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Articles Section

The Problem as an Epistemological Device: Beliefs and Challenges to Problem Solving in Teacher Education

O Problema como Dispositivo Epistemológico: crenças e desafios à Resolução de Problemas na Formação de professores

El Problema como Dispositivo Epistemológico: Creencias y Desafíos para la Resolución de Problemas en la Formación Docente

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Abstract

This study aims to analyze beliefs about mathematics teaching and learning expressed in preservice teachers' written justifications concerning Problem Solving and Problem Posing, and to discuss their implications for understanding problems as spaces for investigation and knowledge production. It is a qualitative case study, guided by the naturalistic paradigm, conducted with nine preservice teachers in a Practice as a Curricular Component course. Data were produced through a questionnaire with Likert-type items and written justifications. The results reveal tensions between the valuing of investigative practices and expectations of predictability, teacher control, curriculum coverage, understanding error as risk, and restricted recognition of Problem Posing. These tensions may limit the investigative potential of problem-based work in initial teacher education.

Keywords: Problem solving; Problem posing; Epistemological beliefs; Preservice teacher education.

Resumo

Este estudo tem como objetivo analisar crenças sobre o ensino e a aprendizagem da Matemática expressas nas justificativas escritas de licenciandos acerca da Resolução e da Proposição de Problemas e discutir suas implicações para a compreensão do problema como espaço de investigação e produção de conhecimento. Trata-se de um estudo de caso qualitativo, orientado pelo paradigma naturalístico, realizado com nove licenciandos em uma disciplina de Prática como Componente Curricular. Os dados foram produzidos por questionário com itens do tipo Likert e justificativas escritas. Os resultados evidenciam tensões entre a valorização de práticas investigativas e expectativas de previsibilidade, controle docente, cumprimento curricular, compreensão do erro como risco e reconhecimento restrito da Proposição de Problemas. Essas tensões podem limitar o potencial investigativo do trabalho com problemas na formação inicial.

Palavras-chave: Resolução de problemas; Proposição de problemas; Crenças epistemológicas; Formação inicial de professores.

Resumen

Este estudio tiene como objetivo analizar creencias sobre la enseñanza y el aprendizaje de las Matemáticas expresadas en justificaciones escritas de licenciandos acerca de la Resolución y la Proposición de Problemas, y discutir sus implicaciones para comprender el problema como espacio de investigación y producción de conocimiento. Se trata de un estudio de caso cualitativo, orientado por el paradigma naturalista, realizado con nueve licenciandos en una asignatura de Práctica como Componente Curricular. Los datos se produjeron mediante un cuestionario con ítems Likert y justificaciones escritas. Los resultados evidencian tensiones entre la valoración de prácticas investigativas y expectativas de previsibilidad, control docente, cumplimiento curricular, comprensión del error como riesgo y reconocimiento restringido de la Proposición de Problemas. Estas tensiones pueden limitar el trabajo investigativo con problemas en la formación inicial.

Palabras clave: Resolución de problemas; Proposición de problemas; Creencias epistemológicas; Formación inicial del profesorado.

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1. Introduction

Problem solving (PS) occupies an important place in curriculum guidelines and is a well-established field of research in mathematics education, being understood both as an object of learning and as a perspective for teaching mathematics (NCTM, 2000; Marcatto; Onuchic, 2024; Rott; Specht; Knipping, 2021). When the problem plays a key role in the teaching process, solving it can encourage the exploration of strategies, the construction of meanings, the establishment of connections, and the production of mathematical knowledge (Marcatto; Onuchic, 2025 <sem resultados>; (Rott; Specht; Knipping, 2021)). However, its effective implementation in the classroom remains a recurring challenge, especially in initial teacher education. Several studies indicate that the presence of problems in teaching sequences does not guarantee practices that are epistemologically oriented toward research, since pedagogical decisions are strongly influenced by teachers' beliefs formed over the course of their schooling (Rott, 2019; Skott, 2015).

In this context, understanding how pre-service teachers conceive of the mathematical problem becomes relevant for analyzing tensions related to problem solving (PS) and problem posing (PP). Beliefs associated with the predictability of teaching, teacher control, adherence to the curriculum and the role attributed to error can limit openness to student investigation and authorship, even in educational programs guided by exploratory approaches (Ernest, 1989; Skott, 2018). Thus, it is important to understand not only the declared appreciation of PS and PP, but also the conceptions of teaching and learning that accompany this appreciation.

