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Meanings and senses about creative thinking and creativity in mathematics: a systematic review

Significados e sentidos sobre pensamento criativo e criatividade em Matemática: uma revisão sistemática

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Abstract

This systematic literature review discusses meanings and senses about creative thinking and creativity in Mathematics, presented in national and international scientific productions, intertwined with experiences in teacher training and practice; it describes and analyzes the contributions of research on creative thinking and creativity in Mathematics to teacher training and practice and to teaching-learning processes. A systematic review was used as a type of research that enabled the search for bibliographic data in different databases. The data reveals the need to provide the experience of creative thinking and creativity in Mathematics, considering the contributions of the meanings and senses of these terms, shared in the systematic literature review and woven into the training experiences, in the places of formative and dialogical meetings at the university and at the primary school.

Keywords: Creativity in mathematics; Creative thinking; Teacher training and practice; Teaching and learning.

Resumo

Esta revisão sistemática de literatura discute significados e sentidos sobre pensamento criativo e criatividade em Matemática, apresentados nas produções científicas nacionais e internacionais, entrelaçadas às vivências na formação e na prática docente; descreve e analisa as contribuições das pesquisas sobre o pensamento criativo e a criatividade em Matemática para a formação e a prática docente e para os processos de ensino-aprendizagem. Utilizou-se a revisão sistemática como uma modalidade de pesquisa que possibilitou a busca de dados bibliográficos em diferentes bases. Os dados revelam a necessidade de proporcionar a vivência do pensamento criativo e da criatividade em Matemática, considerando as contribuições dos significados e dos sentidos desses termos, compartilhados na revisão sistemática de literatura e tecidos nas experiências formadoras, nos lugares de encontros formativos e dialógicos na universidade e na escola básica.

Palavras-chave: Criatividade em Matemática; Pensamento criativo; Formação e prática docente; Ensino-aprendizagem.

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Introduction

The systematic literature review as a type of scientific research (Galvão & Ricarte, 2019) and as a specific methodology (Denyer & Tranfield, 2009) for searching the different bibliographic databases consulted, nationally and internationally, made it possible to analyze and understand the theoretical and practical foundations of creative thinking and creativity in Mathematics in scientific productions that explicitly or implicitly dialogue with the training and teaching practice of teachers who teach (or will teach) Mathematics in basic education.

In the context of the systematic literature review experienced in this study, the specific protocols used in the research (Galvão & Ricarte, 2019; Petticrew & Roberts, 2006) contributed to "locating existing studies, selecting and evaluating contributions, analyzing and synthesizing data, and reporting the evidence in such a way as to allow reasonably clear conclusions about what is and is not known" (Denyer & Tranfield, 2009, p. 671).

Thus, this research used some of the steps that make up the development of a systematic literature review (Denyer & Tranfield, 2009; Galvão & Ricarte, 2019; Petticrew & Roberts, 2006), such as "delimiting the question to be addressed in the review; selecting bibliographic databases for consultation and collection of material; developing advanced search strategies; selecting texts and systematizing the information found" (Galvão & Ricarte, 2019, p. 62). We will discuss each of the stages in the next section, which will certainly contribute to the experience of this research methodology in different areas of knowledge, especially Mathematics Education.

The formative experiences we, the author of this article, have had in formative and dialogical meetings in university and elementary school training spaces, as well as the scientific productions selected in the systematic literature review process, have contributed to defining the theme - "creative thinking and creativity in mathematics in teacher training and practice" - and the question being investigated: "*What theoretical and practical meanings and senses of creative thinking and creativity in mathematics are presented in scientific productions, intertwined with experiences in teacher training and practice and in mathematics teaching-learning processes?* ". Thus, the corpus of analysis involves the theoretical and practical foundations of the keywords - "creative thinking" and "creativity in mathematics" - presented and discussed in scientific articles in Portuguese, English and Spanish, which we will share in the following sections of this text.

The theoretical-practical discussions of these keywords in the scientific articles that we will present in Frame 1, in the following section, reveal "that words produce meaning, create realities and sometimes function as powerful mechanisms of subjectivation" (Larrosa, 2002, pp. 20-21; Larrosa, 2022, p. 16). In this way, we corroborate the author's statement, because "creative thinking" and "creativity in Mathematics" have involved us in our training activities at the university and at the elementary school, in the teaching, extension and research projects in which we work as a teacher-trainer-researcher, as well as in the teaching-learning processes of Mathematics in classes of curricular components in these different training spaces, in which we have experienced problematizing and creative practices in

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Mathematics.

In this context, openness to innovative ideas, strategies and processes (Araya, 2021; Costa et al., 2021; Fonseca & Gontijo, 2020; Khalid et al., 2020; Miranda & Mamede, 2022; Nadjafikhah & Yaftian, 2013) requires the experience of creative thinking and creativity in Mathematics. In this way, how can we stimulate, in the formative and dialogical encounters in the training and pedagogical practice of teachers who teach (or will teach) this curricular component in basic education, what these authors propose in the teaching-learning processes of Mathematics? What mathematical activities contribute to the development of creative thinking and creativity in mathematics?

These questions will be the subject of reflection in this article, which aims to: discuss the theoretical and practical meanings and senses of creative thinking and creativity in Mathematics, presented in national and international scientific productions, intertwined with experiences in teacher training and practice; describe and analyze the contributions of research on creative thinking and creativity in Mathematics to teacher training and practice and to Mathematics teaching and learning processes. Thus, we will share the thematic analysis (Bardin, 1977; Bauer, 2017; Minayo, 2014) of the scientific productions in the categories entitled "Theoretical and practical meanings and senses of creative thinking and creativity in Mathematics in scientific productions, teacher training and practice" and "Creative and problematizing practices that can stimulate creative thinking and creativity in Mathematics in teaching-learning processes".

In order to present and discuss the theme investigated from the systematic literature review, we have organized the article into four sections. In the first, we will present the stages used in the systematic literature review process. In the second, we will discuss the scientific productions resulting from searches in the bibliographic databases consulted, considering the keywords: "creative thinking", "creativity in mathematics", "creative thinking", "creativity in mathematics", "pensamiento creativo" and "creatividad en matematicas". Next, we will share the thematic units that make up the corpus of analysis and, finally, the final considerations.

Stages experienced in the systematic literature review process

For the production and analysis of bibliographic data through systematic literature review, the steps proposed by researchers are essential for the rigor of the methodological procedures used in each moment experienced in this "research modality, which follows specific protocols, and which seeks to understand and give some logicality to a large documentary corpus, especially by verifying what works and what does not work in a given context" (Galvão & Ricarte, 2019, p. 58).

The systematic literature review is a method that seeks to answer the guiding research question, map areas of uncertainty in the interpreted bibliographic data and identify the results of the investigated theme and which studies are needed (Petticrew & Roberts, 2006).

When conducting a systematic literature review, "the researcher must define pre-

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specified relevance and quality criteria for the selection/inclusion of studies and make these criteria transparent to readers" (Denyer & Tranfield, 2009, p. 671). For this reason, the protocols used in each stage of the systematic literature review are important for searching the databases.

