desenvolvimento curricular e didática

Conferência Internacional Joga-Mate

Indagatio Didactica, vol. 17 (1), junho 2025
https://doi.org/10.34624/id.v17i1.40273

ISSN: 1647-3582

The Use of Games in Mathematics Learning: An Experience with Primary School Teachers

O Uso de Jogos na Aprendizagem da Matemática: Uma Experiência com Professores do Ensino Básico

El Uso de Juegos en el Aprendizaje de las Matemáticas: Una Experiencia con Profesores de Educación Primaria

Andreia Hall
CIDMA, Centro de Investigação e Desenvolvimento em Matemática e Aplicações, Universidade de Aveiro
andreia.hall@ua.pt
https://orcid.org/0000-0001-8759-7927

Nuno Bastos
Instituto Politécnico de Viseu
CIDMA, Centro de Investigação e Desenvolvimento em Matemática e Aplicações, Universidade de Aveiro
nbastos@estgv.ipv.pt
https://orcid.org/0000-0003-1533-1075

Sónia Pais
CITUR, Centro de Investigação em Turismo, Instituto Politécnico de Leiria
CIDMA, Centro de Investigação e Desenvolvimento em Matemática e Aplicações, Universidade de Aveiro
sonia.i.pais@ipleiria.pt
https://orcid.org/0000-0003-2834-2267

Paola Morando
DISAA, Università degli Studi di Milano, Milano, Italy
paola.morando@unimi.it
https://orcid.org/0000-0002-1284-3932

Maria Luisa Sonia Spreafico
DISAA, Università degli Studi di Milano, Milano, Italy
maria.spreafico@unimi.it
https://orcid.org/0000-0001-5787-4057

Abstract

This article presents a workshop aimed at teachers from the 1st to 6th grades on the use of games as a pedagogical strategy for teaching mathematics. The workshop, part of the Mathematics in the Early Years 2024 conference, included the exploration of five educational games – Euclid's

Indagatio Didactica, vol. 17 (1), junho 2025
https://doi.org/10.34624/id.v17i1.40273

ISSN: 1647-3582

Regatta, Garden Animals, Monster Samples, Islands Game, and Mathematical Twins – each one designed to address different mathematical topics, such as Euclidean geometry, descriptive statistics, rational numbers, and mathematical communication.
The playful approach adopted aimed to promote the understanding of mathematical concepts through experimentation and interaction, emphasizing the importance of concrete manipulation and mathematical communication in the learning process. One of the highlights was the use of origami to explore geometric axioms, allowing for mathematical constructions as alternatives to those performed with a ruler and compass.
To assess participants' perceptions of the use of gamification in the teaching-learning process of mathematics, a questionnaire was conducted. The results indicate that teachers recognize the potential of games in motivating students, as well as in engaging them in the teaching-learning process, contributing to better academic performance. Additionally, they suggest that participants intend to incorporate this resource into their teaching practices.
The experience reinforces the need to integrate interactive approaches in education, highlighting the applicability of educational games as effective tools for improving student engagement and performance in mathematics.

Keywords: mathematical games; mathematics education; playful learning; gamification.

Resumo

Este artigo apresenta um workshop direcionado a professores do 1º e 2º Ciclo do Ensino Básico sobre o uso de jogos como estratégia pedagógica para o ensino da matemática. O workshop, enquadrado no Encontro Matemática nos Primeiros Anos 2024, incluiu a exploração de cinco jogos educativos – Regata de Euclides, Animais da Horta, Amostras de Monstros, Jogo das Ilhas e Gémeos Matemáticos – cada um concebido para abordar diferentes tópicos matemáticos, tais como geometria euclidiana, estatística descritiva, números racionais e comunicação matemática.
A abordagem lúdica adotada visou promover a compreensão de conceitos matemáticos através da experimentação e interação, enfatizando a importância da manipulação concreta e da comunicação matemática no processo de aprendizagem. Um dos destaques foi o uso do origami para explorar os axiomas da geometria, permitindo construções matemáticas alternativas às realizadas com régua e compasso.
Para avaliar a perceção dos participantes do workshop sobre a utilização da gamificação no processo de ensino-aprendizagem da matemática, foi realizado um questionário. Os resultados desse questionário indicam que os professores reconhecem o potencial dos jogos na motivação dos alunos, bem como no seu envolvimento no processo de ensino-aprendizagem, contribuindo para que obtenham melhores resultados. Indicam, também, que os participantes tencionam incorporar este recurso nas suas práticas pedagógicas
A experiência reforça a necessidade de integrar abordagens interativas no ensino, destacando a aplicabilidade dos jogos educativos como ferramentas eficazes para melhorar o envolvimento e o desempenho dos alunos em matemática.

Palavras-chave: jogos matemáticos; educação matemática; aprendizagem lúdica; gamificação.

Resumen

Este artículo presenta un taller dirigido a profesores de 1.º a 6.º grado sobre el uso de juegos como estrategia pedagógica para la enseñanza de las matemáticas. El taller, enmarcado en el

desenvolvimento curricular e didática

Conferência Internacional Joga-Mate

Indagatio Didactica, vol. 17 (1), junho 2025 ISSN: 1647-3582
https://doi.org/10.34624/id.v17i1.40273

encuentro Matemáticas en los Primeros Años 2024, incluyó la exploración de cinco juegos educativos – Regata de Euclides, Animales del Huerto, Muestras de Monstruos, Juego de las Islas y Gemelos Matemáticos – cada uno diseñado para abordar diferentes temas matemáticos, tales como geometría euclidiana, estadística descriptiva, números racionales y comunicación matemática. El enfoque lúdico adoptado buscó promover la comprensión de los conceptos matemáticos a través de la experimentación y la interacción, enfatizando la importancia de la manipulación concreta y la comunicación matemática en el proceso de aprendizaje. Uno de los aspectos más destacados fue el uso del origami para explorar los axiomas de la geometría, permitiendo construcciones matemáticas alternativas a las realizadas con regla y compás.
Para evaluar la percepción de los participantes del taller sobre el uso de la gamificación en el proceso de enseñanza-aprendizaje de las matemáticas, se realizó un cuestionario. Los resultados indican que los docentes reconocen el potencial de los juegos para motivar a los estudiantes, así como para involucrarlos en el proceso de enseñanza-aprendizaje, lo que contribuye a mejorar su rendimiento académico. Además, señalan que los participantes tienen la intención de incorporar este recurso en sus prácticas pedagógicas.
La experiencia refuerza la necesidad de integrar enfoques interactivos en la enseñanza, destacando la aplicabilidad de los juegos educativos como herramientas eficaces para mejorar la participación y el desempeño de los estudiantes en matemáticas.

