal, the interactive groups discuss the problem situations exposed in the classroom. Next, we present the two computer games built in Google Presentations (Figure 3).

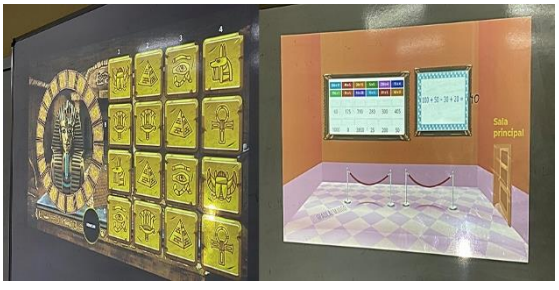

Figure 3. Games applied in the classroom

During the application of Gamification, the teacher provided the rules of the game and which steps to follow for the completion of each game. One can observe the students' initial contact with the game and the information contained in the teacher's explanation, so that they can begin their attempts at solving each problem. With this, we included the data collected from the students' conversations, being named E1, E2, E3, E4, and so on, due to not inserting their real names, considering the norms of the Ethics Committee when working with human beings. In this context, all care was taken during the insertion of data and their analysis in the description of the text of this work. In view of this, subject E8 presented the following question to interactive group 03.

"E8: I observed that at each stage of Game 01 we can learn the step by step of solving the basic operations of mathematics, because when observing the first stage of the museum, we visualize the basic operation of addition, already in the other stages are complemented by subtraction, multiplication and division. So, I made sure to analyze each short problem with my previous knowledge acquired in previous years of teaching".

The lecturer continued the game by questioning the other students in relation to the exposed questions. Subjects E23, E31, E10 responded as follows.

> *"E23: Teacher, I was in doubt when arriving at the division stage, I did not have the necessary knowledge to solve these questions, after your speech I realized how to solve them differently and use in future problems".*
> *"E31: I was able to solve some and I am trying to learn how to solve the other more difficult ones in the two games."*
> *"E10: I thought Game 02 was better, because it had fewer alternatives and the text was closer to the reality experienced in elementary school.*

It was observed that each student explained his difficulties and ways of learning consistent with the two games, substantiating the stages of EE. These reports go through the construction of each student's intuitive idea, which leads them to choose a learning that can generate the necessary knowledge for other types of questions. It is worth noting that the interactive moment with students provided the organization of relevant information structured in the previous step, addressing a formal mathematical language in order to validate the conjectures built in the games, the validation phase was established, which, according to (Hassinger-Das et al., 2017) states that dialectical situation seeks a solution that the actors determine the validity of the knowledge acquired in the didactic situation. It was also realized that the two games adapted in Google Presentations enabled the use of DT, through the dynamization of gamification in the classroom, the development of student autonomy facing the digital technological tool in the use of their basic knowledge of mathematics in relation to the proposed content.

Conclusion

During the application of this work, it was observed in the epistemological and didactic investigation about the relationship of the fundamental arithmetic operations applied with interactive games using the methodology of DE, the need to work this application with other classes of Comprehensive High School, through Gamification workshops with the basic concepts of mathematics.

The application Google Presentations was also used as a technological tool that helped the teacher in the didactic transposition of the proposed problems, allowing a better understanding of the content of some issues explained in both games, as in the ability to understand which methods to use in solving each problem situation.

In this way, this work seeks to investigate the results obtained in the mathematics grade and the contents little worked on in elementary school, for a better understanding of the elements of basic operations and measures of central tendencies, through the application Presentations. Therefore, this investigation included mathematical problems adapted with the help of Google Presentations, providing teachers with a digital didactic model based on the DE that provided, in the classroom, a methodology that differed from the traditional and repetitive teaching of concepts worked by textbooks, as well as making available the responsibility of the student for the construction of his reasoning and mathematical knowledge.

It is hoped that the methodology discussed in this work will serve other teachers and classes as teaching material to explore basic mathematics with other related contents. Since this is an ongoing research, the goal is to (re)apply other didactic models in the Presentations application during the school year to collect other data and observations

Reference

Aggleton, J. (2019). Defining digital comics: a British Library perspective. *Journal of Graphic Novels and Comics*, *10*(4). https://doi.org/10.1080/21504857.2018.1503189

Ahmed, M. A., & Kumalasari, N. (2023). ANDIN-MU: Development of Android-Based Descriptive Text Interactive Multimedia Materials in High School English Subjects. *Assyfa Learning Journal*, *1*(1), 49–59.

