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MELHORAR A COMPREENSÃO DA ADIÇÃO DE NÚMEROS INTEIROS COM O JOGO ABSOLUTE BLAST!: UMA EXPERIÊNCIA DIDÁTICA NO ENSINO BÁSICO

ENHANCING UNDERSTANDING OF INTEGER ADDITION WITH THE ABSOLUTE BLAST! GAME: A DIDACTIC EXPERIMENT WITH MIDDLE SCHOOL STUDENTS

MEJORAR LA COMPRENSIÓN DE LA SUMAR DE NÚMEROS ENTEROS CON EL JUEGO ABSOLUTE BLAST!: UNA EXPERIENCIA DIDÁCTICA EN LA ENSEÑANZA PRIMARIA

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RESUMO

Introdução: A literatura evidencia que a introdução dos números negativos constitui uma das transições mais complexas no currículo de Matemática, exigindo dos alunos a construção de novas representações mentais para além dos padrões adquiridos com os números naturais, sendo fundamental promover experiências significativas que relacionem o simbólico e o manipulativo. Neste enquadramento, a utilização de jogos de tabuleiro começa a ser reconhecida como uma ferramenta promissora para tornar tangíveis ideias abstratas e promover o envolvimento ativo dos alunos na resolução de problemas.
Objetivo: Este caso de estudo exploratório procura compreender o potencial do jogo de tabuleiro Absolute Blast! para apoiar a aprendizagem da adição com números inteiros em alunos do 6º ano.
Métodos: Estiveram envolvidos no estudo vinte e nove alunos de uma escola do Norte de Portugal, numa abordagem de investigação quase experimental, com recolha de dados de natureza mista. O grupo experimental (GE) explorou o jogo ao longo de três sessões, e o grupo de controlo (GC) trabalhou tarefas do tipo puzzle como primeiro contacto aos números inteiros. Para reunir os dados quantitativos, foi elaborado um teste de conhecimento pelos autores, com 60 questões sobre a adição de números inteiros.
Resultados: Os resultados sugerem que o GE, apesar de começar com um desempenho significativamente inferior ($p = 0{,}032$), não só atingiu níveis comparáveis ao GC após a intervenção ($p = 0{,}342$), como em termos percentuais relativos, os alunos do GE corrigiram mais respostas erradas ($p < 0{,}001$) e erraram menos respostas corretas ($p = 0{,}006$) do pré para o pós-teste, demonstrando um progresso coletivo mais consistente. Os dados qualitativos confirmaram que o jogo estimulou a verbalização, a negociação de significados e a validação do raciocínio.
Conclusão: Estes achados sugerem que o *Absolute Blast!* tem potencial como recurso didático para promover a aprendizagem eficaz e estável da adição de números inteiros através da integração da prática de cálculo e dos processos comunicativos numa base lúdica.

Palavras-chave: números inteiros; educação matemática; aprendizagem baseada em jogos de tabuleiro; Absolute Blast

ABSTRACT

Introduction: The literature shows that the introduction of negative numbers is one of the most complex transitions in the mathematics curriculum, requiring students to construct new mental representations beyond the patterns acquired with natural numbers. It is therefore essential to promote meaningful experiences that relate the symbolic and the manipulable. In this context, the use of board games is beginning to be recognised as a promising tool for making abstract ideas tangible and promoting students' active involvement in problem solving.
Objective: This exploratory case study seeks to understand the potential of the board game Absolute Blast! to support the learning of integer addition in 6th grade students.
Methods: Twenty-nine students from a school in northern Portugal participated in a quasi-experimental design with mixed data collection. The experimental group (EG) used the game across three sessions, while the control group (CG) worked on puzzle-type tasks as a first contact with the set of integers. Quantitative data were gathered through a 60-item test designed by the authors.
Results: Results suggest that, although the EG began with significantly lower performance ($p = 0.032$), it reached levels comparable to the CG after the intervention ($p = 0.342$). In relative terms, EG students corrected more wrong answers ($p < 0.001$) and lost fewer correct ones ($p = 0.006$), showing more consistent collective progress. Qualitative data confirmed that the game stimulated verbalisation, negotiation of meanings, and validation of reasoning.
Conclusion: These findings indicate that Absolute Blast! has potential as a didactic resource to promote effective and stable learning of integer addition by integrating calculation practice and communicative processes in a playful setting.

Keywords: integer numbers; mathematics education; board game-based learning; Absolute Blast