The five stages experienced in this research's systematic literature review reveal the consistency of the search in the bibliographic databases consulted - Portal de Periódicos Capes, SciELO, Scopus, Web of Science and ERIC. Thus, each stage contributed to the production and thematic analysis of the bibliographic data shared in this study.

The first stage of the systematic literature review - "Delimiting the question" (Galvão & Ricarte, 2019) or "Formulating the question" (Denyer & Tranfield, 2009; Petticrew & Roberts, 2006) must explicitly include a well-defined question that is intended to be investigated and answered. Thus, "the existence of a well-defined question will be essential for the other stages of the literature review to be developed" (Galvão & Ricarte, 2019, p. 63). Therefore, we sought to delimit the guiding question of the research - *What meanings and theoretical-practical meanings of creative thinking and creativity in Mathematics are presented in scientific productions, intertwined with experiences in teacher training and practice and in Mathematics teaching-learning processes?* -, as well as the objectives: to discuss the meanings and theoretical-practical meanings of creative thinking and creativity in Mathematics, presented in national and international scientific productions, intertwined with experiences in teacher training and practice; to describe and analyze the contributions of research on creative thinking and creativity in Mathematics to teacher training and practice and to Mathematics teaching-learning processes.

In the second stage, "Selecting databases" (Galvão & Ricarte, 2019) or "Locating studies" (Denyer & Tranfield, 2009), we determined "which databases will be consulted to search for articles and other bibliographic materials that can be included or excluded from the intended literature review" (Galvão & Ricarte, 2019, p. 64). Thus, the bibliographic databases consulted in this research were: Portal de Periódicos Capes, SciELO, Scopus, Web of Science and ERIC.

In this respect, we would point out that the different searches in these databases were aimed at "locating, selecting and evaluating as much of the relevant research as possible ..." (Denyer & Tranfield, 2009, p. 683), considering the guiding question of this study and its objectives.

The third stage, "Elaboration of the search strategy" (Galvão & Ricarte, 2019; Petticrew & Roberts, 2006), includes "existing technological procedures and mechanisms" (Galvão & Ricarte, 2019, p. 65), which make it possible to locate and analyze information relating to the topic researched in the systematic review process. This stage is a "procedure for identifying evidence for a systematic review. This includes specifying sources (such as databases), keywords and search terms" (Petticrew & Roberts, 2006, p. 282).

At this stage, we defined the following search strategies: keywords and their combinations with the Boolean operator AND to filter out scientific productions that address

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the meanings and theoretical-practical meanings of the keywords defined in accordance with the guiding question and the research objectives. We used the following keywords combined with AND in Portuguese, English and Spanish in the five selected bibliographic databases: "pensamento criativo" AND "criatividade em Matemática", "creative thinking" AND "creativity in mathematics", "pensamiento creativo" AND "creatividad en matematicas".

Other Boolean operators can be used in the search strategy process, such as: "OR - select records that contain at least one of the parameters used in a search. NOT - select records that do not contain certain search parameters" (Maldonado, 2013, pp. 26-28). Indeed, Boolean operators contribute to the "construction of advanced search strategies, where AND is equivalent to intersection, OR is equivalent to union and AND NOT is equivalent to exclusion" (Galvão & Ricarte, 2019, p. 67).

In order to systematize the data obtained from the bibliographic databases consulted, after reading the title, abstract, keywords and full text of the scientific article selected in the systematic review, we used, as a strategy for synthesizing the data, the organization of the abstracts of the scientific productions saved in a Word file on the notebook of the first author of this research. Based on interpretative and investigative readings of the named texts, we highlighted with the colors yellow and red all the parts of the text that contemplate the meanings and theoretical-practical meanings, respectively, of "creative thinking" and "creativity in mathematics" in the three languages already specified. We then drew up Frame 1, which we'll share in the next section, with the following data: **Author(s)/Year, Title of articles, Research objectives, Journals, Databases.** Finally, Table 1, which we will present in the fourth stage of the systematic review, will provide information on the search results in the databases.

In "Elaborating the search strategy", we selected only peer-reviewed and open-access scientific articles on the platforms of the databases consulted, with a time frame from 2010 to 2022.

The fourth stage, "Selection and systematization of documents" (Galvão & Ricarte, 2019), consists of using criteria to include or exclude the documents found in the bibliographic databases. According to Petticrew and Roberts (2006), some documents can be safely excluded after an interpretative analysis of the abstract and full text to check whether they meet the inclusion and exclusion criteria defined in the systematic review.

The scientific articles in the systematic review were selected according to the following inclusion criteria: studies that included the keywords defined in the search process; time frame from 2010 to 2022; only scientific productions written in Portuguese, English and Spanish; studies on the meanings and theoretical-practical meanings of creative thinking and creativity in mathematics in the different contexts of teacher training and practice.

As exclusion criteria, we determined those that did not meet the inclusion factors presented, namely: studies that discussed only one keyword defined in the systematic review stage; scientific productions before 2010; articles written in a language other than Portuguese,

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English and Spanish; studies on creative thinking and creativity in mathematics that do not dialog with the research question and objectives.

Thus, the shared inclusion and exclusion criteria helped "to assess the relevance of each study found and to check whether it really addresses the review question" (Denyer & Tranfield, 2009, p. 684), as well as the research objectives. Table 1 below shows the number of scientific articles identified, excluded and selected in the search results in the bibliographic databases consulted in the second half of 2022.

Table 1: *Number of scientific articles selected in the database search process*

Database search results	***Capes Periodicals Portal***	***SciELO***	***Scopus***	***Web of Science***	***ERIC***	**Total**
Identified articles	27	6	9	14	8	64
Excluded articles	17	5	5	13	7	47
Selected articles	10	1	4	1	1	17

Source: Prepared by the authors of this article.

The organization of this table contributed to the process of thematic analysis of the scientific articles shared in Frame 1, which we will discuss in the fifth stage of the systematic review and in the categories that make up the corpus of analysis of the research.

Frame 1: *Summary of themes, objectives and authors for the corpus of research analysis*

Author(s) / Year	**Article titles**	**Research objectives**	**Journals**	**Databases**
Nadjafikhah e Yaftian (2013)	The frontage of creativity and mathematical creativity	Present an overview of the definitions and characteristics of creativity based on contemporary literature.	*Procedia: Social and Behavioral Sciences*	Capes Journal Portal
Gilat e Amit (2014)	Exploring young students creativity: the effect of model eliciting activities	Show how involving students in real-life mathematical situations can stimulate their creative mathematical thinking.	*PNA*	Capes Journal Portal
Llorente Aguilera et al. (2014)	Potencialidades creadoras de los estudiantes de preuniversitario mediante el aprendizaje de las matemáticas	Encourage the development of creative potential, in particular the flexibility of students' thinking.	*Didáctica y Educación*	Capes Journal Portal
Panaoura e Panaoura (2014)	Teachers' awareness of creativity in mathematical teaching and their practice	Investigate new teachers' perceptions of creativity in mathematics and, above all, their ability to transfer pedagogical knowledge to mathematical creativity in their lesson plans suggested as an indication of practice.	*IUMPST: The Journal*	*ERIC*
Ayllón Blanco et al. (2016)	Mathematical thinking and creativity through invention and mathematical problem solving.	Show the relationship between the development of mathematical thinking and creativity with the invention and resolution of mathematical problems.	*Propósitos y Representaciones*	Capes Journal Portal
Torres Soler (2018)	Mathematics, a strategy for creative thinking	Investigate creative characteristics that teachers and students possess.	*Revista Ingeniería, Matemáticas y Ciencias*	Capes Journal Portal