AN Vidyastuti, MM Effendi, & Darmayanti, R. (2022). Aplikasi Tik-Tok: Pengembangan Media Pembelajaran Matematika Materi Barisan dan Deret Untuk Meningkatkan Minat Belajar Siswa SMA. *Jurnal Math Educator Nusantara: Wahana Publikasi Karya Tulis Ilmiah Di Bidang Pendidikan Matematika*, *8*(2), 91–106. https://doi.org/10.29407/jmen.v8i2.18267

Aranda, M. R., Roca, M. E., & Marti, M. M. (2019). Didactical suitability in early childhood education: mathematics with Blue-Bot robots. *Edmetic*, *8*(2).

Arif, V. R., Afnan, M., Usmiyatun, U., & Lestari, C. Y. (2023). Development of Social Studies Animation Video (S2AV) Teaching Materials on the Material" Plurality of Indonesian Society" for Junior High School Students. *Assyfa Learning Journal*, *1*(1), 1–11.

Azizah, N., Nengsih, E. W., Wati, L., Rahimah, & Nastiti, L. R. (2021). The perspective on monopoly as media in physics learning by using teams games tournament. *Journal of Physics: Conference Series*, *1760*(1). https://doi.org/10.1088/1742-6596/1760/1/012015

Bogoslovskiy, V. I., Busygina, A. L., & Aniskin, V. N. (2019). Conceptual foundations of higher education in the digital economy. *Samara Journal of Science*, *8*(1). https://doi.org/10.17816/snv201981301

Bzhalava, L., Hassan, S. S., Kaivo-Oja, J., Köping Olsson, B., & Imran, J. (2022). Mapping the Wave of Industry Digitalization by Co-Word Analysis: An Exploration of Four Disruptive Industries. *International Journal of Innovation and Technology Management*, *19*(2). https://doi.org/10.1142/S0219877022500018

Cardinot, A., & Fairfield, J. A. (2019). Game-based learning to engage students with physics and astronomy using a board game. *International Journal of Game-Based Learning*, *9*(1). https://doi.org/10.4018/IJGBL.2019010104

Cardinot, A., McCauley, V., & A Fairfield, J. (2022). Designing physics board games: A practical guide for educators. *Physics Education*, *57*(3). https://doi.org/10.1088/1361-6552/ac4ac4

Casey, B. M., Lombardi, C. M. P., Pollock, A., Fineman, B., & Pezaris, E. (2017). Girls' Spatial Skills and Arithmetic Strategies in First Grade as Predictors of Fifth-Grade Analytical Math Reasoning. *Journal of Cognition and Development*, *18*(5). https://doi.org/10.1080/15248372.2017.1363044

Chen, K. Z., & Chi, H. H. (2022). Novice young board-game players' experience about computational thinking. *Interactive Learning Environments*, *30*(8). https://doi.org/10.1080/10494820.2020.1722712

Danilovic, S., & de Voogt, A. (2021). Making Sense of Abstract Board

Games: Toward a Cross-Ludic Theory. *Games and Culture*, *16*(5). https://doi.org/10.1177/1555412020914722

Darmayanti, R., Baiduri, B., & Sugianto, R. (2022). Learning Application Derivative Algebraic Functions: Ethnomathematical Studies and Digital Creator Books. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *06*(02), 2212–2227.

Darmayanti, R., Nguyen, T., & Serpe, A. (2023). Gema Cow-Pu: Development of Mathematical Crossword Puzzle Learning Media on Geometry Material on Middle School Students' Critical Thinking Ability. *Assyfa Learning Journal*, *1*(1), 37–48.

Darmayanti, R., Sugianto, R., Baiduri, Choirudin, & Wawan. (2022). Digital comic learning media based on character values on students' critical thinking in solving mathematical problems in terms of learning styles. *Al-Jabar: Jurnal Pendidikan Matematika*, *13*(1), 49–66. http://ejournal.radenintan.ac.id/index.php/al-jabar/index

Dell'Angela, L., Zaharia, A., Lobel, A., Vico Begara, O., Sander, D., & Samson, A. C. (2020). Board Games on Emotional Competences for School-Age Children. *Games for Health Journal*, *9*(3). https://doi.org/10.1089/g4h.2019.0050

Eriksson, M., Kenward, B., Poom, L., & Stenberg, G. (2021). The behavioral effects of cooperative and competitive board games in preschoolers. *Scandinavian Journal of Psychology*, *62*(3). https://doi.org/10.1111/sjop.12708

Ezezika, O., Fusaro, M., Rebello, J., & Aslemand, A. (2021). The pedagogical impact of board games in public health biology education: the Bioracer Board Game. *Journal of Biological Education*. https://doi.org/10.1080/00219266.2021.1909638

Fauza, M. R., Inganah, S., Darmayanti, R., Prasetyo, B. A. M., & Lony, A. (2022). Problem Solving Ability: Strategy Analysis of Working Backwards Based on Polya Steps for Middle School Students YALC Pasuruan. *Jurnal Edukasi Matematika Dan Sains)*, *10*(2), 353–363. https://doi.org/10.25273/jems.v10i2.13338

Fikri, M., Darmayanti, R., & Hussain, N. (2023). How applicable are the KuMo and FiC as teaching tools for mathematics content? *Assyfa Journal of Islamic Studies*, *1*(2).