RESUMEN

Introducción: La literatura evidencia que la introducción de los números negativos constituye una de las transiciones más complejas en el currículo de Matemáticas, ya que exige a los alumnos la construcción de nuevas representaciones mentales más allá de los patrones adquiridos con los números naturales, siendo fundamental promover experiencias significativas que relacionen lo simbólico y lo manipulable. En este contexto, el uso de juegos de mesa comienza a reconocerse como una herramienta prometedora para hacer tangibles las ideas abstractas y promover la participación activa de los alumnos en la resolución de problemas.
Objetivo: Este caso de estudio exploratorio busca comprender el potencial del juego de mesa Absolute Blast! para apoyar el aprendizaje de la suma de números enteros en alumnos de 6.º grado.
Métodos Veintinueve alumnos de una escuela del norte de Portugal participaron en un diseño cuasi-experimental con recopilación de datos mixtos. El grupo experimental (GE) utilizó el juego a lo largo de tres sesiones, mientras que el grupo de control (GC) trabajó en tareas tipo rompecabezas como primer contacto con el conjunto de números enteros. Los datos cuantitativos se recopilaron mediante una prueba de 60 ítems diseñada por los autores.
Resultados: Los resultados sugieren que, aunque el GE comenzó con un rendimiento significativamente inferior ($p = 0{,}032$), alcanzó niveles comparables a los del GC tras la intervención ($p = 0{,}342$). En términos relativos, los alumnos del GE corrigieron más respuestas incorrectas ($p < 0{,}001$) y perdieron menos respuestas correctas ($p = 0{,}006$), lo que demuestra un progreso colectivo más consistente. Los datos cualitativos confirmaron que el juego estimuló la verbalización, la negociación de significados y la validación del razonamiento.
Conclusión: Estos resultados indican que Absolute Blast! tiene potencial como recurso didáctico para promover un aprendizaje eficaz y estable de la suma de números enteros, al integrar la práctica del cálculo y los procesos comunicativos en un entorno lúdico.

Palabras clave: números enteros; enseñanza de las matemáticas; aprendizaje basado en juegos de mesa; Absolute Blast

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INTRODUCTION

In Portugal, the curriculum guidelines recommend introducing the teaching of integers and their operations at the beginning of 7th grade. Within the broader topic of Numbers, students are expected to develop an understanding of positive and negative integers, learn to perform addition and subtraction using the properties of operations, and apply these skills to simplify and calculate numerical expressions (Canavarro et al., 2021).

Several studies have pointed out that students often struggle with these mathematical concepts, which are perceived as abstract (Alfarisi et al., 2022). In particular, students tend to struggle understand the concept of integers and the main arithmetic operations involving negative integers (Alfarisi et al., 2022; Aqazade & Bofferding, 2021), in part due to the lack of tangible examples of negative numbers in everyday life (Alfarisi et al., 2022). Also, the literature indicates that students who are exposed to negative numbers at an earlier stage tend to achieve a better understanding in subsequent grades (Aqazade & Bofferding, 2021), and the use of visual models has been shown to support the construction of meaning for negative numbers and their operations (Saparuddìn et al., 2022).

In this context, the use of playful activities in mathematics teaching, such as board games, has been suggested as a promising approach to increase student engagement and help them develop a deeper understanding of mathematical concepts (Boghian et al., 2019; Maffia et al., 2025). By offering challenges that are equally accessible and stimulating, playful approaches create conditions for students to actively engage in problem-solving and significantly develop their mathematical skills (Estrada-Plana et al., 2024). On this basis, board games offer rich and structured real-time situations, decision-making, and experimenting (Sousa et al., 2023), activities strongly connected to mathematical thinking (Maffia et al., 2025).

Given students' difficulties in understanding operations with integers and the potential of playful approaches, such as board games, to support learning, it is relevant to explore how such activities can contribute to the development of meaningful mathematical skills. In this exploratory case study, involving 6th grade students with no formal instruction on integers, we aimed to understand how the board game Absolute Blast! (Institute of Play, 2013) can support learning addition in the set of integers. Thus, the study addresses the following research questions: What is the potential impact of the game Absolute Blast! on 6th grade students' learning of addition with integers in terms of progress in performance? And, what individual and collective skills emerge during gameplay that may support students' learning of addition with integers?

This study brings its contribution to research on the use of games in mathematics education by exploring the potential of a board game as a context for introducing abstract concepts on the field of integer numbers. By analyzing 6th grade students' interaction with the game Absolute Blast! prior to curricular instruction on integer numbers, the study emphasizes how the game can function as an environment for conceptual exploration of addition with positive and negative numbers. Also, by simultaneously considering the evolution of students' performance and the individual and collective skills mobilized during the game, this study offers clues about the processes through which the game can support the construction of meaning.

1. THEORETICAL FRAMEWORK

Neuroscience has been showing that mathematical understanding is distributed across different regions of the brain (Clark et al., 2020). Learning abstract concepts, such as negative numbers, involves increased activation of the prefrontal cortex, which is responsible for reasoning and cognitive flexibility (Elgavi & Hamo, 2024). Students who rely only on rules and procedures face greater difficulties, as they do not develop a deep understanding of negative numbers, often making errors in operations and representations (Fuadiah et al., 2016; Gullick & Wolford, 2013; Vlassis, 2008). In this sense, the introduction of integers, especially the operations with negative numbers, is recognized as one of the most difficult transitions for students in the early mathematics curriculum. Studies suggest that the main difficulties students face are related to the conceptual understanding of what negative numbers represent, as they lack a concrete reference in daily life (Alfarisi et al., 2022). This fact requires students to build new mental representations, which makes learning more challenging (Clark et al., 2020). Also, students' prior knowledge of patterns and operations with natural numbers can interfere with learning this new concept, often leading to incorrect interpretations and solutions (Aqazade & Bofferding, 2021). This frequently leads to conceptual difficulties, misunderstandings, and confusion between the propreties of positive and negative numbers (Aqazade & Bofferding, 2021; Fuadiah et al., 2016). The incorrect use of the minus sign is frequent, with students restricting its meaning, which makes it harder to solve equations and to interpret negative solutions (Aqazade & Bofferding, 2021; Vlassis, 2008). As for arithmetic operations with negative numbers, research has been pointing out that the students' struggle to translate real-life situations into mathematical expressions involving negative numbers limits their problem-solving abilities (Alfarisi et al., 2022; Saparuddìn et al., 2022).