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Santos e Santana (2019)	Creativity in mathematics: a mapping of theoretical and practical aspects	Analyze the theoretical or practical aspects of creativity in mathematics; interpret proposals on how to develop or attribute creativity in mathematics.	*Educação Matemática em Revista*	Capes Journal Portal
Fonseca e Gontijo (2020)	Critical and creative thinking in mathematics in national curriculum guidelines	Discuss theoretically critical and creative thinking, particularly in the field of mathematics; exemplify through activities how critical and creative thinking can be stimulated in the classroom.	*Ensino em Re-Vista*	Capes Journal Portal
Khalid et al. (2020)	Enhancing creativity and problem solving skills through creative problem solving in teaching mathematics	Stimulating creativity by teaching mathematics through problem solving that challenges creative problem solving, which is defined as creative problem solving.	*Creativity Studies*	Capes Journal Portal *Scopus*
Araya (2021)	Promoting creative thinking in the mathematics classroom: two case studies in elementary classrooms.	To understand the way in which teaching practices, characterized based on the model of analysis of teaching environments, act to enable or inhibit the emergence of creative mathematical thinking in the classroom.	*Bolema: Boletim de Educação Matemática*	*SciELO*
Costa et al. (2021)	Creativity workshops in mathematics: an experience in the early years	To carry out an intervention in creativity in the field of mathematics, with a focus on stimulating divergent thinking, in order to analyze the effects of using creativity techniques on the academic performance, motivation and critical and creative thinking in mathematics of students in the early years of elementary school.	*Zetetiké*	Capes Journal Portal
Munakata et al. (2021)	Promoting creativity in general education mathematics courses	To describe the development and implementation of course modules course modules designed to stimulate creative thinking in a general education undergraduate mathematics course.	*PRIMUS*	*Scopus*
Miranda e Mamede (2022)	Appealing to creativity through solving and posing problems in mathematics class	To understand how 6th grade students understand problem solving and formulation, identifying their problem solving strategies, their skills and their difficulties when formulating and solving problems.	*Acta Scientiae*	*Scopus*
Newton et al. (2022)	'Allowing them to dream': fostering creativity in mathematics undergraduates	To identify some of the obstacles to promoting creative thinking in mathematics undergraduates arising from tutors' notions about mathematical creativity and its place in education.	*Journal of Further and Higher Education*	Capes Journal Portal *Scopus Web of Science*

Source: Prepared by the authors of this article.

As shown in Table 1, in the search results in the databases, we selected 17 scientific articles that relate to the research. However, in Frame 1 there are 14 articles, because 3 are

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repeated in the databases consulted. Next, we will reflect on the results of the studies carried out by the researchers cited, mapping, describing and systematically analyzing the contributions of research into creative thinking and creativity in mathematics.

Finally, the fifth stage, "Analysis of the data from the scientific productions", allows the reviewers/researchers to "systematically describe, report, tabulate and integrate the results of the studies" (Petticrew & Roberts, 2006, p. 286), taking into account the guiding question of the research and the objectives set for its realization. Thus, the type of analysis chosen allowed for an in-depth and broader understanding and interpretation of the data produced in the research.

The scientific productions shown in Frame 1 make up the corpus of thematic analysis, which is a type of content analysis (Bardin, 1977; Minayo, 2014). Thus, "the notion of theme is linked to a statement on a particular subject. It involves a bundle of relationships and can be graphically presented through a word, a phrase or a summary" (Minayo, 2014, p. 315). We emphasize that words, phrases and summaries made up the thematic analysis of the subject under investigation and were relevant in the categories created.

In addition to this concept of theme, we emphasize that "it is the unit of meaning that

naturally emerges from a text analyzed according to certain criteria relating to the theory that guides the reading" (Bardin, 1977, p. 105). In the scientific articles analyzed, the interpretative and investigative readings of the full texts made it possible to identify and discuss the theoretical and practical meanings and senses of "creative thinking" and "creativity in mathematics" in Portuguese, English and Spanish.

In this context, we emphasize that "meaning and sense, for Vygotsky, are not the same thing", since "for him, in internal speech, meaning predominates over meaning. In internal speech, or speech to oneself, the word is much more loaded with meaning than in speech to others, or external speech" (Prestes, 2010, p. 81). The different meanings attributed to the keywords "creative thinking" and "creativity in mathematics" in Portuguese, English and Spanish by the authors of the scientific articles (Frame 1) will be presented and discussed in the following sections.

> Thus, meaning is always a dynamic, fluid, complex formation that has several zones of varying stability. Meaning is only one of these zones of meaning that a word acquires in the context of a discourse, and it is also a more stable, uniform and exact zone. As we know, in different contexts the word easily changes its meaning. The meaning, on the other hand, is an immovable and unchanging point that remains stable in all the changes of meaning of the word in different contexts (Vygotsky, 2001, p. 465).

To analyze the results of the scientific productions found in the systematic literature review process, we adapted the three stages of thematic analysis presented by Minayo (2014), in which the author appropriates the phases of content analysis - pre-analysis; exploration of the material; and treatment of the results, inference and interpretation - proposed by Bardin (1977). Therefore, "content analysis is a social construction. Like any viable construction, it

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takes into account some reality, in this case the text corpus, and it must be judged by its result" (Bauer, 2017, p. 203).

Therefore, through the three stages - pre-analysis of the selected documents; investigation of the data; approach and interpretation of the results obtained in the research - we will share the process of thematic analysis carried out in the context of the systematic literature review.

In the first stage, "Pre-analysis of the selected documents", we experienced a "floating" reading (Bardin, 1977; Minayo, 2014) of the scientific articles selected in the systematic literature review, entering into "direct and intense contact with the field material, allowing ourselves to be impregnated by its content" (Minayo, 2014, p. 316), with the aim of analyzing the data in a way that would allow us to understand its content. 316), with the aim of identifying and analyzing, in the texts read and interpreted in this first moment, the contributions of creative thinking and creativity in mathematics to teacher training and practice and to mathematics teaching and learning processes. In this way, we sought to get to know each scientific production and involve, in the analysis of the data, dialogues with our training practices, highlighting some training experiences lived in the context of the Doctorate in Education by the first author of the article, in the period from 2019 to 2022.

In the selected articles, we used the colors yellow and red to identify and analyze the meanings and theoretical-practical meanings (Frame 2) of "creative thinking" and "creativity in mathematics" in the three languages, according to the publication of the text. In the thematic categories, we will discuss the data in Frame 2, dialoguing with our training experiences.

