PEDAGOGICAL PRACTICES FOR CREATIVITY AND INNOVATION IN MATHEMATICS TEACHING

PRÁTICAS PEDAGÓGICAS PARA A CRIATIVIDADE E INOVAÇÃO NO ENSINO DE MATEMÁTICA

PRÁCTICAS PEDAGÓGICAS PARA LA CREATIVIDAD Y LA INNOVACIÓN EN LA ENSEÑANZA DE LAS MATEMÁTICAS

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How to reference this article:

TAVANO, P. T.; SAMBUGARI, M. R. do N. Pedagogical practices for creativity and innovation in mathematics teaching. **Revista Ibero-Americana de Estudos em Educação**, Araraquara, v. 19, n. esp. 2, e024077, 2024. e-ISSN: 1982-5587. DOI: https://doi.org/10.21723/riaee.v19iesp.2.18572

| **Submitted:** 09/10/2023
| **Revisions required**: 16/02/2024
| **Approved**: 20/03/2024
| **Published**: 20/07/2024

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ABSTRACT: The article presents the study, of a bibliographic nature, on teaching Mathematics from a creative and innovative perspective. By surveying articles on Mathematics teaching published in the Revista Ibero-Americana de Estudos em Educação, we sought to identify the role of pedagogical practices in breaking aversions to the mathematics curricular component. From the analyzes undertaken, it was possible to identify the following as practices of a creative and innovative nature: (i) student participation in proposing teaching material; (ii) use of mathematical games, interactive digital whiteboards, manipulative materials and literature books that allow students to discuss real situations in their daily lives; (iii) use of assistive technologies in a collective and collaborative way, favoring inclusive education. It was also found that all articles deal with practices in the context of teaching Mathematics in Basic Education, leaving the question of how practices occur in Higher Education, within the scope of teacher training courses.

KEYWORDS: Teaching Mathematics. Pedagogical Practice. Creativity. Innovation.

***RESUMO**: O artigo apresenta o estudo, de cunho bibliográfico, sobre a docência em Matemática em perspectiva criativa e inovadora. Por meio do levantamento de artigos sobre o ensino de Matemática publicados na Revista Ibero-Americana de Estudos sobre Educação, buscou-se identificar a função das práticas pedagógicas na ruptura de aversões ao componente curricular matemática. Das análises empreendidas, constatou-se como práticas de caráter criativo e inovador: (i) participação dos alunos na proposição de material didático; (ii) uso de jogos matemáticos, lousa digital interativa, materiais manipulativos e livros de literatura que permitam a problematização com situações reais do cotidiano dos alunos; (iii) uso de tecnologias assistivas de forma coletiva e colaborativa, favorecendo uma educação inclusiva. Constatou-se também que todos os artigos tratam de práticas no contexto do ensino de Matemática na Educação Básica, deixando a indagação de como as práticas ocorrem no Ensino Superior, no âmbito dos cursos de formação de professores.*

***PALAVRAS-CHAVE**: Ensino de Matemática. Prática Pedagógica. Criatividade. Inovação.*

***RESUMEN**: El artículo presenta el estudio bibliográfico sobre la enseñanza de las Matemáticas en una perspectiva creativa e innovadora. A través de la revisión de artículos sobre la enseñanza de la Matemática publicados en la Revista Iberoamericana de Estudios sobre Educación, se buscó identificar el papel de las prácticas pedagógicas en la ruptura de las aversiones al componente curricular de las matemáticas. A partir de los análisis realizados, se encontró que se encontraron las siguientes prácticas creativas e innovadoras: (i) participación de los estudiantes en la propuesta de material didáctico; (ii) uso de juegos matemáticos, pizarra digital interactiva, materiales manipulativos y libros de literatura que permitan la problematización de situaciones reales en la vida cotidiana de los estudiantes; (iii) uso de tecnologías de apoyo de manera colectiva y colaborativa, favoreciendo la educación inclusiva. También se encontró que todos los artículos tratan sobre prácticas en el contexto de la enseñanza de la Matemática en la Educación Básica, dejando la cuestión de cómo ocurren las prácticas en la Educación Superior, dentro del ámbito de los cursos de formación docente.*

***PALABRAS CLAVE**: Enseñanza de Matemáticas. Práctica Pedagógica. Creatividad. Innovación.*

Introduction

Every day we deal with situations that involve problematizing, systematizing and proposing resolutions, integrating Mathematics into our daily lives. Everyday actions such as producing a cake based on your recipe, shopping in supermarkets, or in social groups when social gatherings are organized, lead us to recover mathematical knowledge and insert it into our daily activities. However, as a curricular component, Mathematics can become distant and disconnected from daily life.

