Revista ARACÊ
ISSN: 2358-2472

STEAM'S MATHEMATICAL DEVELOPMENT: CREATIVITY WITH CONCRETE GAMES IN THE MATH LAB

https://doi.org/10.56238/arev7n1-241

Submitted on: 12/30/2024 **Publication date:** 01/30/2025

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ISSN: 2358-2472

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ABSTRACT
Mathematical development within the STEAM context is crucial, and the use of concrete games in the math lab can play a significant role. The integration of games into mathematics education offers an innovative approach to engaging female students and promoting essential skills. This study aims to develop concrete games that contribute to girls' mathematical development with real numbers, highlighting the impact of these games on female learning and participation in STEAM. The methodology applied is a quantitative approach with observation and description of activities in the mathematics laboratory, including board games. The analysis of the student's perceptions was conducted to assess the effectiveness and receptivity of the activities. The results indicate that girls demonstrated improved problem-solving skills, while other points reported improvements in their understanding of mathematical concepts. Gaming has also been associated with an increase in engagement and collaboration. The inclusion of concrete games in mathematics teaching not only promotes creativity and critical thinking but also increases girls' participation and interest in STEAM, suggesting that this approach should be encouraged and expanded in educational practices.

Keywords: Games. STEAM. Laboratory. Mathematics.

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ISSN: 2358-2472

INTRODUCTION

Mathematical development within the STEAM (Science, Technology, Engineering, Arts, and Mathematics) context has gained prominence, with evidence suggesting that girls' active participation can be transformative. As Margolis and Fisher (2002) state, the inclusion of girls in STEAM fields not only diversifies perspectives but also enriches practices and outcomes in these fields.

This research investigates how girls' creativity can be stimulated through concrete games in a mathematics laboratory, seeking to understand their impact on the development of mathematical skills and engagement with STEAM.

The object of study is the interaction of girls with concrete mathematical games and their effect on learning and motivation. The research problem focuses on how these games can influence girls' mathematical development and creativity, as well as increase their interest in STEAM.

The hypotheses formulated are: (1) Concrete games improve girls' understanding and application of mathematical concepts, (2) Girls' creativity is amplified through the use of these games, and (3) Experience with concrete games increases girls' engagement and confidence in STEAM areas. The research aims to provide *feedback* on strategies to promote inclusion.

The objective is to develop concrete games in the mathematics laboratory about the content of real numbers in the mathematical development and creativity of high school students, to promote greater inclusion and engagement of them in the areas of STEAM.

THEORETICAL FRAMEWORK

WOMEN IN EDUCATIONAL SCIENCES

The presence and active participation of girls in STEAM fields have been topics of increasing importance in academic and educational debates. The gender disparity in these fields is well-documented and persists across cultures and contexts (Tereza, 2015). The scarcity of women in science and technology careers can be attributed to a combination of factors, including gender stereotypes, a lack of role models, and deficiencies in the education system that do not favor inclusion and equity. Mathematics education, as one of the foundations of STEAM, plays a crucial role in nurturing skills and promoting girls' interest in STEAM subjects. In this scenario, the use of innovative approaches, such as the

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use of concrete games in mathematics laboratories, emerges as a promising strategy to address these inequalities and foster inclusion.

The choice of this theme is based on the urgent need for strategies that not only promote girls' interest in mathematics and related areas but also transform their educational experiences. The use of concrete games, which involve physical material and practical activities, is effective in teaching mathematical concepts by making learning more interactive and engaging (Ferreira, 2023). These games can facilitate the understanding of abstract concepts and develop problem-solving skills in a playful and stimulating way. In addition, mathematical games have the potential to stimulate creativity, an essential factor for innovation and for addressing complex problems, characteristics valued in STEAM disciplines.

This work has as a guiding question: how to explore concrete Mathematics games in the impact of the development of real number content with high school students in the promotion of creativity in a mathematics laboratory environment with STEAM? The social relevance of this research is significant. The inclusion of girls in STEAM fields not only contributes to gender equity but also to the enrichment of the field with new perspectives and skills. Mathematical skills and creativity are increasingly valued in the global labor market, and empowering girls from an early age is crucial to ensure that they can compete and contribute on an equal footing with their male counterparts (Vasconcelos, 2018).