Fjællingsdal, K. S., & Klöckner, C. A. (2020). Green Across the Board: Board Games as Tools for Dialogue and Simplified Environmental Communication. *Simulation and Gaming*, *51*(5). https://doi.org/10.1177/1046878120925133

Gulo, F. (2020). Tinjauan Teologis Model Pembelajaran Kooperatif Tipe TGT (Team Games Tournament) [A Theological Review of the TGT Type Cooperative Learning Model]. *Diligentia: Journal of Theology and Christian Education*, *2*(2). https://doi.org/10.19166/dil.v2i2.2048

Gündüz, A. Y., & Akkoyunlu, B. (2020). The gamification tool for the classroom response systems: Kahoot! *Hacettepe Egitim Dergisi*, *35*(3). https://doi.org/10.16986/HUJE.2019052870

Han, J., Seo, Y., Lee, C., & Han, D. H. (2018). Comparing the behavioral patterns and psychological characteristics of web board gamers and gamblers. *Psychiatry Investigation*, *15*(12). https://doi.org/10.30773/PI.2018.10.22.4

Hassinger-Das, B., Toub, T. S., Zosh, J. M., Michnick, J., Golinkoff, R., & Hirsh-Pasek, K. (2017). More than just fun: a place for games in playful learning / Más que diversión: el lugar de los juegos reglados en el aprendizaje lúdico. *Infancia y Aprendizaje*, *40*(2). https://doi.org/10.1080/02103702.2017.1292684

Hu, R., & Shang, J. (2018). Application of Gamification to Blended Learning in Elementary Math Instructional Design. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *10949 LNCS*. https://doi.org/10.1007/978-3-319-94505-7_7

Humaidi, N., Darmayanti, R., & Sugianto, R. (2022). Challenges of Muhammadiyah's Contribution in Handling Covid-19 in The MCCC Program in Indonesia. *Khazanah Sosial*, *4*(1), 176–186. https://doi.org/10.15575/ks.v4i1.17201

Hussain, N., & Xi, W. (2023). Islam and International Standards of Human Rights: An Analysis of Domestic Implementation of International Human Rights in Islamic Culture. *Assyfa Journal of Islamic Studies*, *1*(1), 1–12.

Inganah, S., Darmayanti, R., & Rizki, N. (2023). Problems, Solutions, and Expectations: 6C Integration of 21 st Century Education into Learning Mathematics. *JEMS (Journal of Mathematics and Science Education)*, *11*(1), 220–238. https://doi.org/10.25273/jems.v11i1.14646

Jamaluddin, M., & Faroh, N. (2020). Developing authentic assessment: Project assessment on mathematics learning evaluation by using e-learning. *Math Didactic: Jurnal Pendidikan Matematika*, *5*(3). https://doi.org/10.33654/math.v5i3.729

Kaddari, F., Ouahbi, I., & Darhmaoui, H. (2021). Gamification approach in teaching web programming courses in php: Use of kahoot application. *International Journal of Modern Education and Computer Science*, *13*(2). https://doi.org/10.5815/ijmecs.2021.02.04

Karim, S., & Zoker, E. M. (2023). Technology in Mathematics Teaching and Learning: An Impact Evaluation in Selected Senior Schools in Masingbi Town. *Assyfa Learning Journal*, *1*(2), 60–72.

Ke, F., & M. Clark, K. (2020). Game-Based Multimodal Representations and Mathematical Problem Solving. *International Journal of Science and Mathematics Education*, *18*(1). https://doi.org/10.1007/s10763-018-9938-3

Khoiriyah, B., Darmayanti, R., & & Astuti, D. (2022). Design for Development of Canva Application-Based Audio-Visual Teaching Materials on the Thematic Subject "Myself (Me and My New Friends)" Elementary School Students. *Jurnal Pendidikan Dan Konseling (JPDK)*, *4*(6), 6287–6295.