From the perspective of Nunes (2011), Mathematics is a human activity, but also Science, as the learning process at school "[...] is a moment of interaction between mathematics organized by the scientific community, that is, formal mathematics, and mathematics as a human activity" (Nunes, 2011, p. 28, our translation). However, the author warns us that this articulation between science and human activity has not occurred, since "[...] mathematics teaching is traditionally done without reference to what students already know", and also in provoking the challenge of "[...] looking for ways to use the daily mathematical knowledge of students in the classroom" (Nunes, 2011, p. 38, our translation).

In this article, we seek to reflect on practices aimed at creativity and innovation in terms of their contribution to less exclusive Mathematics teaching, understanding creativity in relation to teaching as a double interconnected movement: as a process of teaching with creativity and as teaching creative. Therefore, it is not enough for the teacher to have creative practices, if they do not allow students possibilities so that they can "[...] nurture and express their own creativity" (Neves-Pereira; Alencar, 2018, p. 7, our translation).

For Braun, Fialho and Gomez (2017), this creative dimension needs to permeate the classrooms in order to bring about changes in the way of teaching, because, "[...] as a teaching organization, the school must work on this concept of education and creativity, allowing the student to be creative and for this, promoting creativity practices" (Braun; Fialho; Gomez, 2017, p. 583, our translation).

Our premise that Mathematics in schools based on creative teaching will provide innovative practices led us to carry out this bibliographic study, through a survey of articles on the teaching of Mathematics published in the Revista Ibero-Americana de Estudos em Educação. The objective was to identify, in the publications of the aforementioned Journal, the function of the pedagogical practices proposed and investigated in their creative and innovative potential, as we believe that this potential can help in breaking aversions to the mathematical

curricular component and the construction of affectivity, since which is usually understood as aversive and, at the same time, considered as a defining element of intelligence (Lima, 2018).

The text is organized into four parts, the first being the introduction and the second presenting the methodological path used to survey, organize and analyze the articles. The data are then presented and discussed and, finally, our final considerations are included.

Methodological choices for the selection and analysis of articles

To carry out the survey and selection of articles, we made the following choices, based on the guidelines of Morosini, Kohls-Santos and Bittencourt (2021): (a) repository of scientific publications; (b) time frame; (c) definition of search terms; (d) criteria for systematization, organization and analysis.

Regarding the first orientation, we chose the Revista Ibero-Americana de Estudos em Educação, which had its first issue published in 2006, and provides a search engine on its Portal that was used to select articles for this discussion. Therefore, we did not make a time frame, as the search was carried out since the first published issue. As for the search term, we used "Mathematics Teaching".

After selecting the articles, we moved on to choosing the criteria for systematization, organization and analysis of the data, which consisted of grouping the articles following the steps proposed by Morosini, Kohls-Santos and Bittencourt (2021) in the form of tables in: (i) annotated bibliography; (ii) systematized bibliography; (iii) categorized bibliography; and (iv) propositional bibliography. We highlight that this form of systematization is anchored in some of the elements of Bardin's (2016) French content analysis.

As mentioned, without the period restriction, the survey brought us 26 articles between 2007 and 2022 that were systematized in the annotated bibliography table, presenting the name of the authors, title, abstracts and keywords. We then moved on to the second stage, which is the systematized bibliography, which refers to a floating reading of the material for the purpose of making a second selection, leaving only publications that actually discussed the Mathematics curricular component, which resulted in 10 articles. After reading these articles in full, we move on to the third stage (categorized bibliography) which, according to Morosini, Kohls-Santos and Bittencourt (2021), consists of a more in-depth analysis of the content of the texts with the purpose of grouping the production in themed blocks. Considering the objective of this study, which consisted of analyzing the role of pedagogical practices in teaching Mathematics for

creativity and innovation, we grouped the articles under the theme "pedagogical practice". From this exercise, we excluded three articles because they were not directly related to the practice, therefore remaining seven articles, as indicated in Table 1.