Furthermore, the research aims to address a gap in the existing literature, which often does not fully explore the specific impact of concrete games on girls' engagement and mathematical development. Previous studies have demonstrated the effectiveness of games in mathematics teaching in general (Santos, 2014), but there is a need for a more detailed investigation into how these methods specifically affect girls' performance and motivation. By focusing on this intersection, the survey can provide valuable *feedback* on how to optimize educational practices to maximize female students' potential.

The scientific relevance of this research lies in its potential to contribute to the body of knowledge on effective and equitable teaching methodologies. An in-depth understanding of the effects of concrete games on girls' mathematical development can inform educational policies and pedagogical practices, promoting more inclusive teaching methods tailored to the specific needs of learners. In addition, the results can provide empirical evidence to support the implementation of strategies aimed at reducing the barriers faced by girls in STEAM fields, helping to create a more equitable educational

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environment (Vieira, 2024). Through this investigation, it is expected to provide a significant advance for both educational practice and scientific theory related to the teaching and learning of mathematics.

SEARCHING USING STEAM

Girls' participation in STEAM fields has historically been lower than boys' Studies indicate that this disparity begins early in education and is reflected in different levels of motivation and performance (Margolis; Fisher, 2002). Research by Eccles (2007) suggests that differences in interest between genders in STEAM subjects can be attributed to social stereotypes and cultural expectations, which often discourage girls from engaging with mathematics and science.

In addition, the lack of female role models and the perception that these areas are predominantly male may contribute to the lower participation of girls (Wang; Degol, 2017). The inclusion of innovative educational approaches, such as the use of concrete games, can be an effective strategy to combat these barriers and encourage girls' interest in STEAM.

Concrete games, which involve physical material and hands-on activities, have been widely recognized for their effectiveness in promoting the understanding of mathematical concepts. According to Piaget (1952), mathematical learning is more effective when students interact with tangible materials that help build an understanding of abstract concepts. Several studies highlight that the use of concrete games in the teaching of mathematics facilitates learning by making the process more engaging and interactive (Sarama; Clements, 2009).

In addition, these games help develop problem-solving and critical thinking skills by providing practical and challenging contexts that are fundamental for building meaningful mathematical knowledge (Ginsburg-Block; Rohrbeck; Fantuzzo, 2006). The playful approach also promotes a more inclusive and motivating learning environment, which can be particularly beneficial for girls.

Creativity is an essential component in the field of STEAM, and its importance has been widely recognized in educational research. Torrance's (1987) theory of creativity suggests that learning environments that encourage exploration and experimentation can foster students' creativity. Concrete mathematical games are tools that provide this type of

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environment, allowing students to approach problems in new and innovative ways (Brusilovsky; Millán, 2007).

Studies indicate that playing interactive games not only improves math skills but also increases student engagement and motivation, which is crucial for maintaining girls' interest in STEAM (Healy, 2007). The combination of creativity and engagement not only helps reinforce learning but also prepares students to take on complex challenges in their future STEAM careers.

METHODOLOGICAL PATH

This study aims at a descriptive research method, which allows a detailed analysis of the characteristics and effects of the intervention in a real teaching environment. The applied nature of the research seeks to solve practical problems related to teaching mathematics about real numbers and the inclusion of girls in STEAM areas, offering *feedback* that can be used to improve pedagogical practices and educational policies. The quantitative approach was adopted to measure and analyze the effects of concrete games on girls' mathematical performance and creativity. The choice of this approach allows the collection of numerical data and the application of statistical analyses to identify significant patterns and relationships (Gil, 2010).

The research is descriptive, to describe and interpret the impact of concrete games on the mathematical development and creativity of girls. Gil (2010), the descriptive approach allows the collection and analysis of data that portray the current situation, identifying the specific characteristics and effects of the intervention. The detailed description of the observations and the results obtained will provide a clear understanding of the impact of the educational practices adopted.

The study involves the elaboration and application of concrete games in a mathematics laboratory, with the participation of students from the 1st and 2nd years of high school. During the research period, 13 participants are included in activities that use mathematical games to explore mathematical concepts about real numbers and promote STEAM creativity with recyclable materials.