Palabras clave: juegos matemáticos; educación matemática; aprendizaje lúdico; gamificación.

Introduction

The integration of games into mathematics education has gained increasing attention as a means of enhancing student engagement and learning outcomes. Playful learning environments provide opportunities for students to explore mathematical concepts through interaction and experimentation, fostering a deeper understanding of abstract ideas. The workshop presented in this study, conducted as part of the Mathematics in the Early Years 2024 conference, focused on the use of educational games as a pedagogical strategy for teaching mathematics to students from the 1st to 6th grades.

Throughout the workshop, participants engaged with five distinct games—Euclid's Regatta, Garden Animals, Monster Samples, Azores Islands Game, and Mathematical Twins—each designed to address different mathematical domains, including geometry, mathematical axioms, statistics, and fractions. The hands-on approach emphasised the importance of concrete manipulation and mathematical communication, allowing teachers to experience first-hand the potential of games in fostering conceptual understanding.

A particularly noteworthy aspect of the workshop was the incorporation of origami as a tool for exploring geometric axioms. By constructing mathematical figures through folding rather than using traditional ruler-and-compass methods, participants gained insights into alternative methods of mathematical construction, further reinforcing the versatility of games in mathematics education.

To assess the impact of gamification in the teaching-learning process, a questionnaire was administered to participating teachers. The findings highlight the positive perception of educational games, with teachers recognising their role in motivating students and enhancing engagement,

Indagatio Didactica, vol. 17 (1), junho 2025
https://doi.org/10.34624/id.v17i1.40273

ISSN: 1647-3582

ultimately contributing to improved academic performance. Moreover, the results indicate a strong willingness among educators to integrate games into their teaching practices, underscoring the growing recognition of gamification as an effective approach to mathematics instruction.

This paper discusses the role of gamification in mathematics education, exploring its benefits and implications for fostering engagement, motivation, and conceptual understanding among students.

This study aims to understand how pre-service and in-service teachers from the 1st to 6th grades perceive the use of non-digital games as educational tools for teaching and learning mathematics.

Gamification and Its Benefits in Mathematics Education

Gamification, defined as the application of game-like elements in non-game contexts (Kapp, 2012), has emerged as a powerful educational strategy aimed at enhancing student motivation and learning experiences (Kapp, 2012; Morando and Turconi, 2022; Pais and Hall, 2021). In the context of mathematics education, gamification leverages elements such as challenge, competition, rewards, and interactivity to make learning more engaging and effective (Hall et al, 2024; González-Cutre et al, 2016).

One of the primary benefits of gamification is its ability to increase student motivation (Hall et al, 2024; Morando and Turconi, 2022; Pais and Hall, 2021; Ryan and Deci, 2017). Traditional mathematics instruction often struggles to maintain student interest, particularly when abstract concepts are introduced without meaningful context. Games provide a dynamic and interactive environment that encourages students to actively participate in problem-solving, fostering a sense of achievement and progression. By incorporating elements such as points, badges, and leaderboards, gamification introduces an extrinsic motivational component, which, when combined with intrinsic motivation, can significantly enhance students' willingness to engage with mathematical content (Hall et al, 2024).

Additionally, gamification supports the development of critical thinking and problem-solving skills (Hamari et al., 2014; Kapp, 2012). Many mathematical games require players to strategize, analyse patterns, and apply logical reasoning to achieve objectives. Through repeated exposure to such activities, students develop cognitive skills that are transferable to a wide range of mathematical and real-world situations.

Another significant advantage of gamification is its role in fostering collaboration and communication among students (Ramos, Knaul, & Rocha, 2020). Many educational games involve teamwork and cooperative problem-solving, allowing students to discuss mathematical concepts, share strategies, and learn from one another. This social aspect of learning not only enhances comprehension but also promotes a positive attitude towards mathematics, reducing anxiety and increasing confidence in mathematical abilities.

Moreover, gamification provides immediate feedback, which is crucial for effective learning. Unlike traditional assessment methods, where students often receive delayed feedback, games offer real-time responses that enable learners to identify mistakes and adjust their approach accordingly.

Indagatio Didactica, vol. 17 (1), junho 2025
https://doi.org/10.34624/id.v17i1.40273

ISSN: 1647-3582

This continuous feedback loop enhances the learning process, reinforcing understanding and retention of mathematical concepts.

The integration of games in mathematics education also aligns with constructivist learning theories (Liat & Hayak, 2024), which emphasise active engagement and discovery-based learning. By allowing students to explore mathematical ideas through play, gamification facilitates deeper conceptual understanding and promotes long-term knowledge retention.

Therefore, gamification represents a valuable approach to mathematics education, offering numerous benefits ranging from increased motivation and engagement to improved problem-solving skills and collaboration. The findings from this study reinforce the effectiveness of games as pedagogical tools, highlighting their potential to transform the teaching and learning of mathematics. As educational research continues to explore innovative methodologies, gamification remains a promising strategy for making mathematics more accessible, enjoyable, and meaningful for students.

Methodology

A workshop was organized in which participants had the opportunity to explore five non-digital games.