Table 1 - List of selected articles

Article title	Authors
The issue of the quality of mathematics teaching material in the education of young people and adults in Brazil	Menezes and Logarezzi (2007)
Contributions to understanding what it means to develop students' logical reasoning: study of the book Alice in Wonderland	Vilela and Dorta (2010)
Learning objects and interactive whiteboards: a proposal for evaluating learning objects for teaching mathematics	Fiscarelli, Morgado and Félix (2016)
Mathematical literacy games for students with visual impairments from an inclusive perspective	Mamcasz-Viginheski, Silva, Shimazaki and Pinheiro (2019)
Assistive technologies in mathematics teaching and learning for blind students: investigating the presence of universal design and universal design for learning	Jeremias, Góes and Haracemiv (2021)
Soroban as a mediating instrument for conceptual appropriation in intellectual disability	Mamcasz-Viginheski, Shimazaki and Silva (2021)
Contributions of Vygotskian thought to mathematical modeling	Silva, Braga and Giordano (2021)

Source: Prepared by the authors

After categorization, we reached the last stage (propositional bibliography), which consisted of analyzing, in the selected articles, pedagogical practices in terms of creativity and innovation, the discussion of which is presented below.

Pedagogical practices for creativity and innovation in Mathematics teaching

For Souza and Pinho (2016, p. 1910, our translation), creativity implies "[...] an originality to overcome expectations", which in educational space-time is usually associated with overcoming difficulties. However, creativity is not necessarily innovative, as innovation implies "[...] a paradigmatic rupture and not the inclusion of new things" (Cunha, 2006, p. 40, our translation). Having this basis, when we look at the articles selected for analysis, we will follow a diversity of actions that are sometimes creative, sometimes innovative, sometimes both.

Of the seven articles analyzed, one is a theoretical essay on teaching practice in Mathematics, the others address practices within the scope of Basic Education, two in the context of Youth and Adult Education (EJA), two in the Initial Years of Elementary School (1st to 5th year) and two in the Final Years of Elementary School (6th to 9th year), as seen in Table 2.

Table 2 - Organization of articles according to the research locus

Research Locus	Authors
Elementary School I (1st to 5th year)	Menezes and Logarezzi (2007) Vilela and Dorta (2010)
Elementary School II (6th to 9th year)	Fiscarelli; Morgado; Felix (2016) Jeremiah; Goes; Haracemiv (2021)
Youth and Adult Education (EJA)	Menezes and Logarezzi (2007) Mamcasz-Viginheski, Silva, Shimazaki and Pinheiro (2019)
No specification as it is a theoretical test	Silva, Braga and Giordano (2021)

Source: Prepared by the authors

Menezes and Logarezzi (2007) discuss the adaptation and translation of a Mathematics book in Spanish for EJA. As a characteristic and facilitating aspect of bringing the content closer to its target audience, the fact that the original book was produced in partnership between the authors and the students of this teaching modality, which brings the proposed discussions closer to the reality found, valuing the entire moment, the knowledge already acquired and which these students bring to the school learning journey. As it is a book written for the Spanish reality, EJA students indicated the difficulty and need to adapt some examples and proposals from the publication, bringing the text closer to the Brazilian reality they know and experience. Likewise, the researchers warn that the contents covered did not correspond to the totality of contents that Brazilian legislation proposes for the EJA cycle, thus, adjustments were necessary throughout the use of the book as teaching material.

The authors point out that, despite these cultural dissonances, the book brought important results when used, precisely because it was created with the help of EJA students. This brought the training reality closer to the daily reality of these students, facilitating the learning processes and making them more attractive, especially as it concerns the mathematics curricular component.