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Chart 1 – Stages and descriptions of working with STEAM.

Stage	Description
1. Introduction to the Concept	Exploration of the concept of STEAM: Explanation of the meaning of STEAM (Science, Technology, Engineering, Art, and Mathematics) and how mathematics integrates with other areas.
2. Importance of Girls	Relevance of Female Inclusion: Discourse on the importance of encouraging the participation of 1st and 2nd-year high school students in STEAM, highlighting how gender diversity contributes to new perspectives and innovations.
3. Concrete Games	Game Development: Construction of concrete games in the mathematics laboratory, highlighting how manipulative games and practical activities can facilitate the understanding of mathematical concepts.
4. Creativity in Teaching	Stimulation of Creativity: Visualization of playful and creative activities helps in the development of critical thinking and the resolution of mathematical problems, encouraging experimentation and discovery.
5. Active Methodologies	Methods and Strategies: Exploration of the active Problem-Based Learning methodology that uses games and hands-on activities to teach mathematics, emphasizing how this methodology can be adapted to foster an inclusive environment with female students.
6. Evaluation and *Feedback*	Evaluation of Results: Application of the form to evaluate the impact of concrete games on girls' mathematical development, including *feedback* from participants and adjustments needed to improve practices.

Source: Prepared by the authors (2024).

Data were collected through a structured form (*Google Forms*), which includes four evaluation questions applied before and after the intervention with concrete games for high school students. The form is designed to assess girls' level of mathematical comprehension, creativity, and interest in STEAM.

Data analysis was performed using quantitative techniques, focusing on descriptive and inferential statistical methods (Agresti; Finlay, 2012). Initially, descriptive analyses will be carried out to summarize and present the data collected.

The research participants, together with their legal guardians, signed the Informed Consent Form (ICF) before being included in the study. The signing of the ICF ensured that all participants were aware of the objectives, procedures, and possible impacts of the research, and that participation was voluntary. The information collected is treated with the utmost confidentiality and used exclusively for research purposes, ensuring that the privacy and rights of the participants are respected throughout the study process.

ANALYSIS AND DISCUSSION OF THE RESULTS

The construction of the STEAM mathematical games in the math lab involved a collaborative and multidisciplinary approach.

The process included prototyping, testing with students, and feedback-based adjustments, ensuring that the games not only reinforced mathematical learning but also

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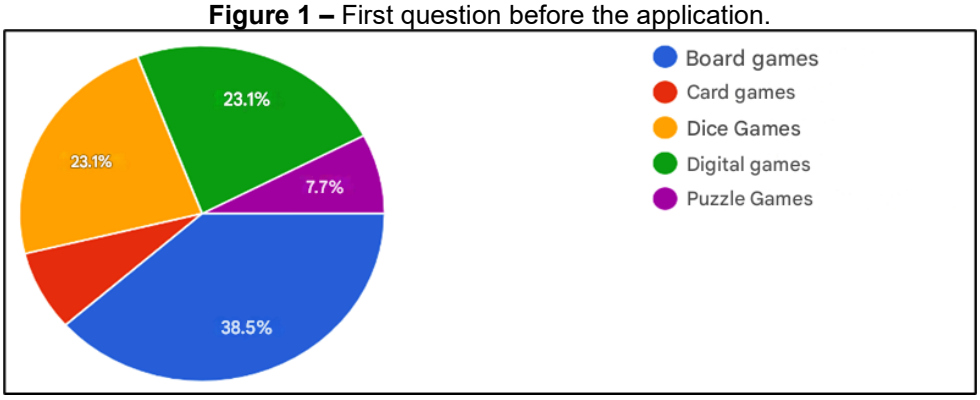
fostered critical thinking and collaboration. This dynamic approach aimed to make learning more accessible and inspiring, especially for girls, by encouraging their active participation in STEAM skill development.

The application of mathematical games in the classroom was done in a planned and interactive way, starting with the introduction of games to students as engaging learning tools. The students were guided in the use of the games, highlighting how each activity related to specific mathematical concepts and encouraging exploration and experimentation. During the sessions, group discussions and collaborative activities were promoted to deepen the understanding of the concepts covered by the games.