Inquiry techniques and direct observation, were used, employing the following instruments: field notes and questionnaire. During the task implementation, the teachers adopted the participant observation technique. The questionnaire was filled out on Google Forms. The questionnaire included lists of statements and respondents were asked to rate their level of agreement using a 5-point agreement (Likert) scale.

The analysis of the results was based on observations of participants' performance and feedback collected through a questionnaire completed at the end of the activity.

Workshop Description

The workshop, entitled "Engaging and Effective: Using Games to Learn Mathematics," was held as part of the Mathematics in the Early Years 2024 conference, organized by the Associação de Professores de Matemática (APM). The event took place in November 2024 in Viseu, bringing together educators, researchers, and mathematics enthusiasts to explore innovative teaching strategies.

This two-and-a-half-hour interactive workshop engaged both pre-service and in-service teachers spanning the 1st to 6th grade levels. The primary objectives of the workshop were twofold: first, to provide participants with a thorough comprehension of the pedagogical affordances of non-digital games within mathematics education; and second, to equip them with pragmatic, low-cost game concepts readily applicable in their classroom settings.

The workshop began with an introductory discussion on the cognitive and social benefits of game-based learning in childhood, emphasizing how structured play can enhance mathematical reasoning, problem-solving skills, and student engagement.

Indagatio Didactica, vol. 17 (1), junho 2025
https://doi.org/10.34624/id.v17i1.40273

ISSN: 1647-3582

Following this, the workshop shifted to a hands-on approach, where attendees had the opportunity to play and analyze a selection of carefully designed math games. These games were chosen for their adaptability across various mathematical topics—such as number sense, arithmetic operations, geometry, and logical thinking—making them versatile tools for different grade levels and curricula. A key feature of these activities was their reliance on inexpensive and accessible materials, such as dice, cards, paper, and everyday classroom objects, ensuring that teachers could replicate them without significant financial investment.

Throughout the workshop, participants engaged in collaborative reflection, sharing insights on how to modify the games for diverse learning needs and classroom settings. The workshop also addressed assessment strategies, discussing how gameplay can serve as a formative assessment tool to monitor student progress informally. To conclude, participants completed an anonymous opinion survey.

The games played

This section provides a concise overview of the pedagogical games utilized during the workshop. Developed by the authors of this paper, one game was specifically adapted for the Azorean context. It is pertinent to note that the final two authors possess substantial expertise in the design of mathematical games, as evidenced in prior publications (La Fortuna, Morando & Spreafico, 2022; Morando & Spreafico, 2023; Morando & Turconi, 2022). The described games are readily reproducible and primarily necessitate common materials such as paper and timers.

Euclid's Regatta

Euclid's Regatta is an innovative and interactive educational game designed to help students grasp fundamental concepts of plane geometry and point location in a dynamic and engaging manner. By merging physical activity with mathematical reasoning, the game transforms abstract geometric principles into a hands-on experience, making learning both tangible and enjoyable. Structured around a series of challenges, the game requires players to navigate a small boat across a game board using only their breath while adhering to specific geometric constraints. This approach not only reinforces geometric understanding but also promotes teamwork, precision, and strategic thinking.

The game is played by two teams, each consisting of three to four players. Each team is provided with a small boat, a stopwatch, cotton threads (representing lines and segments), buttons (acting as points), and adhesive putty (to secure the game elements). The playing surface is configured differently for each of the five challenges, each focusing on key geometric concepts such as perpendicular and parallel lines, angles, line segments, and reflections. The boats begin at a designated starting point, and the team that rolls the highest number on a dice takes the first turn. For subsequent challenges, the team that lost the previous round starts, ensuring fairness and maintaining engagement. In the event of a tie, the dice are rolled again to determine the starting team.

Indagatio Didactica, vol. 17 (1), junho 2025
https://doi.org/10.34624/id.v17i1.40273

ISSN: 1647-3582

During their turn, players must blow on their boat to guide it toward the target position specified by the challenge. The use of breath as the sole means of propulsion introduces a physical skill component, requiring players to carefully control their force and direction. A stopwatch records the time taken to complete each challenge, and the clock stops when a team declares that their boat is correctly positioned. The opposing team then verifies the placement. For the position to be valid, at least one point of the boat's triangular prow must lie precisely on the designated geometric locus. If the placement is incorrect, the team incurs a 30-second penalty, and the boat is reset to its original position. Additional penalties are applied if the boat falls off the table, reinforcing the need for precision and control.

The competitive framework of Euclid's Regatta offers two scoring strategies. The first awards one point to the team with the fastest correct placement in each challenge, with the overall winner being the team that accumulates the most points. The second strategy, which the game adopts, sums the total time taken by each team across all challenges, with the team having the lowest cumulative time declared the winner. This approach encourages teams to balance speed and accuracy consistently, ensuring that performance in every challenge contributes to the outcome.

The five challenges are thoughtfully structured to address fundamental geometric concepts. The initial task necessitates that participants orient the boat's bow along a line perpendicular to a designated segment [AB] and intersecting an external point P (a potential initial configuration is illustrated in Figure 1). This exercise reinforces the principle of perpendicularity and the geometric construction of perpendicular lines. The subsequent challenge transitions to the concept of parallelism, requiring the boat to be positioned on a line parallel to [AB] and passing through P. These introductory challenges serve to establish a foundational understanding of the relationships between lines and points within a two-dimensional plane.

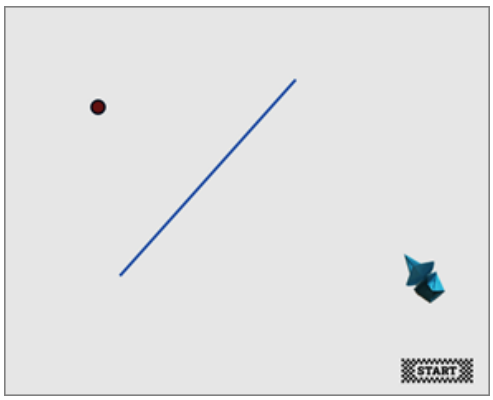

Figure 1. A possible initial layout for the first challenge.