Research has been showing that metaphors used in teaching, such as thermometers, debts, or movements on number lines, can help introduce the concept of negative numbers (Amir et al., 2022; Saparuddìn et al., 2022). However, they are often not enough to ensure a deep and robust understanding of the concepts and need to be accompanied by other hands-on and experimental strategies (Elgavi & Hamo, 2024). Thus, learning about Mathematical abstract content, such as integers, requires meaningful experiences that allow students to explore, test, and discuss procedures, reducing the gap between symbolic manipulation and

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conceptual understanding. It is therefore important to consider didactic resources that connect the symbolic dimension with practical and interactive experiences. Board games, especially those that include numerical representations, appear to be a promising way to enrich learning by creating playful contexts in which students can work abstract ideas in a more concrete way (Maffia & Silva, 2022; Maffia et al., 2025).

Number line board games have been identified as didactic tools that can significantly improve preschool and primary school students' numerical knowledge, including their ability to estimate number lines, compare numerical order, count, and identify numbers (Berner et al., 2024; Ramani &Siegler, 2008). Although consistent positive results have been reported, some recent studies challenge this view, showing that the effects are not guaranteed (James-Brabham et al., 2024). In fact, not only number line board gameplay seems to have potential to improve students' numerical skills, including counting, number comprehension, and arithmetic abilities (Bayeck, 2020). It appears that board games offer opportunities for students to develop important numeracy skills, such as recognizing printed numerals, and comparing numerical quantities, while also providing an engaging and enjoyable way to promote learning (Hendrix et al., 2020).

The use of board games in Mathematics Education has been related to the development of fundamental number sense, with evidence suggesting that they help students build a basic understanding of numbers and create a framework for more advanced mathematical activities (Maffia & Silva, 2022). Although the impact of playing games varies according to the stage of students' cognition development and the type of mathematical skill involved, introducing students to board games that include counting, ordering or calculating can lead to significant and lasting improvements in their understanding of numbers (Estrada-Plana et al., 2024).

Beyond board games with a numerical line to follow and die roll, board games have been changing with an unprecedented transformation of creativity. Consequently, the interest in board games and their growing popularity is being renewed (Antunes, 2023). In the last two decades, hundreds of board games have been released each year, with themes and mechanics showing a remarkable diversity (Antunes, 2023; Sousa & Bernardo, 2019), making a revolution on the board game industry. Currently, board games are designed to keep all players active until the end, with outcomes determined by performance and strategy rather than elimination or chance. They encourage interaction, limit the role of luck, and players can make meaningful decisions and choose from multiple strategies, remaining engaged (Antunes, 2023).

Contrasting with number line games that focus mainly on sequential counting, this new generation of board games make it possible to develop different components of number sense, in a more integrated way, providing richer contexts for the construction of mathematical meaning (Bayeck, 2020; Estrada-Plana et al., 2024; Maffia & Silva, 2022). The diversity of experiences held by these new generation of board games is particularly relevant in the teaching of integers, since understanding negatives requires going beyond the simple numerical sequence (Maffia & Silva, 2022; Vlassis, 2008). It involves comparing numbers in symmetrical contexts, assessing positions in relation to zero, and recognizing patterns in operations that challenge the intuition built with natural numbers (Gullick and Wolford, 2013).

However, among the numerous board games that are available, to be eligible to be used in a Math classroom, some characteristics are particularly important. Games should have simple rules and present mathematical interest in an explicit way (Estrada-Plana et al., 2024; Lantarón et al., 2021). They act as more effective when they are strategy-based, encouraging logical reasoning and decision-making, while also offering an attractive visual design and engaging mechanics (Bayeck, 2020; Estrada-Plana et al., 2024). A suitable board game for Math classes should also stimulate interaction between peers, allow for the correction of possible mistakes as a natural activity, and remain appropriate for the grade level and the diversity of skills found in the classroom (Maffia et al., 2025; Sousa et al., 2023).

Absolute Blast! (Institute of Play, 2013) is a print and play game, categorized as educational math board game, published by the Institute of Play. The game was designed by its authors with the aim of allowing students to practice their calculation skills while also strengthening their understanding of operations with integers. It has all the characteristics highlighted previously. In this game, each player uses an individual board with three rockets and a personal deck of cards that include the boosters (positive and negative integers), modifiers, and action cards. Players aim to launch the rockets, taking turns to place cards strategically, with victory determined by achieving the highest total absolute value of the addition of their rockets' values. The dynamic mechanics and content of this game place it in a promising position to help students develop meaningful understanding of integers and the operation of addition within the set of integers.

The literature highlights that learning integers, especially negative numbers, requires more than applying rules or using metaphors in isolation. It is necessary to provide rich experiences that combine symbolic manipulation, logical reasoning, and peers' interaction. Board games, with their engaging nature and strategic possibilities, appear as promising didactic resources to create such experiences in the classroom. Within this context, the game Absolute Blast! emerges as a relevant proposal, bringing together playful and mathematical features that can support students in building a stronger understanding of operations with integers, which to our knowledge has not been studied yet.