Given these tensions, the question guiding the study is: What beliefs about teaching and learning mathematics are expressed in pre-service teachers' justifications when they take a stance on statements related to problem solving and problem posing, and what implications do these beliefs have for understanding the problem as a space for investigation and knowledge production?

The study presented in this article aims to analyze the beliefs about teaching and learning mathematics expressed in the written justifications of pre-service teachers when taking a stance on statements related to PS and PP, and to discuss their implications for understanding the problem as a space for research and knowledge production.

In this study, the mathematical problem is understood not only as a teaching resource or type of task, but as a space that organizes the investigation, the formulation and comparison of strategies, the validation of results and the production of meanings. This understanding corresponds to what is called a problem as a device for producing knowledge. The status assigned to the problem, whether as an exercise, a guided activity or a space for investigation, is related to beliefs about mathematics, teaching, and learning, as well as the forms of participation considered legitimate in the classroom. The analysis thus seeks to identify tensions between the declared appreciation of investigative approaches and school conceptions associated with predictability, teacher control, and compliance with the curriculum.

2. Theoretical framework

2.1 Problem solving and problem posing and teachers' epistemological beliefs

In this study, problem solving (PS) is understood not as a didactic technique or a specific methodological strategy, but as an organizing principle of teaching practice, in which the problem can play a central role in the production of mathematical knowledge (Marcatto, 2025b; Allevato; Onuchic, 2014). From this perspective, solving problems involves exploring non-routine situations, formulating and revising strategies, making decisions, dealing with impasses and validating results, in a non-linear process of producing mathematical meanings (Rott; Specht; Knipping, 2021).

In this sense, this study uses the term problem as an epistemological device. The term refers to an understanding of the problem that goes beyond its function as a task or teaching aid: it is a situation capable of organizing conditions for mathematical investigation, the formulation and review of strategies, decision-making, the validation of results, and the production of meanings. In this sense, the epistemological character does not reside in the problem in isolation, but in the way it is mobilized in teaching practice and in the possibilities for producing knowledge that this mobilization fosters.

Problem posing (PP) expands this perspective by shifting students from the position of solvers of previously formulated problems to participation in the formulation of new problem situations. This process involves understanding and exploring a situation, making connections, generating problems, and reflecting on how they are formulated, including their coherence and possible solutions (Cai; Rott, 2024). Thus, PP expands opportunities for authorship and the production of mathematical knowledge by requiring students to mobilize conceptual knowledge to formulate, analyze, and validate problems (Marcatto, 2025b, 2025a; Cai; Hwang, 2020).

In this approach, the teacher acts as an epistemological agent responsible for selecting, formulating, and exploring problems with investigative potential, sustaining cognitive demand, interpreting students' work, and making pedagogical decisions in contexts of uncertainty (Marcatto, 2025b; Rott; Specht; Knipping, 2021).

The concept of PS as an epistemological practice is further developed by the descriptive model proposed by Rott, Specht e Knipping (2021), which shows that authentic PS processes are non-linear, exploratory, and characterized by continuous regulatory decisions. By distinguishing problems from routine tasks through the presence of heuristic exploration, the authors show that PS involves returns, deviations, errors, and reformulations, characteristics that cannot be captured by normative or sequential models. This interpretation aligns directly with the proposal of Marcatto (2025b,a), which understands the mathematical problem as an epistemological device that organizes teaching practice around investigation, the production of meanings and situated pedagogical decision-making.

Teaching mathematics through PP requires recognizing the teacher as the central agent in the analysis, selection, adaptation, and exploration of the problems produced by students. These decisions involve ongoing judgments about mathematical validity, the level of cognitive challenge and alignment with teaching objectives, which makes PP a complex professional practice that depends on constant pedagogical interpretation and regulation (Ma; Cai, 2024).

To interpret the conceptions that permeate the work with PS and PP, the study draws on the discussion of teachers' beliefs systematized by Ernest (1989). The author understands these beliefs as structures related to the nature of mathematics, knowledge, teaching and learning, offering a framework for interpreting different ways of attributing meaning to mathematical problems and to the participation of teachers and students.