The third challenge introduces angles by presenting four rays emanating from a common origin. Players must navigate the boat to the right angle among them, reinforcing angle recognition and measurement. The fourth challenge simplifies the task by requiring the boat to be placed on the line AB but outside the segment [AB], emphasizing the distinction between infinite lines and finite

Indagatio Didactica, vol. 17 (1), junho 2025
https://doi.org/10.34624/id.v17i1.40273

ISSN: 1647-3582

segments. The final and most complex challenge involves reflection: players must position the boat's prow at the reflection of a given triangle over an external line. This integrates spatial reasoning and transformational geometry, requiring players to visualize and execute a geometric reflection.

Beyond its application in geometry, Euclid's Regatta is highly adaptable to other subjects, demonstrating its versatility as a pedagogical tool. For example, a history-themed adaptation could involve placing the boat on dates or time intervals corresponding to historical events drawn from a deck of cards. This flexibility highlights the game's potential to enhance learning across disciplines by combining physical interaction with academic content.

The game's design aligns with constructivist learning theories, which emphasize active engagement and hands-on experience as pathways to deeper understanding. By physically manipulating the boat and observing geometric relationships in real time, students internalize abstract concepts more effectively than through passive instruction. The collaborative nature of the game also fosters social learning, as players discuss strategies, verify solutions, and learn from mistakes collectively.

In conclusion, Euclid's Regatta is a multifaceted educational tool that successfully bridges the gap between theoretical geometry and practical application. Its combination of physical activity, teamwork, and geometric problem-solving creates a dynamic learning environment that is both challenging and enjoyable. The game's adaptability extends its utility beyond mathematics, making it a valuable resource for educators seeking innovative ways to engage students across various subjects. By transforming geometric principles into a competitive and interactive format, Euclid's Regatta not only enhances students' understanding of plane geometry but also cultivates essential skills such as precision, collaboration, and critical thinking.

Garden Animals

The game Garden Animals is a strategic and engaging card game designed for two teams, each consisting of two to four players. The gameplay revolves around quick thinking, logical reasoning, and teamwork, as players must analyse patterns and verify conditions under time constraints. The materials required for the game include a deck of 40 animal cards, each depicting a specific number of ladybugs, caterpillars, snails, and bees. Figure 2 (left) shows one of the animal cards. Additionally, there is a separate deck of 36 condition cards, which present specific logical or mathematical challenges, such as determining whether there are more ladybugs than caterpillars or whether the sum of bees and caterpillars is an even number. The game also incorporates a one-minute hourglass to limit each turn and beans or penalty cards to track infractions.

At the beginning of the game, four animal cards are placed face-up on the table, visible to allplayers. Teams take turns drawing a condition card from the deck, and within the strict one-minute time limit, they must assess whether any of the exposed animal cards meet the specified condition. If a card satisfies the condition, the team collects it as a point. However, if none of the cards fulfil the requirement, the team must declare this, and they are then allowed to draw another condition card for a new attempt. The time pressure adds a layer of intensity to the game, requiring players to think swiftly and accurately to maximize their score. Figure 2 (right) shows two teams playing the game.

Indagatio Didactica, vol. 17 (1), junho 2025
https://doi.org/10.34624/id.v17i1.40273

ISSN: 1647-3582

Figure 2. A card example (left) and participants playing the Garden Animals game (right).

A critical aspect of Garden Animals is the verification process, which ensures fairness and penalizes errors. Whenever a team collects a card, the opposing team must confirm that the card indeed meets the condition. If the collecting team has made a mistake, they incur a penalty in the form of a bean or penalty card and must return the incorrectly claimed card to the table. Similarly, if a team asserts that no cards satisfy the condition, the opposing team has the right to verify this claim. If the assertion is incorrect, the team that made the error suffers a one-point penalty and loses its turn. These rules encourage players to be meticulous in their evaluations and foster a competitive yet fair environment.

The game continues until all condition cards have been played or a predetermined number of rounds have been completed. The team with the highest number of correctly collected animal cards at the end of the game is declared the winner. Garden Animals is not only entertaining but also educational, as it enhances players' abilities in pattern recognition, arithmetic, and logical deduction. The combination of time pressure and collaborative problem-solving makes it an excellent tool for developing cognitive skills in a playful setting. Its structured yet dynamic nature ensures that each round is unique, offering endless replayability and opportunities for strategic refinement. Overall, Garden Animals stands out as a thoughtfully designed game that balances fun with intellectual challenge, making it suitable for players of various ages and skill levels.

Monster Samples

The "Monster Samples" game is a pedagogical activity designed to engage students in the practical application of descriptive statistics, particularly focusing on the concepts of mean and median. It utilizes a playful and interactive format to deepen students' understanding of statistical measures through hands-on experience. In this game, each team, composed of three to four students, is provided with a deck of 20 monster cards, each presumably representing a fictional creature with specific quantifiable characteristics—such as number of eyes, colour, or size. Additionally, a separate deck of 36 sample instruction cards is used by the teacher to guide the activity.

Indagatio Didactica, vol. 17 (1), junho 2025
https://doi.org/10.34624/id.v17i1.40273

ISSN: 1647-3582

The game begins with each team being asked to eliminate five of their monster cards, which introduces an immediate strategic element. This choice is far from arbitrary; it can significantly influence the team's ability to complete future tasks. For instance, discarding all monsters of a certain colour or those with extreme values (such as a very high number of eyes) may later hinder the team's capacity to construct a valid sample that meets a specific statistical requirement. This early decision introduces the concept of variability and its implications for sampling, laying a foundation for understanding sample bias and the importance of maintaining diversity in a dataset.

During each round, the teacher draws a sample instruction card and reads it aloud. These instructions might specify, for example, that the sample must have a mean number of eyes equal to a certain value or include a particular median colour or attribute. Teams must then quickly select a subset of their remaining 15 cards that matches the criteria. The first team to declare a completed sample has their selection evaluated; if it is correct, they gain a point. If it is incorrect, they are penalized and another team may attempt to construct a correct sample, introducing a competitive yet collaborative dynamic to the game. Figure 3 shows two teams playing the game.