Frame 2: *Theoretical and practical meanings of the keywords in the articles*

Scientific articles	Key words	Meanings	Theoretical and practical meanings
The frontage of creativity and mathematical creativity	Creative thinking	A dynamic mental process that involves divergent and convergent thinking in tasks or problems (Nadjafikhah & Yaftian, 2013).	Creative thinking processes include convergent thinking, which refers to the search for a single correct solution to a given task or problem. Divergent thinking, on the other hand, encompasses different solutions to the problem (Nadjafikhah & Yaftian, 2013).
	Creativity in Mathematics	At school level, creativity in mathematics is related to solving and formulating different problems (Nadjafikhah & Yaftian, 2013).	Students should have opportunities to solve challenging mathematical problems that can lead them to experiment with creativity and be encouraged to reflect on their own ideas (Nadjafikhah & Yaftian, 2013).
Exploring young students creativity: the effect of model eliciting activities	Creative thinking		Involve students in everyday mathematical situations to stimulate the development of creative thinking (Gilat & Amit, 2014).
	Creativity in Mathematics	Dynamic mathematical skill that can be experienced by students (Gilat & Amit, 2014).	Silver (1997) presents the approach of experiencing mathematical creativity through formulating and solving problems in terms of fluency, flexibility and novelty (Gilat & Amit, 2014).

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Creative potentialities of pre-university students through mathematics learning.	Creative thinking		Stimulating creative thinking processes in the formation of mathematical knowledge in pre-university students (Llorente Aguilera et al., 2014).
	Creativity in Mathematics		Stimulating mathematical creativity by solving and formulating problems involving situations from the students' sociocultural environment (Llorente Aguilera et al., 2014).
Teachers' awareness of creativity in mathematical teaching and their practice	Creative thinking		Presenting activities in math classes that students can solve in different ways, thus developing creative thinking. Creativity begins with curiosity. In this way, exploratory and investigative tasks can contribute to the development of students' creative thinking (Panaoura & Panaoura, 2014).
	Creativity in Mathematics	It is non-algorithmic decision-making, as well as divergent and flexible thinking, which allows us to seek different paths and perspectives when solving a problem (Levenson, 2013 cited by Panaoura & Panaoura, 2014).	In order to foster the mathematical creativity of their students, teachers must acquire adequate pedagogical knowledge during their training (Shriki, 2008 cited by Panaoura & Panaoura, 2014, p. 2).
Mathematical thinking and creativity through invention and invention and resolution of mathematical problems	Creative thinking	Nadjafikhah and Yaftian (2013) state that creative thinking is a dynamic mental process that encompasses divergent and convergent thinking (Ayllón Blanco et al., 2016, p. 179).	In order to properly develop mathematical thinking, invention and problem solving become fundamental tasks (Ayllón Blanco et al., 2016, p. 185).
	Creativity in Mathematics	Creativity is a form of problem-solving and vice versa; in other words, problem-solving is an effective way of developing creativity (Ayllón Blanco et al., 2016, p. 177).	Students have to learn to think, do and undo freely in order to unleash their imagination and generate new things (Ayllón Blanco et al., 2016, p. 186).
Mathematics, a strategy for creative thinking	Creative thinking		We need to be aware that mathematics, creatively contextualized in the classroom, is a source of energy for the development of creative thinking, abstraction and observation, among many other skills (Torres Soler, 2018, p. 24).
	Creativity in Mathematics	It is an ability or characteristic that leads to producing new and original ideas, and seeing hidden details (Torres Soler, 2018, p. 25).	A teacher who promotes creativity needs to show different alternatives to transmit knowledge, to make the concepts experienced by the student in their environment, which allows different ways of thinking, feeling and expressing, which can solve the exercises by the desired methods (Torres Soler, 2018, p. 24).
Creativity in mathematics: a mapping of theoretical and practical aspects	Creative thinking		Propose tasks that allow for creative thinking, so that students feel stimulated and challenged, committing themselves to finding appropriate solutions. In order to do this, it is necessary to motivate them to: variety in the forms of resolution (fluency), changes in thinking and strategies for resolution (flexibility) and the search for a resolution that diverges from the ordinary (originality) (Santos & Santana, 2019, p. 78).

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	Creativity in Mathematics		Creativity in mathematics can be seen as an alternative for diversifying lessons in this subject in the school context. In addition, it favors working on its contents through problem-solving and formulation situations which, in turn, bring students closer to the relationships that mathematical content has with everyday activities (Santos & Santana, 2019, p. 75).
Critical and creative thinking in mathematics in national curriculum guidelines	Creative thinking		Open-ended problems are especially important for the development of creative thinking in mathematics, as they allow the generation of many ideas (fluency), addressing different configurations of solutions (flexibility) and the possibility of unusual answers (originality) that can solve the problem adequately and reasonably (Fonseca & Gontijo, 2020, p. 973).
	Creativity in Mathematics	The ability to come up with numerous possibilities for an appropriate solution to a problem situation ... (Gontijo, 2007b, p. 38 referred to by Fonseca & Gontijo, 2020, p. 962).	Through creativity, we can find plausible plausible solutions and thus think about how we can improve this capacity for thought in our classrooms, improving the practice we adopt in educating our students. (Fonseca & Gontijo, 2020, p. 976).
Enhancing creativity and problem solving skills through creative problem solving in teaching mathematics	Creative thinking		Nurturing creativity in school is possible through continuous enrichment of the child's environment, such as the development of creative programs for creative thinking, and can be fostered in many content areas (Costa, 2001, p. 246 referenced by Khalid et al., 2020, p. 272).
	Creativity in Mathematics		In mathematics, creativity emerges when students devise and create new approaches to solving problems that are carefully planned by their mathematics teachers. Aspects of creativity appropriate to their level can be demonstrated as a result of their personal investigation (Khalid et al., 2020, p. 271).
Promoting creative thinking in the mathematics classroom: two case studies in elementary classrooms.	Creative thinking		Different aspects of teaching practices, such as challenging tasks, an institutionalization that incorporates students' ideas, validations that give the student back the responsibility for knowing, and fostering communication between peers and with the teacher, allowed students to show different creative productions such as the design of solution strategies, the emergence of new questions and the relationship between concepts (Araya, 2021, p. 1387).
	Creativity in Mathematics		It consists of the ability to generate new relationships and questions in which they take into account the logical nature of the domain (Leikin, 2013 referred to by Araya, 2021, p. 1371).
Creativity workshops in mathematics: an experience in the early years	Creative thinking	Competence to engage productively in the generation, evaluation and improvement of ideas, which can result in original and effective solutions, advances in knowledge and impactful expressions of the imagination (OECD, 2019, p. 7	The development of creative potential in the classroom happens when the teacher helps the student to get rid of emotional blocks, such as fear of making mistakes, fear of being criticized, feelings of inferiority and insecurity. Thus, in the moments of the workshops when the students felt autonomous and confident, we identified