Kim, J. W., Wi, J. A., Jang, S. J., & Kim, Y. Bin. (2020). Sequential recommendations on board-game platforms. *Symmetry*, *12*(2). https://doi.org/10.3390/sym12020210

König, M., Ungerer, C., Baltes, G., & Terzidis, O. (2019). Different patterns in the evolution of digital and non-digital ventures' business models. *Technological Forecasting and Social Change*, *146*. https://doi.org/10.1016/j.techfore.2018.05.006

Lazarenko, V. A., Kalutskiy, P. V., Dremova, N. B., & Ovod, A. I. (2020). Adaptation of higher medical education to the conditions of digitalization of healthcare. *Vysshee Obrazovanie v Rossii*, *29*(1). https://doi.org/10.31992/0869-3617-2020-29-1-105-115

Leton, S. I., Wahyudin, & Darhim. (2019). Mathematical connection ability of deaf student in completing social arithmetic tests. *Journal of Physics: Conference Series*, *1280*(4). https://doi.org/10.1088/1742-6596/1280/4/042012

Lin, D. T. A., Ganapathy, M., & Kaur, M. (2018). Kahoot! It: Gamification in higher education. *Pertanika Journal of Social Sciences and Humanities*, *26*(1).

Liu, M. (2018). Gamification's impact on manufacturing: Enhancing job motivation, satisfaction and operational performance with smartphone-based gamified job design. *Human Factors and Ergonomics In Manufacturing*, *28*(1), 38–51. https://doi.org/10.1002/hfm.20723

Meirbekov, A., Maslova, I., & Gallyamova, Z. (2022). Digital education tools for critical thinking development. *Thinking Skills and Creativity*, *44*. https://doi.org/10.1016/j.tsc.2022.101023

Mercier, M., & Lubart, T. (2021). The effects of board games on creative potential. *Journal of Creative Behavior*, *55*(3). https://doi.org/10.1002/jocb.494

MM Effendi, Darmayanti, R., & In'am, A. (2022). Strengthening Student Concepts: Problem Ethnomatmatics Based Learning (PEBL) Singosari Kingdom Historical Site Viewed from Learning Styles in the Middle School Curriculum. *Indomath: Indonesia Mathematics Education*, *5*(2), 165–174. https://jurnal.ustjogja.ac.id/index.php/

Montiel, H., & Gomez-Zermeño, M. G. (2021). Educational challenges for computational thinking in k–12 education: A systematic literature review of "scratch" as an innovative programming tool. *Computers*, *10*(6). https://doi.org/10.3390/computers10060069

Morschheuser, B. (2018). How to design gamification? A method for engineering gamified software. *Information and Software Technology*, *95*, 219–237. https://doi.org/10.1016/j.infsof.2017.10.015

Mosalanejad, L., Abdollahifard, S., & Abdian, T. (2020). Psychiatry gamification from blended learning models and efficacy of this program on students. *Journal of Education and Health Promotion*, *9*(1). https://doi.org/10.4103/jehp.jehp_352_19

Nasiha, W., Afifah, N., & Amir, A. N. (2023). Design of a website-based arabic typing application for students of arabic language education program at university. *Assyfa Learning Journal*, *1*(1), 12–24.

Nelson, R., Marone, V., Garcia, S. A., Yuen, T. T., Bonner, E. P., & Browning, J. A. (2021). Transformative Practices in Engineering Education: The Embedded Expert Model. *IEEE Transactions on Education*, *64*(2). https://doi.org/10.1109/TE.2020.3026906

Palinussa, A. L., Molle, J. S., & Gaspersz, M. (2021). Realistic mathematics education: Mathematical reasoning and communication skills in rural contexts. *International Journal of Evaluation and Research in Education*, *10*(2). https://doi.org/10.11591/ijere.v10i2.20640

Qian, M., & Clark, K. R. (2016). Game-based Learning and 21st century skills: A review of recent research. *Computers in Human Behavior*, *63*. https://doi.org/10.1016/j.chb.2016.05.023

Rahman, M. A. (2023). Professional Development in an institution through GROW Model. *Assyfa Learning Journal*, *1*(2).

Sah RWA, Darmayanti, R., & Maryanto BPA. (2022). Updating Curriculum Through 21st-Century Learning Design. *Seminar Nasional Teknologi Pembelajaran*, *2*(1). http://snastep.um.ac.id/pub/index.php/proceeding/indexKeahliandanPerformaPakardalamTeknologiPendidikanuntuk

Santiago, P., Alves, F. R. V, & Darmayanti, R. (2023). GeoGebra in the light of the Semiotic Representation Registers Theory: an international Olympic didactic sequence. *Assyfa Learning Journal*, *1*(2), 73–90.