What makes this game particularly effective from an educational standpoint is its reversal of the typical statistical process. Diverging from standard practice, which involves the computation of measures such as the mean or median from a provided dataset, this game requires students to generate datasets that satisfy predetermined statistical values. This reversal necessitates a more profound engagement with the interplay between individual data elements and aggregate statistical properties. Consequently, students develop a more robust conceptual understanding of the mean and median, alongside fostering adaptable thinking regarding data selection to achieve specific outcomes. After several rounds, the game concludes and the team with the most points is declared the winner.

Figure 3. Participants playing the Monster Samples game

Indagatio Didactica, vol. 17 (1), junho 2025
https://doi.org/10.34624/id.v17i1.40273

ISSN: 1647-3582

However, the true value of the game lies not in the competition but in the opportunity it provides for post-game reflection. Teachers are encouraged to facilitate discussions about the initial choices of discarded cards and how this impacted gameplay, thereby reinforcing lessons about data variability and strategic decision-making in statistics. The game offers a rich, student-centred approach to learning, blending mathematical rigor with imaginative play.

Azores Islands Game

The Azores Islands Game is an innovative pedagogical tool that merges geographical knowledge, arithmetic proficiency, and strategic decision-making within a competitive, rule-based framework. Designed for four teams of one or two players each, the game simulates navigation across the Azores archipelago, requiring participants to collect points from each of the nine islands while adhering to mathematical and spatial constraints. The game's materials—a map of the Azores, four paper boats (one per team), two ten-sided dice (or digital alternatives), a one-minute hourglass, and nine numbered towers paired with point markers—are deliberately simple, ensuring accessibility while emphasizing cognitive engagement over complex components.

Gameplay begins with each team selecting an initial island, placing their boat, and collecting the associated point. The core mechanic revolves around turn-based dice rolls, where teams must compute the four fundamental arithmetic operations—addition, subtraction, multiplication, and division—using the two rolled numbers. These results are then cross-referenced with the numbered towers on unoccupied islands. If a match is found, the team may relocate their boat to that island and claim its point, provided the move is completed within the one-minute time constraint. This mechanic not only reinforces mental arithmetic skills but also introduces an element of time pressure, demanding quick and accurate calculations under limited cognitive bandwidth. Figure 4 shows the game being played using digital dices available through https://polypad.amplify.com/p.

Figure 4. Photo of participants playing the Azores Islands game.

Indagatio Didactica, vol. 17 (1), junho 2025
https://doi.org/10.34624/id.v17i1.40273

ISSN: 1647-3582

Strategic depth is embedded in several key rules, which elevate the game beyond a mere arithmetic exercise. Teams are compelled to move each turn unless no valid destinations exist—that is, if none of their calculated results correspond to numbers on unoccupied islands. Furthermore, revisiting an island does not yield additional points, incentivizing efficient pathfinding and discouraging redundant travel. A particularly noteworthy restriction prohibits direct movement between the western and eastern island groups, mirroring the real-world geographical division of the Azores. This rule compels players to consider archipelago topology when planning routes, adding a layer of logistical complexity that enhances the game's educational value by integrating spatial reasoning with mathematical logic.

The interplay of problem-solving, spatial reasoning, and competitive dynamics renders the Azores Islands Game a compelling interdisciplinary exercise. Beyond its immediate function as a recreational activity, the game serves as an effective means of reinforcing arithmetic fluency, collaborative teamwork, and strategic foresight. Its adaptability ensures high replicability, as the stochastic nature of dice rolls, and the evolving occupancy of islands generate unique scenarios in each session. By embedding academic content within an interactive and engaging format, the game exemplifies how play can be harnessed as a powerful medium for experiential learning. This duality of purpose—combining education with entertainment—makes it equally suitable for structured classroom instruction or informal educational settings, offering a model for how games can bridge the gap between theory and practice in pedagogy.

Math Twins

The Math Twing game is an innovative educational tool designed to strengthen mathematical comprehension, particularly in fractions, through interactive card-based gameplay. During the workshop, participants engaged in the team-based variation of this activity, which proved particularly effective for fostering collaborative learning. This format, designed for multiple competing groups, showcases the game's adaptability to different educational contexts while maintaining its core pedagogical value. Alternative approaches to gameplay exist to accommodate varying group sizes and learning objectives, each preserving the fundamental matching mechanic that reinforces conceptual understanding through symbolic and visual representation.

In the team-based variation played during the session, participants were divided into groups, each provided with a complete deck of cards arranged face-up on a table. The activity challenged teams to identify matching pairs within a constrained timeframe, with each correct pair consisting of a mathematical expression (such as a fraction or arithmetic operation) paired with its corresponding pictorial depiction. Figure 5 shows four players playing the game. This structure created a dynamic learning environment where participants needed to employ strategic thinking, effective communication, and collaborative problem-solving to maximize their matching efficiency. The competitive framework served as a motivational element, while the requirement to verify matches with opposing teams introduced an additional layer of peer assessment and conceptual reinforcement.

Indagatio Didactica, vol. 17 (1), junho 2025
https://doi.org/10.34624/id.v17i1.40273

ISSN: 1647-3582

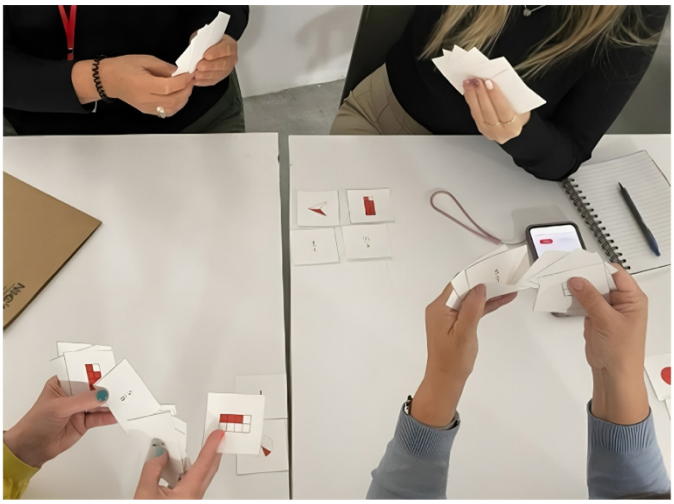

Figure 5. Photo of participants playing the Math Twins game.