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		referred to by Costa et al., 2021, p. 3).	characteristics of creative thinking, such as flexibility and originality in solving problem situations (Costa et al., 2021, p. 16).
	Creativity in Mathematics	The ability to come up with numerous appropriate solutions to a problem situation, so that they focus on different aspects of the problem and/or different ways of solving it... (Gontijo, 2007, p. 37 referred to by Costa et al., 2021, p. 4).	Adopting diversified pedagogical strategies, such as the Mathematics Creativity Workshops, would certainly provide subsidies to expand students' learning, in order to give new meaning to teaching practice itself (Costa et al., 2021, p. 16).
Promoting creativity in general education mathematics courses	Creative thinking		The students noted in their reflections that the mathematics degree course encouraged them to think differently about mathematics and identify connections with creativity (Munakata et al., 2021, p. 44).
	Creativity in Mathematics		Creativity has always been part of the mathematical experience (Munakata et al., 2021, p. 42).
Appealing to creativity through solving and posing problems in mathematics class	Creative thinking	The ability to consider something in a new way, both of which cannot be taught directly (Kampylis & Berki, 2014 cited by Miranda & Mamede, 2022, p. 111).	Problem solving and formulation can play an important role in promoting creative thinking in mathematics (Miranda & Mamede, 2022, p. 109).
	Creativity in Mathematics	Creativity can be understood as the conception of original ideas to produce something (Kampylis & Berki, 2014 cited by Miranda & Mamede, 2022, p. 111).	Creativity is closely related to the capacity for persistence, determination and a risk-taking attitude (Miranda & Mamede, 2022, p. 112). Problem formulation enhances the development of mathematical creativity (Miranda & Mamede, 2022, p. 117).
‘‘Allowing them to dream’: fostering creativity in mathematics undergraduates	Creative thinking	Acer, Burnett and Cabra (2017) describe creative thinking as that which produces something more or less new or original and appropriate or fit for purpose (Newton et al., 2022, p. 1335).	Promoting creative thinking in undergraduate mathematics students (Newton et al., 2022, p. 1335). Describing and exemplifying creative thinking in problem solving (using, for example, historical and contemporary examples that are meaningful to students) (Newton et al., 2022, p. 1340).
	Creativity in Mathematics		Creativity in mathematics is evident in discovering new ways of representing or thinking about a mathematical question, or constructing a new route to its solution. This shows a creative approach to the problem and the generation of a solution (Newton et al., 2022, p. 1337).

Source: Prepared by the authors of this article.

In the context of the first stage of thematic analysis, "Pre-analysis of the selected documents", after "floating" reading, we constituted the corpus of analysis of the scientific productions of the systematic review, according to some data shared in Frame 2. According to Bardin (1977), "the corpus is the set of documents taken into account to be submitted to analytical procedures. Its constitution often involves choices, selections and rules" (pp. 96-97). For this reason, the stages experienced in the systematic literature review process, as

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well as the content analysis modality used to investigate the data produced in the research, were important for the constitution of the analysis corpus.

In the second stage of the thematic analysis, "Data investigation", we carried out interpretative and investigative readings of the data shown in Frame 2, considering the question and objectives of the systematic review, as well as the research objectives shown in Frame 1. Some of the theoretical and practical meanings and senses of creative thinking and creativity in mathematics investigated in the scientific articles are intertwined in our formative and professional trajectory. In this way, the words woven into this context give "meaning to what we are and what happens to us" (Larrosa, 2002, p. 21; Larrosa, 2022, p. 17) in the formative paths taken in encounters with others, "of mutual respect between the subjects who dialog, open to the possibility of knowing and of knowing more - indispensable to knowledge" (Freire, 2001a, p. 80).

In the thematic categories presented in the following sections, we will analyze these stages that are articulated in the systematic literature review. Therefore, the third stage of thematic analysis, "Approach and interpretation of the results obtained in the research", involves inferences and interpretations by the analysts, relating the results obtained in the research to the theoretical framework and the objectives set out in the investigation (Bardin, 1977; Minayo, 2014).

In this context, we corroborate Bardin's (1977) statement: "the results obtained, the systematic confrontation with the material and the type of inferences reached, can serve as a basis for another analysis arranged around new theoretical dimensions, or practiced thanks to different techniques" (p. 101). In this respect, we stress that the scientific productions shared in Frame 1 and Frame 2 can be analyzed considering other guiding questions and objectives.

According to Bauer (2017), "a text corpus offers different readings, depending on the biases it contains" (p. 191). The thematic analysis of the corpus of articles enabled analytical, interpretative and investigative readings of the texts that made up the systematic literature review experienced in this study. Thus, in the following thematic category, we will reflect on the meanings and theoretical-practical meanings of creative thinking and creativity in mathematics in the fabric of teacher training and practice.

Creative thinking and creativity in mathematics in teacher training and practice: theoretical and practical meanings and senses

By reading and re-reading each of the scientific articles found in the systematic literature review process, we sought to understand the meanings and theoretical-practical senses of the keywords - "creative thinking" and "creativity in mathematics" - in our teacher training and practice, thus engaging in "a creative experience around understanding and communication" (Freire, 2002, p. 29).

The meanings and theoretical-practical meanings of the keywords presented in Frame 2 are intertwined with our experiences in the teacher training extension project and the Study

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Group with teachers and future teachers from 2019 to 2022, which we will share in this section and the next. In this way, the challenging mathematical tasks proposed and created in the pedagogical and playful workshops experienced in the formative and dialogical meetings corroborate the authors' statements about creative thinking and creativity in mathematics.

Based on the corpus of thematic analysis of the research data shared in Frame 2, we note that creative thinking and creativity in mathematics are related to each other, as they are woven together by elements such as fluency (the ability to create many ideas in the processes of formulating and solving problems), flexibility (a variety of different ideas and innovative solutions to solve the same problem), originality (the ability to create new and unique ideas based on the search for divergent solutions and/or different ways of solving the problem) and elaboration (the ability and development of an idea) (Ayllón Blanco et al., 2016; Costa et al., 2021; Fonseca & Gontijo, 2020; Gilat & Amit, 2014; Miranda & Mamede, 2022; Llorente Aguilera et al., 2014; Nadjafikhah & Yaftian, 2013; Panaoura & Panaoura, 2014; Santos & Santana, 2019).

In this context, considering the ideas related to these terms with similar characteristics, presented by the authors, we conceptualize creative thinking as an inventive and inquiring mental action that allows the solver of the challenging task or problem to develop different innovative strategies in the process of formulating and solving the problem situation, thus stimulating creativity in Mathematics. In fact, the pedagogical and playful workshops with experiences of diversified activities, such as: games, jokes, dynamics, formulation and elaboration of problems, exploratory and investigative tasks and others provide for the development of the characteristics of creative thinking - fluency, flexibility, originality and elaboration -, intertwined with the experience of creativity in mathematics through the formulation and resolution of problems covering everyday situations of the students participating in the teaching-learning processes of mathematics. Therefore, we conceptualize creativity in mathematics as the creative and inquiring capacity to seek and find diversified strategies and resources to formulate and solve problem situations with innovative ideas, involving fluency, flexibility, originality and elaboration in the weaving of mathematical concepts, contents and procedures intertwined with everyday practices.

The training experiences shared in this article stimulate the development of creative thinking and creativity in Mathematics, according to the data analyzed theoretically and in the training and dialogical meetings with teachers and future teachers, considering the bibliographic data from the systematic literature review that contributed to deepening the theoretical and practical foundations of these two terms present in our work as a teacher-trainer-researcher.