Schabas, A. (2023). Game-Based Science Learning: What are the Problems with Teachers Practicing It in Class? *Assyfa Learning Journal*, *1*(2).

Scott, D., Knowles, N. L. B., Ma, S., Rutty, M., & Steiger, R. (2022). Climate change and the future of the Olympic Winter Games: athlete and coach perspectives. *Current Issues in Tourism*. https://doi.org/10.1080/13683500.2021.2023480

Sugianto, R., Cholily, Y. M., Darmayanti, R., Rahmah, K., & Hasanah, N. (2022). Development of Rainbow Mathematics Card in TGT Learning Model for Increasing Mathematics Communication Ability. *Kreano: Jurnal Matematika Kreatif-Inovatif*, *13*(2), 221–234. http://journal.unnes.ac.id/nju/index.php/kreano

Sugianto, R., Darmayanti, R., Aprilani, D., Amany, L., Rachmawati, L. N., Hasanah, S. N., & Aji, F. B. (2017). Experiment on Ability to Understand Three-Dimensional Material Concepts Related to Learning Styles Using the Geogebra-Supported STAD Learning Model Abstra ct. *Al-Jabar: Jurnal Pendidikan Matematika*, *8*(2), 205–212.

Sugianto, R., Darmayanti, R., Vidyastuti, A. N., Matematika, M. P., Muhammadiyah, U., Jalan, M., & Tlogomas, R. (2022). Stage of Cognitive Mathematics Students Development Based on Piaget's Theory Reviewing from Personality Type. *Plusminus: Jurnal Pendidikan Matematika*, *2*(1), 17–26.

Sugianto, R., & Khan, S. (2023). MONICA-DANCE: Development of Monopoly Media Based on Traditional Indigenous Dances on High School Students' Mathematical Critical Thinking Ability. *Assyfa Learning Journal*, *1*(2).

Syaifuddin, M., Darmayanti, R., & Rizki, N. (2022). Development of a Two-Tier Multiple-Choice (TTMC) Diagnostic Test for Geometry Materials to Identify Misconceptions of Middle School Students. *JURNAL SILOGISME : Kajian Ilmu Matematika Dan Pembelajarannya*, *7*(2), 66–76. http://journal.umpo.ac.id/index.php/silogisme

Tong, D. H., Nguyen, T. T., Uyen, B. P., Ngan, L. K., Khanh, L. T., & Tinh, P. T. (2022). Realistic Mathematics Education's Effect on Students' Performance and Attitudes: A Case of Ellipse Topics Learning. *European Journal of Educational Research*, *11*(1). https://doi.org/10.12973/eu-jer.11.1.403

Tsai, J. C., Chen, S. Y., Chang, C. Y., & Liu, S. Y. (2020). Element enterprise tycoon: Playing board games to learn chemistry in daily life. *Education Sciences*, *10*(3). https://doi.org/10.3390/educsci10030048

Tsai, J. C., Cheng, P. H., Liu, S. Y., & Chang, C. Y. (2019). Using board games to teach socioscientific issues on biological conservation and economic development in Taiwan. *Journal of Baltic Science Education*, *18*(4). https://doi.org/10.33225/jbse/19.18.634

Valiero, E. A. (2020). Algebra vs arithmetic. A didactic proposal that allows the problematized construction of a mathematical space of constructivist work in the classroom. *Educacion Matematica*, *32*(1). https://doi.org/10.24844/EM3201.08

Wen, J. M., Do, H. D., Liu, E. Z. F., Lin, C. H., & Huang, S. K. (2020). Educational board game and flashcard: Which one is better for learners at beginner level of Chinese language? *International Journal of Serious Games*, *7*(4). https://doi.org/10.17083/ijsg.v7i4.347

Whitton, N., & Langan, M. (2019). Fun and games in higher education: an analysis of UK student perspectives. *Teaching in Higher Education*, *24*(8). https://doi.org/10.1080/13562517.2018.1541885

Winson, V. R. V, Arunkumar, V., & Rao, D. P. (2023). Exploring the Landscape of Teaching and Learning English as a Second Language in India. *Assyfa Learning Journal*, *1*(2).

Wu, B., Chen, H., & Luo, Z. (2021). Board games for quantum computers. *Science China Information Sciences*, *64*(2). https://doi.org/10.1007/s11432-020-3038-x

Zirawaga, V., Olusanya, A., & Maduki, T. (2017). Gaming in education: Using games a support tool to teach History. *Journal of Education and Practice*, *8*(15), 55–64. https://files.eric.ed.gov/fulltext/EJ1143830.pdf

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