For teachers working with smaller groups, the game can be restructured as a circular activity where participants individually manage their card collections while selectively acquiring cards from neighbours. This version emphasizes memory skills and strategic planning as players must track card locations while optimizing their own matching opportunities. In whole-class settings, the game transforms into a movement-based exercise where each student receives a single card and must non-verbally locate their corresponding partner within the room. This variation promotes spatial reasoning and observational skills while ensuring full class participation.

The workshop's team-based approach effectively demonstrated how structured competition can enhance mathematical learning. Participants benefited from the immediate feedback inherent in the matching process, where successful pairings confirmed understanding while mismatches prompted reassessment. The inclusion of visual representations alongside symbolic expressions helped bridge abstract concepts with concrete understanding, particularly valuable for learners who benefit from multimodal instruction. Educators can further customize the game's difficulty by adjusting the complexity of the mathematical content or by introducing additional constraints, such as limiting verbal communication during team play.

What distinguishes this game as particularly valuable is its dual focus on procedural fluency and conceptual understanding within an engaging, interactive framework. The team variation showcased in the workshop exemplifies how game mechanics can transform mathematical practice into a socially constructed learning experience. Whether implemented as a competitive team challenge, a strategic small-group activity, or a whole-class movement exercise, the game maintains its effectiveness in reinforcing mathematical concepts through active participation and peer interaction. This adaptability makes it a versatile tool for educators seeking to enhance engagement while addressing diverse learning needs within mathematics instruction.

Indagatio Didactica, vol. 17 (1), junho 2025
https://doi.org/10.34624/id.v17i1.40273

ISSN: 1647-3582

Results and Discussion

This study aims to understand how pre-service and in-service teachers from the 1st to 6th grades perceive the use of non-digital games as educational tools for teaching and learning mathematics.

As previously mentioned, to assess participants' perceptions of the use of gamification in the teaching-learning process of mathematics, a questionnaire was conducted at the end of the workshop using Google Forms.

A total of 18 participants responded, including 12 in-service teachers and 6 pre-service teachers. Figure 6 illustrates the distribution of participants. Among the 12 in-service teachers, 4 had less than 5 years of teaching experience, while the remaining 8 had over 20 years of experience.

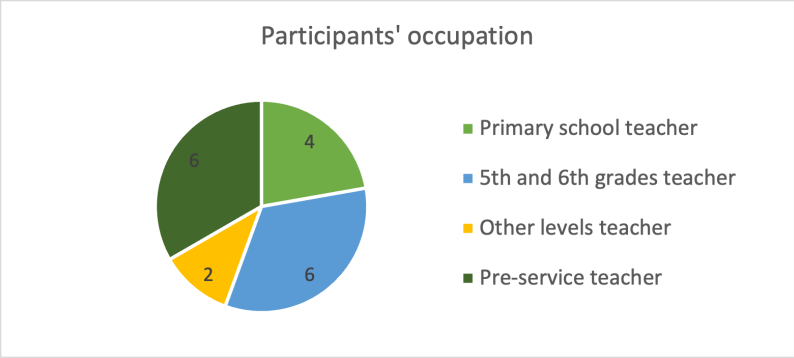

Figure 6. Pie-chart of participants' occupation.

Participants were asked to rate their overall evaluation of the workshop using a 5-point Likert scale. The results, displayed in Figure 7, indicate that all responses were positive, with 78% of participants rating the workshop as 'Very good' and 22% as 'Good.' Notably, no participants selected the 'Neutral,' 'Bad,' or 'Very Bad' options, suggesting a strong overall satisfaction with the workshop.

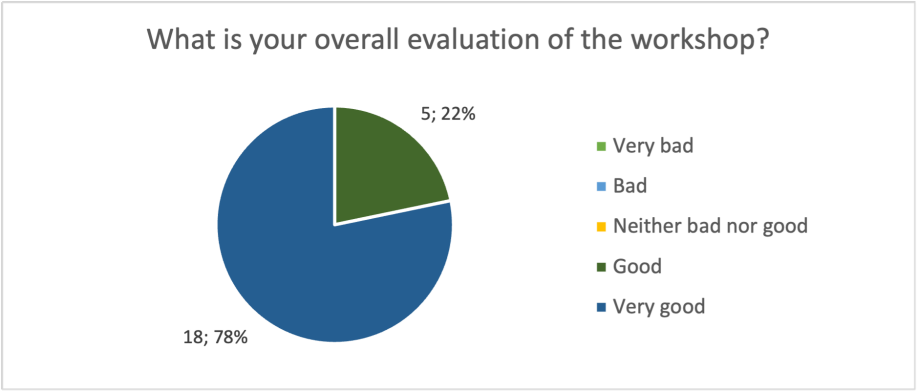

Figure 7. Frequency graph of responses to the overall evaluation.

Indagatio Didactica, vol. 17 (1), junho 2025
https://doi.org/10.34624/id.v17i1.40273

ISSN: 1647-3582

Figure 8 presents participants' evaluations of the workshop in more detail through their agreement with three statements using a 5-point Likert scale (1 – total disagreement; 5 – total agreement). The responses were summarized in a heatmap and highlight their perceptions of the workshop relevance, alignment with expectations, and the level of engagement provided by the activities. The results indicate a predominantly positive assessment, with mean scores above 4.5 for all statements, demonstrating that participants found the workshop valuable and meaningful.