The implementation included moments of continuous evaluation, where teachers from other areas adjusted teaching strategies based on student performance and *feedback*. This dynamic method has helped to make mathematics more accessible and stimulating, promoting an active and participatory learning environment that includes female students in mathematics.

Figure 1 – First question before the application.



Source: Prepared by the authors (2024).

Research data indicate that 38.5% of mathematical games are board games that are most accepted by students, 23.1% are data-based or digital, and 7.7% include cards and puzzles.

As highlighted by Boulton-Lewis *et al.* (2019), mathematical games not only make learning more attractive but also help solidify concepts through practice and concrete application. This diversity of game formats enriches the learning environment and caters to the different styles and preferences of students.

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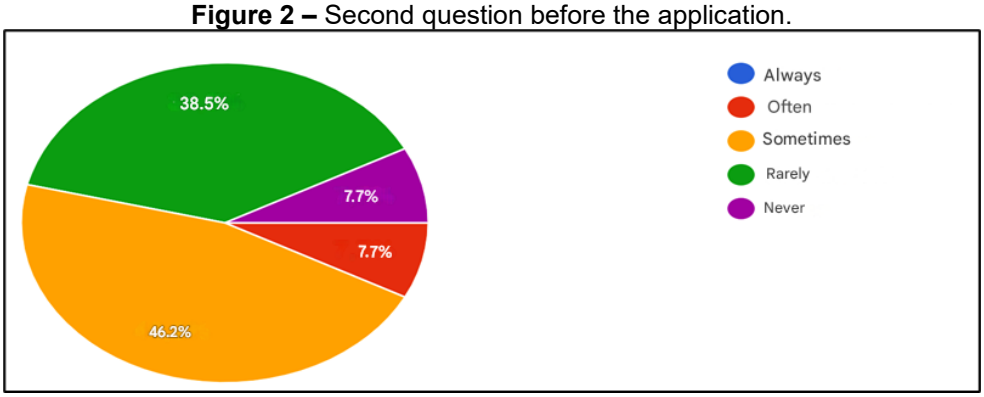
Figure 2 – Second question before the application.



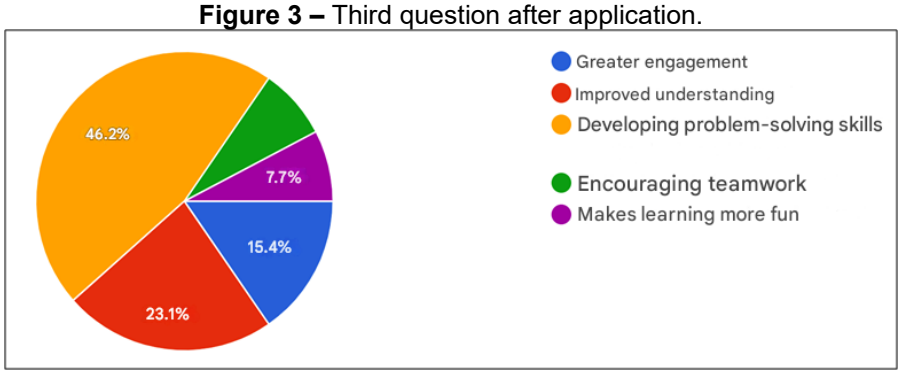
Source: Prepared by the authors (2024).

The use of mathematical games in classrooms presents a diverse panorama of attendance, reflecting different pedagogical approaches and priorities. The data shows that 46.2% of female students use mathematical games sometimes, indicating that these games are an important complementary tool, but not necessarily a constant practice.

In contrast, 38.5% of female students rarely use mathematical games, which may suggest limitations in time, resources, or a preference for traditional teaching methods. Only 7.7% use games frequently, which highlights a significant commitment to active learning and gamification in mathematics education.

The total absence of the use of games by a smaller portion indicates that, for some educators, these games have not yet been integrated into their teaching method. As Gu (2016) argues, the effective application of mathematical games can transform the learning environment, but their integration depends on factors such as teacher training and the availability of resources. Therefore, the challenge remains to find effective ways to incorporate these resources to maximize their impact on learning.

Figure 3 – Third question after application.



Source: Prepared by the authors (2024).