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2. METHODS

This exploratory case study aims to understand the potential of the game Absolute Blast! to support 6th grade students in learning addition with the set of integers. In this sense, we aim to understand the potential impact of playing Absolute Blast! in terms of progress in performance, as well as the individual and collective skills that emerge during the game play.

To build a first understanding that may guide future research on this topic, a quasi-experimental study was carried out. It involved a pre-test with experimental and control groups, a pedagogical intervention of three 45-minute sessions using the game, and finally a post-test with both groups. The intervention took place in a Non-Formal Mathematics subject, which is based on a more ludic environment compared to a traditional Math class.

Following the ethical guidelines of the European Federation of Psychologists' Associations (EFPA), informed consent was obtained from the legal guardians of the students, from the school board, as well as from the students involved in the study, to ensure awareness of voluntary participation and confidentiality. Information on students' sex (female/male) was obtained from school records and used uniquely for sample description, in line with the SAGER guidelines on sex and gender equity in research.

2.1 The game and rules of Absolute Blast!

Absolute Blast! is a game for two or three players, where each player tries to launch his set of three rockets further than the other players. In pursuit of this task, players can add integer numbers and use their absolute value results. With this dynamic, it is expected to provide students with an increase in their mental calculation skills with integers, their understanding of the algebraic operations covered, and their understanding of the concept of absolute value.

In Absolute Blast!, the player whose sum of the absolute values of his three rockets is the highest is the winner. In each rocket there is room for three boosters, and the boosters are integers numbers that will be added to each other and whose absolute value of their sum is expected to be as distant from zero as possible. The game ends when one of the players launches the three rockets. The winner is the one whose sum of the absolute values of the additions of the boosters is the greatest.

Each player has a board in his/her possession (Figure 1). The game has 60 cards of three categories: (1) Boosters, cards with integer numbers that will be played on the boards, in three colours: green, with numbers between -2 and 2, blue, with numbers between -4 and 4, and red, with numbers between -6 and 6; (2) Booster modifiers, they are played under the booster (times -1, time 0, times 2, times 3, and divide by 2), changing its value; (3) special action cards (dispose, steal, and salvage).

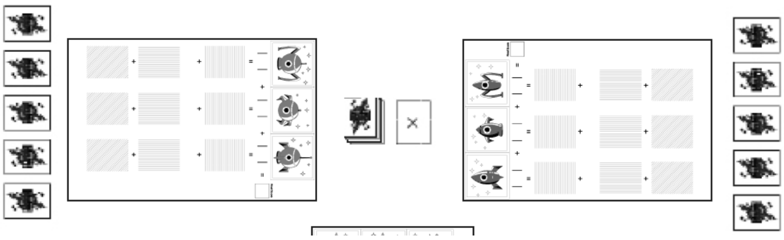

Figure 1 – Example illustration of setup of *Absolute Blast!* (Institute of play, 2013, p.7)

Each player can play up to two cards in their turn. The cards can be played on any player's board. The boosters can only be played on unlaunched rockets, or they can be discarded. To launch a rocket, the addition of its boosters is calculated and the result is written in the proper space, under the rocket. After playing the cards, the player must reset his/her hand until he/she has five cards again.

To each player is given a board along with five cards, dealt randomly. A zone is created for the discard pile and another for the deck of new cards, face down, accessible to all players, (Figure 1). The cards can occupy any empty spot or replace a card already played on the board. The booster modifiers can be played on any booster of any unlaunched rocket. They are placed by sliding them under the booster cards (Figure 3), leaving the operation in question visible. Booster modifiers multiply or divide the booster value. There can only be one modifier per booster. When placing the modifier, if the booster already has a modifier, the new one replaces it and the old one is placed in the discard pile.

Special action cards give certain action instructions (Figure 2). After being played, they are placed in the discard pile. When a special action card refers to an active card, it means any unlaunched rocket boosters or modifiers.

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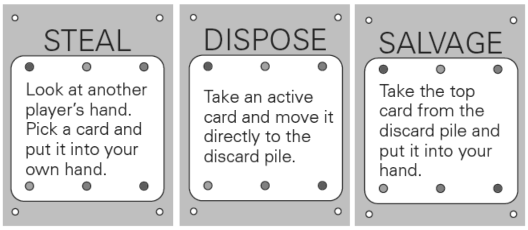

Figure 2 – Illustration of special action cards (Institute of Play, 2013, p.9)

The launch score of each rocket is determined by the absolute value of the sum of the boosters, as shown on Figure 3. The final score is made by adding the scores of the launched rockets. Whoever has the highest score, resulting from the addition of the absolute score values of each rocket, wins.