How do you globally evaluate the workshop in the following aspects:	1	2	3	4	5	mean	std. dev.
the topic addressed is relevant	0	1	0	1	16	4,78	0,54
it met my expectations	0	1	1	4	12	4,50	0,74
the activities were interesting	0	1	1	2	14	4,61	0,72

Figure 8. Heatmap of responses to the second set of statements.

The highest-rated aspect was the relevance of the topic, with a mean score of 4.78. This suggests that participants acknowledge the importance of exploring gamification as a teaching strategy and recognize its applicability in mathematics education. Additionally, the majority of participants indicated that the activities were interesting (mean: 4.61), further emphasizing the effectiveness of the hands-on approach used during the workshop.

The statement "it met my expectations" received a slightly lower mean score (4.50) and a higher standard deviation (0.74), indicating a minor divergence in opinions.

While all participants found the workshop good or very good, a small number may have had different expectations regarding its structure, content depth, or applicability to their specific teaching contexts.

Participants were asked to rate their agreement with two a set of statements using a 5-point Likert scale (1 – total disagreement; 5 – total agreement). The results are summarized in the heatmap in Figure 9, along with the mean and standard deviation of the responses.

The use of gamification in the mathematics teaching-learning process:	1	2	3	4	5	mean	std. dev.
is important	0	0	0	1	16	4,94	0,06
has helped students recognize the importance of mathematics	0	0	0	1	16	4,94	0,06
provides a more interesting learning method	0	0	0	1	16	4,94	0,06
makes lessons more engaging	0	0	0	1	16	4,94	0,06
has contributed to a more positive view of mathematics	0	0	0	1	16	4,94	0,06
involves students in the learning process	0	0	0	1	16	4,94	0,06
increases students' motivation	0	0	0	1	16	4,94	0,06
helps students achieve better results	0	0	0	4	13	4,76	0,19

Figure 9. Heatmap of responses to the first set of statements.

Indagatio Didactica, vol. 17 (1), junho 2025
https://doi.org/10.34624/id.v17i1.40273

ISSN: 1647-3582

The results presented in Figure 9 highlight a strong consensus among participants regarding the benefits of gamification in mathematics education. The vast majority of respondents expressed total agreement with statements related to the effectiveness of gamification, with mean scores consistently high (mostly 4.94) and minimal standard deviation (0.06). This suggests that participants recognize gamification as a valuable tool for enhancing student motivation, engagement, and conceptual understanding.

One particularly noteworthy aspect is that all participants agreed that gamification contributes to a more engaging learning process and provides an interesting alternative to traditional teaching methods. This reinforces the notion that interactive, game-based strategies can foster a more dynamic and enjoyable learning environment. Moreover, the responses indicate that gamification plays a role in shaping a more positive perception of mathematics, which is a crucial factor in improving student attitudes toward the subject.

The only statement that received slightly lower agreement was “helps students achieve better results”, with a mean score of 4.76 and a standard deviation of 0.19. This slight variation suggests that while gamification is widely seen as beneficial, some participants may perceive that its direct impact on academic performance is less immediate or more dependent on additional pedagogical factors. Nevertheless, the overwhelmingly positive responses confirm that gamification is perceived as an effective instructional approach that enhances students’ learning experiences in mathematics.

Finally, participants were asked if they intended to use gamification resources in their practice after attending the workshop (see Figure 10).

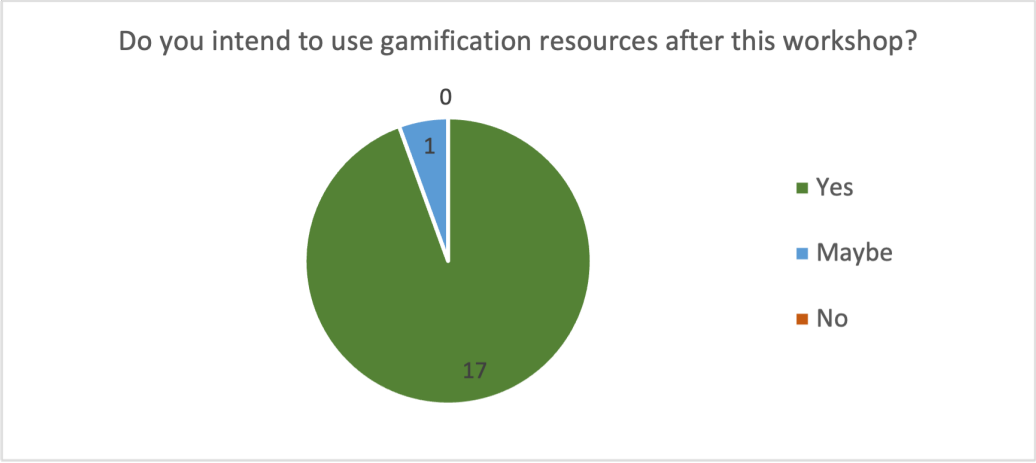

Figure 10. Pie-chart of responses to the Intention to use gamification resources.

Overall, the data supports the conclusion that the workshop was successful in demonstrating the value of gamification in mathematics education and in positively influencing participants’ perceptions of its effectiveness.

Indagatio Didactica, vol. 17 (1), junho 2025
https://doi.org/10.34624/id.v17i1.40273

ISSN: 1647-3582

Conclusions

Overall, the results confirm that the workshop successfully engaged participants and provided them with valuable insights into gamification in mathematics education. The findings further support the integration of interactive and game-based approaches as effective pedagogical tools, reinforcing the need for continued professional development opportunities in this area.

Participants, both pre-service and in-service teachers, recognized the educational value of non-digital games not only as a means to increase student engagement and motivation but also as a strategy for fostering deeper conceptual understanding of mathematical ideas. The overwhelmingly positive evaluations regarding the relevance, interest, and alignment of the workshop activities with participants' expectations highlight the practical applicability of gamification in primary mathematics education.