This article presents us with a creative initiative to propose teaching material that is unique in its own creation, as it involves the participation of EJA students, which brings languages and expectations closer together. At the same time, we can also identify a degree of innovation, by breaking the constraint of producing textbooks exclusively by renowned authors, who have knowledge that could be considered superior to that of the users of these books.

The article by Vilela and Dorta (2010) addresses the development of logical reasoning in students as one of the focuses of school Mathematics, problematizing what this action would be beyond the reasoning process itself. The authors use as a starting point the book “Alice in Wonderland”, by Lewis Carroll, which, according to them, discusses:

> [...] characteristics of logic and a reflection on it through logical contradictions, circular arguments, difficulties in the concept of identity, development of syllogisms and fallacies, and even its taste for paradoxes and consensus, running up against the limits of language (Vilela; Dorta, 2010, p. 2, our translation).

The article presents a form of pedagogical use of world literature in a different way, as it relates elements of classical logic, which is part of the content of elementary school, with the events narrated in the classic work, stimulating creativity and imagination in children, marking a position in the creativity in the use of a material.

Fiscarelli, Morgado and Félix (2016) start from the proposition of using technologies, specifically the interactive digital whiteboard, as a form of methodological innovation with the potential to improve student learning. Based on the fact that mathematical learning is complex, not only due to the characteristics of the content itself, but due to all the cognitive, cultural and social aspects of the students who are involved, the authors evaluate learning objects that can be used on a digital whiteboard, concluding that potential of learning facilitators of these objects as "innovative and enriching educational experiences" (Fiscarelli; Morgado; Félix, 2016, p. 359, our translation). This experience would be more in line with the innovation as Cunha (2006) proposes, due to the very characteristic of using an interactive technology that is based on an educational paradigm of participation and construction of knowledge by students.

Mamcasz-Viginheski *et al.* (2019) work with the concept of mathematical literacy to discuss the use of games as part of the methodology for including students with visual impairments in basic education. Pointing out that the traditional use of soroban and the Braille code provide mechanical learning, the authors consider that this use:

> [...] appears productive for both the teacher and the student. In relation to the teacher, for using the game as an instrument to facilitate student learning and, to the student, for allowing them to develop their ability to think, reflect, analyze, raise hypotheses, testing and evaluating them, building their knowledge with autonomy and cooperation with their colleagues (Mamcasz-Viginheski *et al.,* 2019, p. 411, our translation).

By exemplifying the use of some mathematical games that are easy to implement in the classroom - such as puzzles and logic blocks - the authors conclude by the benefits that students with blindness obtain in their learning, as they are configured as "[...] mediating instrument that provides conditions for the student to think, question, decide, value and, in this way, helps in the elaboration of knowledge and, consequently, the formation of citizenship" (Mamcasz-Viginheski *et al.,* 2019, p. 417, our translation). However, they reinforce, there is a need for the

teacher to have the sensitivity to understand the specific needs of each student, and provide learning strategies that effect the inclusion of students with blindness.

The authors operate with the binomial creativity and innovation, by proposing a new use for materials already recognized and used by teachers for teaching mathematics, proposing to break with the understanding that there are games that are useful and games that are not useful for students with visual impairments.

Jeremias, Góes and Haracemiv (2021) will also address students with blindness in their potential for learning mathematics, bringing assistive technologies and their production process based on the Universal Design for Learning approach. Through the analysis of two manipulable teaching resources, the authors indicate that the use of assistive technologies "[...] allows students access to curricular content, as opposed to materials for the exclusive use of an individual, which excludes them from socialization and collective learning in the common classroom environment" (Jeremias; Góes; Haracemiv, 2021, p. 3018, our translation). They defend the need to expand the dissemination and contact of teachers with this type of material and with the conception of Universal Design, in order to allow teachers to understand inclusion based on the effective participation of all students.

In the same way as the previous article, by Mamcasz-Viginheski *et al.* (2019), this also operates in the creativity/innovation binomial, when approaching mathematical learning by blind students through the insertion of a new conception of material production, Universal Design, and the use of assistive technologies.