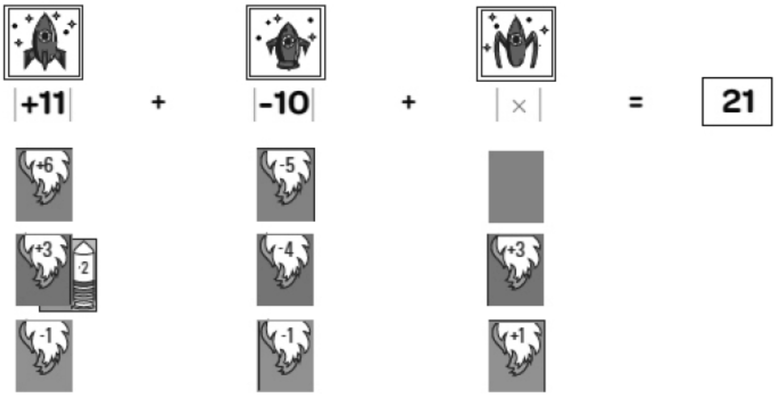

Figure 3 – Example illustration of the final score of one player (Institute of Play, 2013, p.10)

2.2 Sample

Twenty-nine 6th grade students, 12 females and 17 males, participated in this study, fourteen in the experimental group (EG) and fifteen in the control group (CG), aged between eleven and thirteen, with a mean age of 11.66 (sd = 0.55).

The study was conducted in a school in Northern Portugal at the end of school year. At this level, students had not yet received formal instruction on the concept of relative integers or on algebraic operations involving negative integers. According to the curriculum, negative numbers are only formally introduced in the beginning of 7th grade, which for these students would begin three months after this experiment.

Since it was not possible to move students between groups within the school setting, the participants were chosen at convenience from two classes. The class that performed lower at the start was assigned in the EG based on the pre-test results, while the other class constituted the CG.

2.3 Data collection instruments

The same test was used as both pre-test and post-test, consisting of 60 questions divided into three sections, each introduced with three examples. The first section included 24 additions of two numbers between -6 and 6, corresponding to the numbers used in the game. The second section contained 24 additions of two numbers within the wider range of -30 to 30. The third section comprised 12 additions of three numbers, ranging from -20 to 20. This design was chosen to ensure comparability of results while allowing a link with the game context and a gradual extension to more complex situations. In Table 1, the examples used in the test are presented.

During the pedagogical intervention, on the EG, audio recording of the sessions was also used.

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Table 1 – Examples used in the test

Section 1 (S1)	Section 2 (S2)	Section 3 (S3)
$-2+6=4$	$16-10=6$	$6-2-5=-1$
$4-5=-1$	$14-17=-3$	$-3-2+7=2$
$-2-5=-7$	$-21-15=-36$	$5-10+9=4$

2.3 Statistical analysis

The collected quantitative data were organized to obtain the correct number of answers in each question. In the total calculation of correct answers, a value was attributed to the correct answers and half a value to those where only the sign was wrong. In the statistical analysis of data, a significance level of 5% was considered. The variables were constructed in SPSS and tests of normality yielded significant results for all variables, indicating that the assumption of normal distribution was rejected. Consequently, the non-parametric Mann–Whitney test (for independent samples) and the Wilcoxon signed-rank test (for related samples) were applied to analyse the variation in the number of correct responses to each question between the pre-test and the post-test. For the statistical analysis of the results of the pre and post-tests, the SPSS software, version 25, with license 40695777 was used.

3. RESULTS

Statistical analysis produced the results shown in Table 2. It explains the descriptive analysis of the sample used in the statistical analysis, the results of the statistical analysis by the Mann-Whitney U test, chosen due to the paired nature of the sample and its reduced size.

Table 2 – Descriptive analysis of the correct answers for each question

Variable	Experimental Group (N=14)		Controle Group (N=15)		Test Statistic	$p^{a,b}$
	Mean ($\bar{x}$)	sd	Mean ($\bar{x}$)	sd		
Pretest	**5.31**	**2.066**	**7.14**	**2.810**	**62.5**	**0.032***
S1_pre	6.16	1.981	7.49	2.422	68.0	0.056
S2_pre	5.32	2.139	7.19	2.933	67.5	0.051
S3_pre	3.57	2.618	6.33	3.454	53.0	0.012*
Post-test	**7.76**	**1.666**	**7.16**	**2.332**	**95.5**	**0.342**
S1_pos	8.30	1.270	7.94	2.082	102.5	0.457
S2_pos	7.86	1.685	7.26	2.345	98.0	0.390
S3_pos	6.52	2.862	5.36	3.467	84.0	0.189

a. Independent-Samples Mann Whitney U Test, the significance level is 0.050; b. Asymptotic significance is displayed (1-tailed)

These reasons imply that the normality of the data cannot be guaranteed through the Shapiro-Wilk test (Pretest: p=0.016; S1_pre: p=0.040; S2_pre: p=0.011; S3_pre: p=0.002; Post-test: p=0.003; S1_pos: p=0.011; S2_pos: p=0.001; S3_pos: p=0.039), a necessary assumption for the application of the t-student parametric method. The test applied consisted of 60 questions. For ease of data analysis, the results were normalised to a scale from 0 to 10.

From the analysis of the results presented in Table 2, the pre-test indicates that the EG began the experiment with a disadvantage compared to the CG. In the global score of the pretest, EG had a mean of 5.31 (sd = 2.07), while the CG reached 7.14 (sd = 2.81), with a statistically significant difference (U = 62.5, p = 0.032). Analysing the subsections of the test, this difference appeared mainly in S3, where the EG obtained a lower mean ($\bar{x}$ = 3.57, sd = 2.618) compared to the CG ($\bar{x}$ = 6.33, sd = 3.454), also statistically significant (U = 53.0, p = 0.012). In subsections S1 and S2, although the EG also had lower results, the differences did not reach statistical significance but were very close (p = 0.056 and p = 0.051). Thus, at the beginning of the study the two groups were not balanced, with the CG showing better overall performance on the test. This initial difference reflects the fact that the groups correspond to classes naturally formed in the school context, and it was not possible to redistribute students between conditions.