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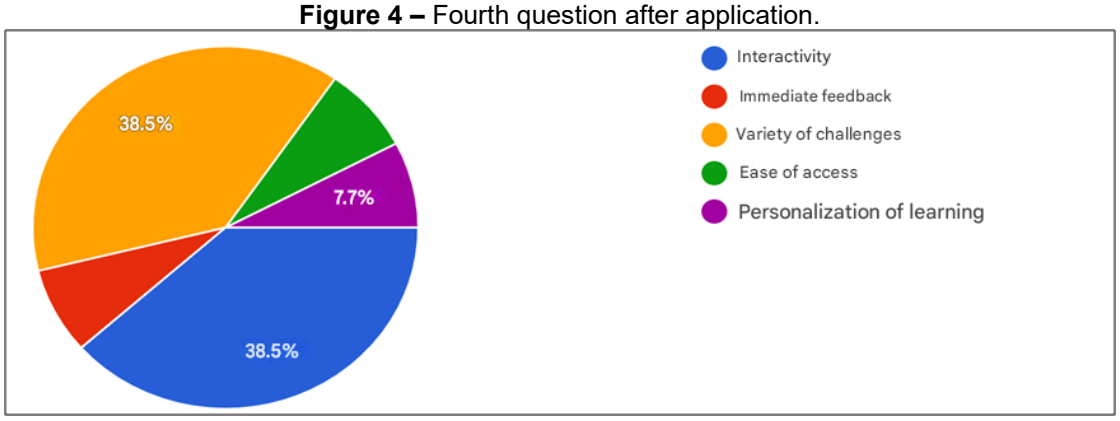
After the use of mathematical games, the positive effects on learning are varied and significant. Data show that 46.2% of educators observe a remarkable development in problem-solving skills. This is because many math games challenge students to apply concepts practically and creatively, promoting critical thinking and the ability to solve complex issues. In addition, 23.1% report improvements in the understanding of mathematical concepts, indicating that games help to clarify and reinforce the knowledge acquired in the classroom.

On the other hand, 15.4% of teachers noted an overall improvement in comprehension, reflecting how the playful approach can benefit a broader understanding of mathematical content. Finally, 7.7% of educators noted that games make learning more fun and encourage teamwork.

Figure 4 – Fourth question after application.



Source: Prepared by the authors (2024).

After the use of mathematical games, the aspects of interactivity and a variety of challenges are widely recognized, with 38.5% of educators highlighting that these elements are particularly valued. Interactivity allows students to actively engage with the content, promoting more dynamic and engaging learning. On the other hand, 7.7% of teachers mention that personalization of learning, immediate feedback, and ease of access are significant factors after using games. Customization allows you to tailor games to students' individual needs, offering more fine-tuned learning experiences. Immediate *feedback*, provided by many games, makes it easy to correct errors and reinforce concepts in real time.

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ISSN: 2358-2472

FINAL CONSIDERATIONS

The research on the role of girls in mathematical development within the STEAM context and the effectiveness of concrete games in the mathematics laboratory with the contents of real numbers achieved its main objectives. The investigation allowed them to assess the impact of games on girls' mathematical comprehension and creativity, as well as to explore how these activities affect their interest and engagement in STEAM.

The overall results indicate that the use of concrete games contributed positively to the development of girls' mathematical skills, improving their understanding of abstract concepts and promoting a more engaging learning environment. In addition, a significant increase in the creativity of the students was observed, reflected in the way they approached mathematical problems in an innovative and problem-solving way. Girls' engagement and interest in STEAM were also stimulated, confirming the importance of games as an effective tool to encourage female participation in these areas.

The hypotheses formulated were amply confirmed. The research showed that concrete games improved girls' mathematical understanding, expanded their creativity, and increased their interest in STEAM. These findings corroborate the premise that playful and practical approaches can have a significant impact on mathematics education and the inclusion of girls in technical and scientific fields.

Data collection instruments, such as questionnaires and assessment scales, played a crucial role in obtaining accurate and relevant information. They allowed a detailed analysis of the changes in the participants' skills and perceptions, contributing to the validation of the research hypotheses.

To enhance the research, it is recommended to further explore the influence of different types of concrete games and their variations on the development of specific skills. In addition, it would be useful to expand the study to include a larger and more diverse sample to validate the results in different contexts.

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