Mamcasz-Viginheski, Shimazaki and Silva (2021) will discuss the use of Soroban as teaching material for mathematical learning used with students with intellectual disabilities. The authors start from previous observation of children with intellectual disabilities who usually "[...] expressed difficulty in understanding the concept of number and the principles of the decimal number system" (Mamcasz-Viginheski; Shimazaki; Silva, 2021, p. 3164, our translation) to develop a teaching material called Golden Soroban, based on the concept of assistive technologies for learning for children with disabilities.

Proposing the use of this material as a calculation tool for children with intellectual disabilities, in addition to the already established use with children with visual impairments, the authors indicate that they do not consider intellectual disability an impediment to mathematical learning, however, it is necessary for the teacher to do use of "appropriate signs and mediating instruments" (Mamcasz-Viginheski; Shimazaki; Silva, 2021, p. 3173, our translation), proving

that the use of Golden Soroban managed to promote learning among this audience that has its own specificities.

The authors greatly expand the use of the creativity/innovation binomial by creating new mathematics teaching material, based on an already established teaching concept, but which is not usually applied to the target audience they propose.

Silva, Braga and Giordano (2021) start from Vygotski's historical-cultural theory and Mathematical Modeling to propose an epistemologically differentiated action in teaching practice in mathematics teaching. They propose that both the teacher and the group of students act as learning mediators, using "[...] realistic mathematical problems, contextualized in the universe of students' interests, aligned with the needs of the local community" (p. 1690, our translation). Providing everyone with the experience of "[...] living, dynamic Mathematics, centered on their reality, in a meaningful way for them, that is, that in and through the relationship with it and with others they can produce meaning at school and in other social spaces." (p. 1691, our translation).

By proposing a rupture in teaching practice based on an already recognized theoretical-conceptual conception, Silva, Braga and Giordano (2021) innovate by revealing a dissonance between discourse and practice. A discourse that tends to place the student at the center of learning, as participatory and active, but which implies a transmitting and reproductive practice on the part of some teachers.

Final remarks

From the analysis undertaken of the articles selected in this study, it was possible to see possibilities for teaching Mathematics focused on creativity and innovation, indicating the need to break with a fragmented teaching that is disconnected from the students' reality. The research presented points to several practices that have a creative, as well as innovative, character when considering the reality and the participation of students in proposing teaching material.

A constant aspect in the texts analyzed is the need to consider the student as the center of the teaching and learning process, understanding him as a mediator, breaking with the idea of Mathematics teaching disconnected from the reality of the school and the students. Even though this pedagogical proposal is not in itself innovative, as it has already been suggested since the Manifesto of the Pioneers of New Education (Azevedo, 1932), we have not yet found it as a general practice.

This mediating and inclusive action can have an important impact on breaking the aversive process that the mathematics curricular component sometimes presents to students at different levels and educational modalities, who, when feeling unable to follow the content, do not distinguish between their own difficulty or a difficulty caused by the lack of practices aimed at variations in learning characteristics. This leads students to move away from Mathematics and consider it boring, difficult, and completely disconnected from reality.

In this sense of reconnecting mathematical content to everyday life and overcoming aversions, the importance of pedagogical work became evident through the use of technologies such as interactive digital whiteboards, as well as mathematical games and literature books, so that students question, problematize based on real situations in their daily lives. Assistive technologies are also highlighted in a collective and collaborative way as practices aimed at the inclusion of people with disabilities in Mathematics classes.

It is worth noting that, although the articles analyzed bring up the use of technologies as ways of innovating, they do not deal with technologies as an innovation in themselves, problematizing it and inserting it into the contexts of analysis.

From the general assessment, we found that all articles deal with practices in the context of teaching Mathematics in Basic Education, which provoked us to think about how creativity and innovation occur in the context of Higher Education, in teacher training courses.

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Acknowledgments: Not applicable.

Financing: Not applicable.

Conflicts of interest: There are no conflicts of interest.

Ethical approval: Not applicable, as this is bibliographic research in a public archive.

Availability of data and material: All articles used as data sources can be accessed through the RIAEE Platform.

Author contributions: All authors participated in all stages of production of the work.

Processing and editing: Editora Ibero-Americana de Educação.
Review, formatting, standardization, and translation.