In the post-test the EG reached a mean score of 7.76 (sd = 1.67), while the CG obtained 7.16 (sd = 2.33). The difference between groups is not statistically significant (U = 95.5, p = 0.342) in the post-test, indicating that the groups had become comparable by the end of the intervention. A relevant point is that no significant differences were found in the subsections of the test and, in all cases, the EG achieved results that were similar or higher than those of the CG. Therefore, although the EG started at a clear disadvantage, it managed to recover and reach performance levels comparable to the CG in only three sessions. To consolidate this result, the Wilcoxon test was applied to compare pre and post-test scores. A significant improvement was confirmed in all variables studied in the EG (Post-test – Pretest: Z = −3.297, p < 0.001; S1_pos - S1_pre: Z = −3.306, p < 0.001; S2_pos – S2_pre: Z = −3.185, p < 0.001; S3_pos – S3_pre: Z = −3.063, p < 0.001), in contrast to the absence of significant change in the CG, except in

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section S3 where a significant reduction in the score was observed (Post-test – Pretest: Z = −0.094, p = 0.469; S1_pos - S1_pre: Z = −1.694, p = 0.053; S2_pos – S2_pre: Z = −0.105, p = 0.467; S3_pos – S3_pre: Z = −2.102, p = 0.017).

To explore visually how both groups progressed in terms of the actual number of responses given by students, the number of correct, partially correct (incorrect sign), and incorrect answers was calculated as a percentage of the total responses provided by each student. Then the variation of these percentages from pre- to post-test was calculated. Figure 4 show the results obtained for the EG and the CG. The square, circles and triangles markers represent the percentages' variation of correct, partially correct, and incorrect responses for each student between pre and post-test, with each student generating a trio of different markers displayed vertically along the horizontal axis. The triangle markers are redundant, all three values sum to zero for each student, but they were included in the graphs for a better interpretation.

In the CG, we observe that students show individual progress, with each one advancing in a completely different way from the others, and there does not seem to be a common group pattern in the learning process. In contrast, in the EG we observe the opposite. The graph (Figure 4) suggests a consistent progression in correct and partially correct responses and, consequently, a decrease in incorrect ones. There appears to be a steady development across the whole class, as all square and circular markers tend to be positioned above the horizontal axis, indicating effective group progress.

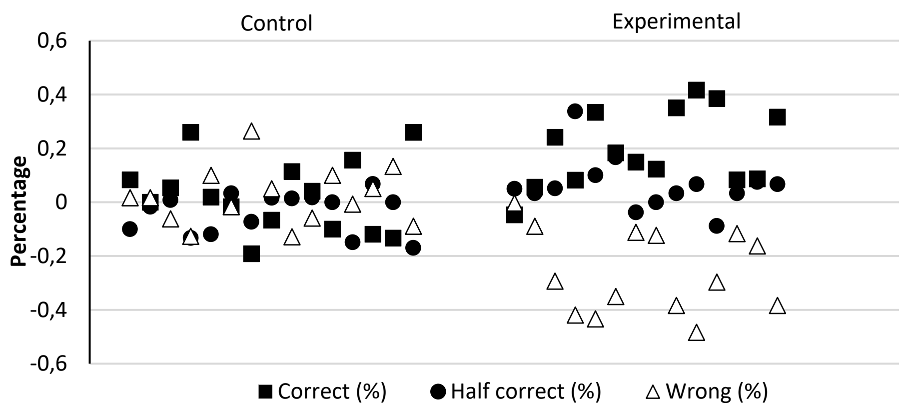

Figure 4 – Percentage's variation in students' response categories between pre-test and post-test per student

To support the previous results, we also calculated the number of wrong answers in the pre-test that were no longer wrong in the post-test for each student. In the CG, the mean value was 1.00 with a standard deviation of 0.93, while in the EG it was 4.50 with a standard deviation of 2.95. The Mann–Whitney test for these data produced a statistic of U = 30.5 with a p-value below 0.001. These findings show that the students in the EG, having more room for progress, improved significantly.

In the opposite direction, when calculating the number of correct answers in the pre-test that were no longer correct in the post-test, the mean value was 2.47 with a standard deviation of 2.06 in the CG, while in the EG the mean was 0.64 with a standard deviation of 0.71. The Mann–Whitney test for these data produced a statistic of U = 50.5 with a p-value of 0.006. This result is even stronger than the previous one, pragmatically suggesting that students in the EG were less likely to lose correct answers, meaning that once knowledge was acquired, it tended to be retained more consistently.

The qualitative analysis of the dialogues recorded during the game sessions highlights different dimensions of mathematical communication that emerged from the activity. Here we present four examples of these interactions.

In Dialogue 1, we observe a process of negotiating meaning around the negative sign. The initial mistake of considering "six divided by two is three" was questioned by a peer and, with minimal teacher intervention, the students reformulated their reasoning until they reached the correct solution. The sequential verbalisation made the reasoning visible and culminated in the validation of the written record. This episode illustrates how the game created a space for the shared construction of mathematical meaning.