The participants' strong intention to incorporate gamification into their future practice suggests a shift toward more dynamic and student-centred mathematics classrooms. This aligns with broader educational trends that advocate for active, participatory learning methodologies that emphasize collaboration, problem-solving, and critical thinking.

Beyond merely showcasing a series of games, the workshop emphasized the intentional design, curricular alignment, and adaptability of these resources to diverse classroom contexts. By focusing on examples that required minimal resources, the workshop demonstrated that gamification is both accessible and feasible, even in settings with constrained budgets.

A particularly valuable aspect of this study was the detailed presentation of the games used. By offering clear, practical descriptions, the paper equips readers with concrete, replicable models that can be readily adapted to different educational realities. This approach not only supports the immediate application of game-based strategies in the classroom but also encourages educators to innovate and develop new games tailored to their curricular objectives and student needs.

In summary, this experience reinforces the importance of incorporating interactive, game-based methodologies into mathematics education. Gamification offers a meaningful pathway to transform the learning environment, making mathematics more accessible, engaging, and enjoyable. Future work should continue to explore the long-term effects of gamified strategies and expand the repertoire of resources available to teachers committed to fostering active and motivated learners.

Authors contributions

Conceptualization: Andreia Hall, Nuno Bastos, Sónia Pais, Paola Morando and Maria Luisa Sonia Spreafico; Methodology: Sónia Pais and Andreia Hall; Software: N/A; Validation: N/A; Formal analysis: Sónia Pais and Andreia Hall; Investigation: Nuno Bastos, Andreia Hall and Sónia Pais; Resources: Andreia Hall, Nuno Bastos, Paola Morando and Maria Luisa Sonia Spreafico; Data curation: Sónia Pais; Writing – original draft: Andreia Hall, Sónia Pais and Nuno Bastos;

Indagatio Didactica, vol. 17 (1), junho 2025 ISSN: 1647-3582
https://doi.org/10.34624/id.v17i1.40273

Writing – review and editing: Andreia Hall, Sónia Pais, Nuno Bastos, Paula Morando and Maria Luisa Sonia; Visualization: Andreia Hall, Sónia Pais and Nuno Bastos; Supervision: N/A; Project administration: N/A; Funding acquisition: N/A.

Funding

This work is supported by CIDMA under the FCT (Portuguese Foundation for Science and Technology) Multi-Annual Financing Program for R&D Units, within project reference UID/04106.

References

González-Cutre, D., A. Sicilia, A. C., Sierra, R. F., & Hagger, M. S. (2016) "Understanding the Need for Novelty from the Perspective of Self-Determination Theory", Personality and Individual Differences, 102, 159–169.

Hall, A., Alvelos, H. & Pais, S. (2024) Jogar e Aprender: à descoberta do potencial dos jogos não digitais no ensino da matemática. In Santos, V., Bernardino Lopes, J., Cabrita, I., Neto, T. & Pinheiro, M. (Eds.), *Matemática Com Vida: diferentes olhares sobre Dados e Probabilidades*, pp. 61-67, UA Editora. ISBN: 978-972-789-935-7 https://doi.org/10.48528/weem-ts03

Hall, A., Pais, S., Morando, P., & Spreafico, M., 2024. Fun and Functional: Using Non-Digital Games to Promote Maths Engagement in Pre-service Teachers. *European Conference on Games Based Learning*: https://doi.org/10.34190/ecgbl.18.1.2675

Hamari, J., Koivisto, J., & Sarsa, H. (2014) "Does Gamification Work? – A Literature Review of Empirical Studies on Gamification", Proceedings of the 47th Hawaii International Conference on System Sciences (HICSS), pp 3025–3034.

Kapp, K. (2012) The gamification of learning and instruction: Game-based methods and strategies for training and education, Pfeiffer.

La Fortuna, L., Morando, P., & Spreafico, M. L. S. (2022). Hands-on and game-based activities for teaching math in prison. In Gómez Chova, L., López Martínez, A., & Candel Torres, I. (Eds.), EDULEARN22 Proceedings (pp. 1514–1521). IATED Academy. https://doi.org/10.21125/edulearn.2022.0400

Liat, E., & Hayak, M (2024). "The integration of digital games into teaching and learning—A unique constructivist framework", British Journal of Educational Technology. https://doi.org/10.1111/bjet.13555

Morando, P., & Turconi, P. (2022) "Brains on in math classes", *EDULEARN22 Proceedings*, pp 1522–1529, IATED. https://doi.org/10.21125/edulearn.2022.0401

Morando, P., & Spreafico, M.L. (2023) "Math Inhabits the Museum", *EDULEARN23 Proceedings*, pp 2074–2081, IATED. https://doi.org/10.21125/edulearn.2023.0630

Pais, S., & Hall, A. (2021) "Enhancing Tourism Students' Motivation in Mathematics Classes With Kahoot! - A Case Study", Proceedings of ECGBL 2021 15th European Conference on Game-Based Learning, pp 591–597.

Pais, S., & Hall, A. (2024) "When Games get in the way: Gamification Approach for Teaching Maths – A Case Study With Undergraduate Tourism Students*", Proceedings of ECGBL 2024, 18th European Conference on Game-Based Learning*, pp 685–694. https://doi.org/10.34190/ecgbl.18.1.2649

Indagatio Didactica, vol. 17 (1), junho 2025
https://doi.org/10.34624/id.v17i1.40273

ISSN: 1647-3582

Ramos, D.K., Knaul, A.P., & Rocha, A. (2020) "Jogos analógicos e digitais na escola: uma análise comparativa da atenção, interação social e diversão", Revista Linhas, Vol 21, No. 47, pp 328–354. https://doi.org/10.5965/1984723821472020328

Ryan, R. M., & Deci, E. L. (2017) Self-Determination Theory: Basic Psychological Needs in Motivation, Development and Wellness, Guilford Press, New York. https://doi.org/10.1521/978.14625/28806

Yin, R. (1994). *Case study research: design and methods*. Thousand Oaks: Sage Publications.