The author proposes three major belief systems: (i) instrumentalist; (ii) Platonic; and (iii) problematizing. Each of the systems is associated with different conceptions of teaching, learning, and mathematical problems (Ernest, 1989). While instrumentalist and Platonic beliefs tend to reduce the problem to an exercise or a guided path, the problematizing belief recognizes the problem as a space for investigation and knowledge production.

The relationship between epistemological beliefs and teaching practice is explored in depth based on the contributions of Rott (2019), who investigates how beliefs about mathematics and PS manifest themselves in observable teaching behaviors (Rott, 2019). The author demonstrates that teachers can declare their adherence to PS but implement it in a guided and controlled manner to preserve the teacher's central role and the focus on the correct result.

Studies show that the implementation of PS is sensitive to teachers' beliefs, especially regarding the degree of control over the process, the value placed on multiple strategies, and the status attributed to errors (Rott, 2019; Rott; Specht; Knipping, 2021).

2.2 Traditional class, school mathematics tradition, and participation patterns

To understand the persistence of conceptions that are not very compatible with investigative practices, we draw on the notion of school mathematical tradition discussed by Skovsmose e Penteado (2015). In this tradition, the class tends to be organized around the centrality of the exercise, the search for the correct answer, the teacher leading the way, and the pre-established progression of the content. These recurring forms of organization help to stabilize expectations about what it means to teach, learn, and participate in a math class.

The social perspective of mathematics education makes it possible to understand these expectations beyond individual dispositions alone. Lerman (2000) shifts the focus to participation in social practices, while Foucault (2014) makes it possible to interpret school processes of normalization and regulation of conduct. In this context, repeated practices of correction, control, and validation can contribute to the production of predictable forms of mathematical participation. The contribution of Skovsmose e Penteado (2015) reinforces this interpretation by highlighting tensions between a school tradition guided by certainty and control and practices that value inquiry, openness, and authorship. These perspectives offer elements for understanding teachers' beliefs in relation to the school practices in which they are produced and reiterated.

Studies on the education of mathematics teachers indicate that formative paths historically marked by technocratic and reproductive approaches have contributed to the consolidation of teaching models centered on transmission, the predictability of paths, and the leading role of the teacher. This configuration can make it difficult to incorporate reflective and investigative practices and can

encourage the reproduction of traditional teaching patterns, even amid innovative discourses in initial teacher education (Costa Junior *et al.* 2024). Although fundamental, beliefs alone do not explain the persistence of traditional practices. Skott (2015, 2018) questions approaches that treat beliefs as stable mental entities and proposes the concept of participation patterns, understood as recurring forms of action and interaction that become established in school practices and define what is possible, legitimate, and expected in the classroom. From this perspective, beliefs are simultaneously causes and effects of repeated participation in social practices (Skott, 2018).

As part of these contributions, this study understands that the epistemological beliefs of pre-service teachers are formed within the school mathematics tradition, supported by disciplinary mechanisms and historically stabilized patterns of participation. These beliefs manifest in specific ways of conceiving the problem and the roles of the teacher and the students, and they can constitute barriers to problem-based investigative work and to understanding PS and PP as practices open to investigation. Thus, understanding and transforming problem-based teaching practice requires not only methodological changes, but also a critical analysis of the conceptions of teaching and learning internalized in schools throughout education.

3. Methodology

3.1 Research design, epistemological framework, and research context

The research is configured as a qualitative, interpretive case study (Ponte, 2006), anchored in the naturalistic research paradigm (Guba; Lincoln, 1982, 1989). It is assumed that the epistemological beliefs of pre-service mathematics teachers are contextual and socially produced constructs, not reducible to isolated variables or measurable by statistical procedures.

In line with the study's objective, the research does not seek to test hypotheses or quantify trends, but rather to interpret, in depth, the beliefs expressed in the undergraduates' written justifications within a specific educational context. This framework is consistent with the conception of methodology discussed by Moschkovich (2015, 2018), according to which qualitative research in mathematics education involves articulating theoretical assumptions, research questions, the context investigated, and analytical procedures, rather than merely applying techniques.

The research was conducted within a Practice as a Curriculum Component (PCC) course in a mathematics teaching degree program. The course's thematic focus was on exploratory mathematics teaching and working with mathematical tasks, with an emphasis on analyzing, selecting, and discussing problems with investigative potential.