Student_1 – Six divided by two is three.
Student_2 – But this is minus six.
Teacher – Well, that's why it's minus three.
Student_1 – Oh, okay. Minus six divided by two is minus three. Minus three plus three…zero. Zero minus two…. minus two.
Student_2 – You must write minus two here.
(Dialogue 1 between peers during the counting of points, 2025)

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Dialogue 2 illustrate an appropriation of signs as a personified identity, when students say they are playing "with the plus" or "with the minus." Although this does not correspond to the formal language of mathematics, such discourse reveals flexibility in the use of representations and in the elaboration of personal strategies within the context of the game. Here, the signs are no longer only abstract symbols but acquire with a strategic function, reinforcing students' engagement with the content.

Student_3 – I'm playing with the plus. She with the minus. And you?
Student_4 – With the plus and with the minus.
Student_3 – I'll help myself. I'm going to make this row minus too.
(Dialogue 2 between peers during the game, 2025)

In Dialogue 3, the difficulty lies in the interpretation of notations: students confuse the multiplication dot with a minus sign, leading to errors in reading and reasoning. The teacher's intervention clarified the situation, turning the error into an opportunity to discuss the difference between addition, subtraction, and multiplication in the set of integers. This episode shows how the game can expose ambiguities in mathematical language while at the same time creating opportunities for conceptual clarification.

Student_5 – Wait, wait. teacher, this is plus six times minus one.
Teacher – yes, it is, so it turns plus.
Student_6 – Shouldn't it be minus seven? Minus six minus one is minus seven.
Teacher – It's times. This dot represents times.
Student_5 – That's plus six. It is backwards.
(Dialogue 3 between peers and the teacher during the game, 2025)

Lastly, dialogue 4 highlights the persistent difficulties in correctly assigning signs to numbers. Although the students identified the numerical values, they constantly shifted between positive and negative, showing conceptual insecurity. The teacher's repeated emphasis that "it is not the same thing" underlined the importance of consolidating this distinction. This episode illustrates how the game brought underlying misconceptions to the surface, offering immediate opportunities for correction and reflection.

Student_7 – But here I put fifteen.
Teacher – You should write minus fifteen. These bars will then give you the fifteen.
Student_7 – Here is eleven.
Teacher – It's minus eleven.
Student_7 – Oh, it's the same teacher.
Teacher – It is not the same thing.
Student_7 – Here is minus eight. No, plus eight. I put here eight.
(Dialogue 4 between peers and the teacher during the game, 2025)

These dialogues illustrate that Absolute Blast! not only encouraged playful engagement but also initiated valuable processes of mathematical communication, such as questioning, negotiating meanings, validating solutions, and clarifying ideas. These moments went beyond the simple execution of operations, underlining the communicative and collaborative dimensions in building an understanding of integers. Throughout the sessions, discussion and sharing of ideas were constant, and every stage of gameplay became a moment of decision-making and analysis, inevitably strengthening mental calculation. Although Absolute Blast! is not a cooperative game by nature, the final step of counting points turned into a cooperative moment, as students helped each other with the operations. The game, therefore, created an environment where mistakes were observed as opportunities for improvement. As the sessions progressed, a rapid gain in autonomy was observed, with the games playing becoming faster and students showing less need for support from the teacher or their peers in a general way.

4. DISCUSSION

Playing board games facilitates learning in a variety of ways (Bayeck, 2020; Sousa et al., 2023). When playing board games, players deal with challenges in a dynamic way, they frequently have to plan ahead and consider all possible outcomes before taking a new action (Maffia & Silva, 2022; Sousa et al., 2023). Absolute Blast! has the potential to give tangibility to abstract ideas, such as negative numbers, which is a fundamental aspect in the learning process of this concept (Alfarisi et al., 2022). Its concept is centered on sending rockets into space as a way to encourage group learning, in which students' difficulties are overcome by the group's collective knowledge, in a combination of individual and group discovery, and in an emotionally supportive learning environment (Leo et al., 2019).

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The results obtained allow for some relevant considerations. From the analysis of Table 2, we can see that the results confirm that the groups were not balanced at the beginning of the study, since the CG showed higher performance in the pre-test. This finding reinforces the idea that the EG started from a weaker position in relation to addition with integers. As the CG performed better in the pre-test, the observed progress should be interpreted primarily in terms of convergence between the groups rather than as a direct comparison of gains. Nevertheless, the fact that, after only three sessions of gameplay, the students in the experimental group achieved performance levels similar to those of the control group is a relevant indicator of the game's potential as a context for exploring addition within the set of integer numbers. The EG not only improved its overall performance significantly but also achieved results comparable to those of the CG across all subsections of the test. A significant result given the short period of work and the absence of prior formal teaching on the set of integers. This result is particularly relevant from an educational perspective, since a game-based approach can be an effective support for students who start from lower levels of understanding (Raveh et al., 2025).

The convergence between groups suggests that the game Absolute Blast! may be an effective didactic strategy to support the learning of addition within the set of integers. These findings are reinforced by the analysis of response evolution, showed on the graphic of Figure 4, which confirms and deepens the previous results. In the CG, progress took place individually and without a common pattern, while in the EG the progression was more consistent across the whole class.