The interpretative and investigative readings of the corpus of thematic analysis of the research data gave us the opportunity to recall our training experiences in different training environments that reveal experiences of creative thinking and creativity in mathematics, thus corroborating the statements and reflections of the authors presented in Frames 1 and 2. Therefore, "training involves experimentation, innovation, testing new ways of working in

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teaching. And critical reflection on their use. Training involves research processes that are directly linked to educational practices" (Nóvoa, 1992, p. 16).

In our ongoing training, critical reflection on the theoretical-practical context is essential in mathematics teaching-learning processes, as it contributes to the (re)creation of their pedagogical practice through the action-reflection-action of teachers, in a dialogical relationship between the subjects who teach-learn (Freire, 2001a, 2001b, 2002, 2021), in the formative and dialogical meetings held within the scope of teaching, extension and research projects at the university and at the basic school.

According to Josso (2004), "formation describes the processes that affect our identities and our subjectivity" (p. 41). For this reason, recalling memories-references as formative experiences, according to the author, contributes to sharing experiential learning in our formative journeys. In this way, Josso (2004) conceptualizes formative experience as "learning that hierarchically articulates know-how and knowledge, functionality and meaning, techniques and values in a space-time that offers everyone the opportunity to be present for themselves and for the situation, through a plurality of registers" (p. 39).

In the different contexts of ongoing training, we consider that "experience is what passes through us, what happens to us, what touches us" (Larrosa, 2002, p. 21; Larrosa, 2022, p. 18). Therefore, reflecting on creative thinking and creativity in mathematics through the thematic analysis of the research corpus has allowed us to recall our formative experiences, which will be shared in this section.

Among our memories-references, we will share some experiences of creative thinking and creativity in mathematics within the scope of the teacher training extension project entitled "*Teaching and learning mathematics in the continuing education of teachers in the early years"*, carried out in the first and second semesters of 2019, in the municipality of Ponte Nova, Minas Gerais. We will also share some of the moments we experienced in the Study Group *"Professional Development of Teachers who Teach Mathematics"*, from 2021 to 2022.

The pedagogical and playful workshops experienced in all the formative and dialogical meetings of this extension project, which included the participation of teachers who teach mathematics, enabled them to experience activities that contributed to developing creative thinking and creativity in mathematics, according to the meanings and theoretical-practical meanings presented in Frame 2. Thus, the formulation of mathematical problems (Figure 1) by the teachers participating in the first meeting[3] on March 29, 2019, in the morning and afternoon shifts, corroborates the statements and reflections of some researchers shown in Frame 2.

[3] In the articles "Experiences of early years teachers in working with problem solving in continuing education" (Oliveira, Rezende, Garcia-Reis, et al. (2021) and "Pedagogical workshops intertwined with thematic units of mathematics and experiences in teacher training and practice" (Oliveira, Magalhães, Silva, et al., 2021), published in journals in the area of Mathematics Education, we present some data regarding continuing education in the municipality of Ponte Nova.

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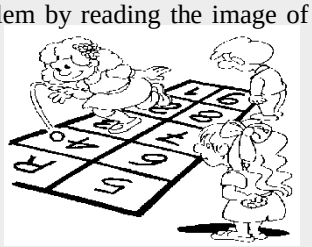
At this meeting, we experienced the pedagogical and playful workshop "Geometry from a playful perspective in the teaching and learning process", which allowed teachers to create different strategies to solve the mathematical problems presented in the diverse contexts of dynamics, games, the children's story "The three parts", the formulation and resolution of problems involving the thematic unit Geometry and others (Ministry of Education, 2018) in the teaching-learning processes of mathematical concepts, contents and procedures.

Among the activities experienced in this workshop, we share in Figure 2 some of the mathematical problems created by the teachers based on the statement (Figure 1) drawn up by us, the authors of this article, in the context of the "Group puzzle" game, which gave the Lúdica and Dinâmica teams the opportunity to put together the Amarelinha puzzle and subsequently formulate and solve problems. "Thus, the activities of formulating and solving problems, and the creative characteristics of such activity - fluency, flexibility and novelty - are well established within the practice of assessing creativity" (Silver, 1997, p. 76).

Figure 1: *Formulating mathematical problems*

Work out a mathematical problem by reading the image of the "Amarelinha" puzzle put together in the workshop..



Source*: Continuing education collection (2019)*

Formulating a mathematical problem by reading an image allows participants to analyze the information presented in the picture and its respective meanings and senses related to everyday situations, observing the constitutive aspects of the interpreted image. Subsequently, different problem situations can be created from the interweaving of mother tongue and mathematical language in the process of developing and solving the problem.

The mathematical problems (Figure 2) created by the teachers who took part in the continuing training indicate some theoretical and practical meanings and senses of creative thinking and creativity in mathematics, referring to the dynamic processes used when formulating and solving different problems through diversified strategies and resources (Costa et al., 2021; Fonseca & Gontijo, 2020; Gilat & Amit, 2014; Llorente Aguilera et al., 2014; Miranda & Mamede, 2022; Nadjafikhah & Yaftian, 2013; Santos & Santana, 2019).

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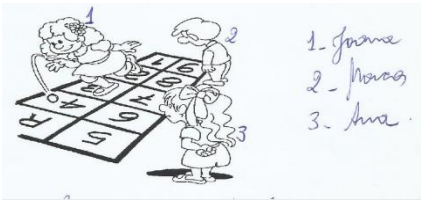
Figure 2: *Problems created by reading the image of the "Amarelinha" puzzle*

1) Peter, Mary and John like to play Hopscotch. Maria has a lot of fun because she likes to play multiplication. She discovered that multiplying gives a result of 20. What numbers did she use to get this result? (**Teachers Alessandra and Sandra Regina)**
2) Start with square 9 or 1. To move forward, perform an operation whose answer is the number of the next square, until you reach the Kingdom. (**Teachers Dávia and Eliliane)**
3) John, Mary and Luke were playing Hopscotch. Maria threw the ball at the number 4. What number comes before 4? What letter comes after 4? (**Teachers Elaine Cristina and Magna)**
4) The 1st player must jump only on the squares where the numbers are multiples of 2. The 2nd player must jump on the multiples of 3. The sequence is repeated. Which multiple will the 3rd player jump on? (**Teachers Denize and Angélica)**
5) If the children only have to step on the even numbers, which numbers should they step on? **(Teachers Rosana, Nice, Karina and Maria de Lourdes)**
6) The 3rd grade class is playing Hopscotch. Maria played only the even numbers and Joana played the odd numbers. What total number of points did Maria score and what total number of points did Joana score? And how many points did they score together? (**Teachers Vanda, Marli and Luiz)**
7) Megan threw the pebble that landed on the third number to her right. Mark threw the pebble that landed on the second number to his right. Ana hit the last number on her left. Which number did the pebble thrown by Joana, Marcos and Ana land on? If we multiply the number that Marcos hit by the predecessor of the number that Ana hit, what is the result? (**Teachers Claucia and Vanice)**



Source*: Continuing education collection (2019)*

These seven problems, selected according to the numerical sequence of each one's digitization, present different mathematical concepts and contents in their statements, such as: numbers, mathematical operations, multiples, predecessor, successor, geometric figures, even numbers, odd numbers, right, left, among others. Thus, the experience of creative thinking in the process of solving these problems includes convergent thinking, when finding a single correct solution to the proposed problem, and also divergent thinking involving different solutions to the problem (Nadjafikhah & Yaftian, 2013).

In formulating these problems based on reading the image of the Amarelinha puzzle, the teachers reveal the importance of developing creative thinking and creativity in mathematics in teacher training, providing opportunities to create diverse mathematical problems, which contribute to thinking mathematically with creativity. "Without a doubt, creativity is a fundamental task of mathematics education" (Llorente Aguilera et al., 2014, p. 112). Thus, "curiosity as an inquisitive restlessness, as an inclination to unveil something, as a question verbalized or not, as a search for clarification, as a sign of attention that suggests alertness, is an integral part of the vital phenomenon" (Freire, 2021, p. 31).

In this context, we corroborate the reflections of Costa et al. (2021), regarding the potential of pedagogical workshops to stimulate the creativity of students in math classes and of teachers in the formative and dialogical meetings they take part in at university and basic

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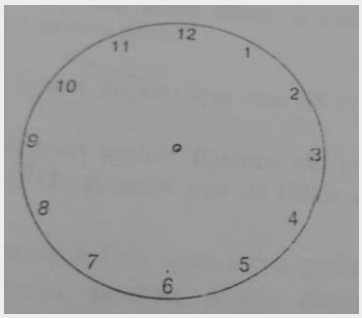
school. Therefore, the experience of diversified activities in pedagogical and playful workshops as theoretical-methodological strategies makes it possible to discuss and problematize the thematic units of the Mathematics area in the BNCC (Oliveira, Magalhães, Silva, et al., 2021).

With regard to the development of creative thinking and creativity in Mathematics in the training experiences in the Study Group "Professional Development of Teachers who Teach Mathematics", in the period from 2021 to 2022, we shared the resolution of the problem "The clock" (Rosa, 1987, p. 179) in the pedagogical workshop "Dynamization of problem solving in teacher training and mathematics classes" held in the formative and dialogical meeting on May 18, 2022, from 7pm to 9pm, via the Google Meet platform.

Figure 3: *Solving the problem "The clock"*

Use two lines to divide the watch into three parts so that the numbers in each part add up to the same number.



Source*: Study Group Collection (2022)*

In this pedagogical and playful workshop, we experienced the problem-solving methodology through the theoretical-methodological perspectives of researchers: Andrade and Onuchic (2017), Oliveira (2012), Oliveira and Passos (2014), Onuchic (1999), Onuchic and Allevato (2011), Polya (1994), Van de Walle (2009), Vila and Callejo (2006), among others.

In solving the problem "The clock" we experienced the three phases - before, during and after - proposed by Van de Walle (2009), which present the methodological procedures:

> No primeiro momento, “antes”, o professor deve garantir que os estudantes estejam mentalmente prontos para receber a tarefa e assegurar-se de que todas as expectativas estejam claras. No segundo momento, “durante”, os estudantes buscam resolver o problema, criando estratégias, e o professor observa e avalia esse trabalho. No terceiro momento, “depois”, os estudantes compartilham as suas ideias na resolução do problema e o professor conduz a discussão, enquanto os estudantes apresentam seus resultados e as estratégias utilizadas. No final das discussões, o professor sintetiza as ideias principais compartilhadas . . . (Oliveira, 2012, p. 57; Oliveira & Passos, 2014, p. 76).
>
> In the first moment, "before", the teacher must ensure that the students are mentally ready to receive the task and make sure that all expectations are clear. In the second moment, "during", the students try to solve the problem by creating strategies, and the

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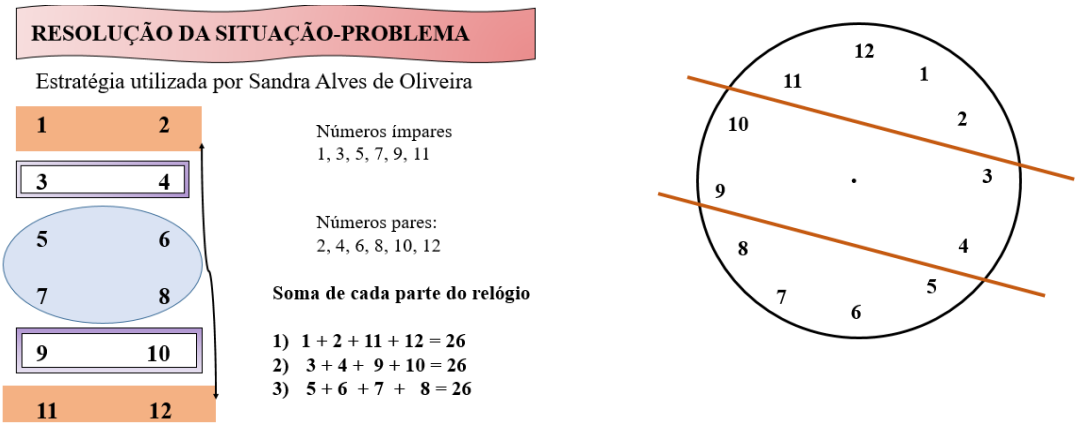
> teacher observes and evaluates this work. In the third moment, "after", the students share their ideas on solving the problem and the teacher leads the discussion, while the students present their results and the strategies they used. At the end of the discussions, the teacher summarizes the main ideas shared ... (Oliveira, 2012, p. 57; Oliveira & Passos, 2014, p. 76).

The students, future teachers, teachers and the teacher-coordinator of the Study Group "*Professional Development of Teachers who Teach Mathematics*" experienced these moments while solving the problem "The Clock". In this way, they experienced creative thinking and creativity in mathematics by recording the strategies developed and the resources used to solve the problem proposed in the formative and dialogical meeting. Figure 4 shows the process experienced by Sandra, a PhD student in the Graduate Program in Education (PPGE) at the Federal University of Juiz de Fora (UFJF), who took part in this Study Group.

Figure 4: *Strategy used to solve the problem "The clock"*



Source*: Study Group Collection (2022)*

Each participant in the Study Group tried to solve the problem at the "during" moment. Most were unable to find the sum 26 for the parts of the clock. Students Leandra and Milena, from the Pedagogy course at the Faculty of Education (FACED) at UFJF, shared their ideas for solving the problem in the "after" moment. They highlighted the use of the strategy "*Experiment and check...*". A good way to work on a task that has stumped you is to try something. Give it a try! Reflection, even on a failed attempt, can lead to a better idea" (Van de Walle, 2009, p. 78). So they drew the clock and tried to group the numbers to find the sum of 26 in each part of it. So they didn't give up on solving the problem, but thought mathematically and creatively until they reached the result.

We systematized the strategies developed by Sandra, Leandra and Milena, discussing the mathematical concepts and contents interwoven in the problem statement and solving process: sum, decimal numbering system, even numbers, odd numbers, lines, lines, mathematical operations, circle, time measure, geometric figures, among others.