This group effect is important because it indicates that the game encouraged collective development rather than isolated gains. Students in the EG not only transformed significantly more wrong answers into correct ones but also lost fewer correct answers between the pre- and post-test. Previous research suggests that understanding abstract concepts such as integers requires the construction of new mental representations and meaningful experiences that connect symbolic manipulation with exploration and discussion (Clark et al., 2020; Elgavi & Hamo, 2024). When students move beyond the simple application of rules and develop conceptual understanding, learning tends to become more stable and less prone to errors (Fuadiah et al., 2016; Gullick & Wolford, 2013). The data suggest that the game Absolute Blast! promoted not only the improvement of performance but also retention of acquired knowledge, reinforcing its relevance as a didactic resource in educational contexts. The gameplay appeared to create opportunities for students to discuss their reasoning and explore operations with integers within a playful learning context.

The ludic atmosphere created by the dynamic of the game allowed students to freely express what they thought, without fear of failure, attributes that enhance the emotion of joy (Hoyos & Rivero, 2022; Leo et al., 2019), collective learning, and mutual help. In Bayeck's (2020) literature review, it is stated that board games have been found to enhance sociability, communication, decision-making, teamwork, and mathematical self-concept, thereby promoting motivation to learn, characteristics also observed in this exploratory study. Overall, board games provide engaging and interactive opportunities for students to develop their mathematical abilities (Bayeck, 2020).

The qualitative data helped to explain further the potential of the game for learning addition in the set of integers. The recorded dialogues indicate that the game created moments of negotiating meaning and mathematical verbalization, where typical errors caused by the interference of natural numbers were discussed and reformulated. Minimal teacher mediation was enough to trigger conceptual clarification, while pair work supported mutual validation and the consolidation of formal notation. This communicative dimension partly explains why the EG not only improved but also maintained the acquired learning more consistently, in contrast with the irregular progress of the CG.

Absolute Blast! also had important contributions in the exercise of mental calculation, a constant exercise by doing active and experimental, not only the addition of integer numbers, but also their multiplication. In this classroom setting, the use of gameplay encouraged the learning of new ideas and self-discovery, leading students to collaborate and interact, and to acquire knowledge from one another.

In this sense, research has been pointing out that playing board games often involves strategic thinking, problem-solving, and making calculations in order to make the best decisions and this can help improve mental math skills, as players have to calculate scores and make calculations based on the game rules and objectives (Hafiz et al., 2019; Maffia et al., 2025; Sousa et al., 2023). Board games are seen as shared mathematical activities and as instruments for social development that can help students solve problems and stimulate different mental processes by mixing mathematical concepts, making them a valuable teaching tool for Math (Maffia & Silva, 2022).

The findings of this study suggest that Absolute Blast! can be a valuable didactic resource for supporting the learning of integers, especially addition with negative numbers. By combining playful engagement with opportunities for communication, reasoning, and reflection, the game provided conditions for collective and individual progress. Although the intervention was short and conducted before formal instruction on integers, the results indicate meaningful gains in performance and retention. These insights highlight the potential of board games to make abstract concepts more tangible and to create rich learning environments that complement traditional approaches to mathematics education.

CONCLUSION

The findings of the statistical analysis suggest that the intervention, including the board game Absolute Blast! had a positive effect on the students' comprehension of adding integers. This exploratory study displayed that the game Absolute Blast! helped the EG reduce its initial disadvantage in learning addition with integers. After only three sessions, students who began with significantly lower results reached performance levels comparable to the CG. The EG transformed more wrong answers into correct ones, lost

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fewer correct answers between pre and post-test, and showed more homogeneous collective progression. The game also created opportunities for verbalisation, negotiation of meanings, and validation of reasoning, supporting not only performance gains but also qualitative progress in mathematical communication and reasoning. Therefore, Absolute Blast! reveals potential as a didactic tool for learning addition with integers, combining practice in addition in the set of integers, strategy decision making, and the development of communicative skills.

Limitations of the study

The study encountered some issues that may had an impact on the analysis and outcomes. The sample size was small, and the groups were not randomly assigned, which limits the generalization of the findings and reduces control over possible external influences. Factors such as class dynamics or the role of the teacher were not addressed, aspects that may have influence in the results. Also, the intervention was relatively short, and no delayed post-test was conducted, which limits conclusions about the long-term consolidation of the observed learning gains. For these reasons, the findings should be regarded as indicative and exploratory, underlining the need for further studies with larger samples and the inclusion of other relevant variables.

Recommendations for future studies

Following this exploratory study, we consider that future research should include larger and more diverse samples, with randomized group allocation, in order to strengthen the validity of the findings. It would also be valuable to explore the impact of board games such as Absolute Blast! in different school contexts, with longer interventions, and to compare their effects with other didactic strategies for teaching integers.

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AUTHORS' CONTRIBUTION

Conceptualization, A.M., H.S., C.D. and A.P.A.; data curation, A.M. and H.S.; formal analysis, A.M. and H.S.; funding acquisition, A.M.; investigation, A.M. and J.R.; methodology, A.M., H.S., C.D. and A.P.A.; project administration, A.M.; resources, A.M. and H.S.; software, A.M. and H.S.; supervision, H.S., C.D. and A.P.A.; validation, A.M., H.S., C.D. and A.P.A; visualization, A.M. and H.S.; writing – original draft, A.M. and H.S.; writing – review & editing, A.M., H.S., C.D. and J.R.

CONFLICT OF INTERESTS

The authors declare no conflict of interest.

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