And you, the reader of this article, how would you solve "The Clock" problem? What are your thoughts on the strategies used by Sandra, Leandra and Milena? In order to solve the

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problem, everyone will develop creative thinking and creativity in mathematics. In this context, "ideas must be related, concepts associated, memory used and critical thinking employed. It is therefore based on innovation and creativity in invention and problem-solving tasks" (Ayllón Blanco et al., 2016, p. 185). "Imagination, the basis of all creative activity" (Vygotsky, 2021, p. 16), is also present in these training experiences, which include experiential learning (Josso, 2004) in the creative and problem-solving practices experienced in the training paths that contributed to learning to teach mathematics creatively.

Creative and problematizing practices that can stimulate creative thinking and creativity in mathematics in teaching-learning processes

In the weaving of the Teacher Training Extension Project and the Study Group, we experienced some creative and problematizing practices that enabled participants to develop creative thinking and creativity in Mathematics in the teaching-learning processes of mathematical concepts, contents and procedures inserted in the different contexts of the pedagogical and playful workshops held in the formative and dialogical meetings of these extension, teaching and research activities.

Creative and problematizing practices in teacher training and mathematics classes contribute to the constitution of "a problematizing learning environment, in which there is room to communicate ideas, question, defend points of view, formulate questions, that is, actively participate in the process of reflection on their own learning" (Mengali & Nacarato, 2019, p. 87).

The children's story "The three parts" (Kozminski, 2003) experienced in the pedagogical and playful workshop "Geometry from a playful perspective in the teaching and learning process" allowed teachers to reflect on the knowledge objects and skills presented in the Geometry thematic unit (Ministry of Education, 2018). In the dialogical presentation, we problematized situations involving the location of our objects in the continuing education space in the municipality of Ponte Nova, using some reference points from the rooms we used to carry out the workshop activities in the first formative and dialogical meeting. We also tried to use vocabulary appropriate to the fundamentals of geometry. Other geometric concepts, contents and procedures were presented, discussed and experienced, as they "form an important part of the mathematics curriculum in elementary school because, through them, students develop a special type of thinking that allows them to understand, describe and represent, in an organized way, the world in which they live" (Ministry of Education, 1997, p. 55).

Among the issues raised in the different contexts of this workshop's activities, we highlight: 1 - In the shared reading of the children's story "The Three Parts", which knowledge objects and skills from the Geometry thematic unit are covered in the story and in your teaching practices? 2 - In the round table discussion held at the meeting, we told and reflected on the story "The Three Parts" and the Geometry thematic unit. How many teachers took part in the activity? Did the space allow for a circular format with the participation of

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the teachers present at the training? 3 - Using the three parts of the story, what would you create?

In these creative and problematizing practices, we creatively contextualized all the playful and challenging activities discussed and experienced in the workshop, thus contributing to the development of creative thinking and creativity in mathematics in teachers and their students, so that they are more curious, observant and reflective subjects, as well as seeking solutions to the mathematical problems formulated and the situations proposed in the best way possible (Torres Soler, 2018).

We consider creative and problematizing practices to be the pedagogical and playful workshops we developed and experienced in the formative and dialogical meetings during the continuing education held in Ponte Nova in 2019, and some of the workshops developed in the Study Group between 2021 and 2022, as they made it possible to stimulate creative thinking and creativity in Mathematics. The participants in these activities "were encouraged to think critically, having their answers problematized, with questions that led them to reflect on the elements that determined each possible answer" (Costa et al., 2021, p. 6).

It is therefore important to promote creative thinking through creative and problematizing practices in undergraduate Mathematics (Newton et al., 2022) and Pedagogy, so that future teachers can creatively invent Mathematics teaching-learning processes and, furthermore, "experiment with creative processes, even when their results do not extend to the field of Mathematics" (Araya, 2021, p. 1372).

In the pedagogical and playful workshops, we provide participants with "the process of using creativity to produce new solutions to carefully planned problems" (Khalid et al., 2020, p. 271) by us, the workshop facilitators, and to the problems created by the students and teachers.

The creative and problematizing practices experienced in the formative and dialogical meetings intertwined creative thinking and creativity in mathematics "in the interaction between problem formulation and problem solution. It is in this interaction of formulating, trying to solve, reformulating and finally solving a problem that creative activity is seen" (Silver, 1997, p. 76). Thus, experiencing these practices in teacher training and in math classes is essential to making the teaching-learning process more dynamic, curious, joyful, challenging, motivating and thought-provoking.

In fact, "it is by teaching mathematics that I also teach how to learn and how to teach, how to exercise the epistemological curiosity that is indispensable to the production of knowledge" (Freire, 2021, p. 120), in dialogical relationships with the subjects who share their experiential knowledge and their learning from teaching. In this context, "training is an interactive and dynamic process. The exchange of experiences and the sharing of knowledge consolidate spaces for mutual training, in which each teacher is called upon to play the role of trainer and teacher at the same time,

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the role of trainer and trainee" (Nóvoa, 1992, p. 14). The Teacher Training Extension Project and the Study Group were developed considering the perspectives of these authors and others shared in this article, which sought to describe and analyze the contributions of research into creative thinking and creativity in Mathematics to teacher training and practice and to teaching and learning processes.

Final considerations

The five stages used in this study's systematic literature review process, taking into account the specific protocols proposed by the authors behind this specific methodology and modality of scientific research, as well as the guiding question and research objectives, contributed to understanding and interpreting the bibliographic data found in the databases consulted: Portal de Periódicos Capes, SciELO, Scopus, Web of Science and ERIC.

The thematic analysis of the 14 articles shown in Frames 1 and 2, intertwined with our experiences as trainers and those of the participants in the teacher training extension project "Teaching and learning mathematics in the continuing training of teachers in the early years" and the Study Group "Professional Development of Teachers who Teach Mathematics", points to the possibilities for stimulating creative thinking and creativity in mathematics in teacher training and in mathematics classes in elementary school and universities. Thus, formulating and solving different mathematical problems; experiencing pedagogical and playful workshops; dynamizing, playing and gaming; telling and dramatizing children's stories; reading, writing and interpreting; and other creative and problematizing practices provide opportunities to develop creative thinking and creativity in mathematics in training actions and in the teaching-learning processes of mathematical concepts and content.

The data produced in this research, based on a systematic review of the literature in the bibliographic databases consulted, highlights the contributions of the meanings and theoretical-practical senses of creative thinking and creativity in mathematics to teacher training and practice and to the teaching-learning processes of mathematics in the training spaces of universities and basic schools. We highlight training experiences that made it possible to experience creative thinking and creativity in mathematics theoretically and in practice, in the weaving of pedagogical and playful workshops carried out in the extension project and the Study Group, which contributed to formulating and solving different challenging and creative problems, considering everyday mathematical practices.

Thinking mathematically with creativity contributes to the mediation of more interactive, dynamic, challenging, problematizing, motivating, creative and curious math classes, which provide subjects with dialogical relationships in the teaching-learning processes of the thematic units woven with their mathematical concepts, contents and procedures.

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