Exploratory teaching constituted the educational context in which the research was conducted, and not an additional object of analysis. In this context, PS and PP were addressed as ways of working that could promote the exploration, formulation, and comparison of strategies, discussion of ideas, and validation of results. The research concerns the beliefs expressed by undergraduate students when taking a stance on aspects related to working with problems. This delimitation makes it possible to distinguish the course's pedagogical context from the phenomenon investigated in the study.

In line with the National Curriculum Guidelines for Initial Teacher Education (Brasil, 2024), this study understands the PCC as an essential formative space, whose normative function is to link real pedagogical experiences with theoretical and methodological foundations. This conception distances the practice of teaching from an applicative or instrumental logic, recognizing it as a privileged space for problematization, analysis, and production of knowledge about teaching. This understanding aligns with the concept of exploratory practice proposed by Marcatto (2023), in which teaching is an investigative, situated, and non-linear process supported by challenging mathematical tasks, teacher mediation, and systematic reflection on students' work. From these perspectives, conducting research within the scope of PCC hours is justified not only normatively, but also with a coherent vision of professional education that integrates teaching, research, and critical reflection on practice.

The course was developed in the third semester of the initial education program. Before using the instrument, the pre-service teachers participated in an eight-hour workshop that included theoretical discussion, task analysis, problem-solving and problem-posing activities, strategy discussion, and lesson planning. The questionnaire was administered after this module, so the justifications were provided in a context in which the participants had already discussed these teaching perspectives.

In the semester when the data were collected, the course had 11 regularly enrolled undergraduates, of whom 9 voluntarily completed the instrument. To preserve anonymity, the participants were identified by the codes L1 to L9. In cases where a justification was recorded jointly by two participants, their identification is presented by associating their respective codes. In the results, the participants' codes are followed by the item number in the instrument to which the justification refers (Q1–Q12). The number of participants and the situated nature of the case delimit the scope of the conclusions, while allowing for an in-depth analysis of the justifications produced within this specific educational context.

3.2 Data collection instrument and analysis procedures

The data collection instrument consisted of 12 statements related to exploratory teaching, working with mathematical tasks, the role of the teacher and students, the curriculum, error, creativity, and problem posing. The statements were organized into five dimensions: (i) conception of mathematics and predictability of learning paths; (ii) student participation and degree of teacher control; (iii) conceptual understanding and curriculum compliance; (iv) role attributed to error and difficulty; and (v) creativity and problem posing.

For each statement, the pre-service teachers indicated their position on a Likert-type scale (Likert, 1932) and were required to provide a written justification. The options provided were strongly agree; somewhat agree; neither agree nor disagree/it depends; somewhat disagree; and strongly disagree. The intermediate alternative allowed participants to record conditioned or ambivalent positions, which are particularly relevant for the qualitative analysis of the justifications. The choices made on the scale were used to contextualize the positions, while the written justifications constituted the main empirical material of the study.

In line with the naturalistic paradigm (Guba; Lincoln, 1989) and the methodological perspective discussed by Moschkovich (2018), the choices on the scale were not the analytical focus but were used

to contextualize the positions. The analysis focused mainly on the written justifications, understood as material for accessing the arguments, assumptions, and conditions mobilized by the pre-service teachers.

In mathematics education, Likert-type scales are particularly suitable for investigating the beliefs, perceptions, and epistemological positions of pre-service teachers, provided they are linked to qualitative analyses of written reasoning. Likert scales make it possible to identify trends and patterns of agreement or disagreement with statements about teaching, learning, and problem-solving, and they function as exploratory and interpretative tools rather than as isolated psychometric measures (Likert, 1932; Carifio; Perla, 2007). When combined with open-ended comments, as in this study, such scales help to make visible the tensions between discursive adherence to investigative approaches and more traditional beliefs, favoring a qualitative and situated reading of the data, consistent with the naturalistic paradigm adopted in the research.

The statements were designed to preserve the instrument's ecological validity (Moschkovich, 2015) by directly addressing the course's context and challenging key dichotomies in PS/PP teaching, such as predictability *versus* unpredictability, teacher control *versus* student autonomy, exercise *versus* problem, and prescribed curriculum *versus* conceptual understanding.

The data analysis followed a qualitative categorization process of an inductive-deductive nature. Initially, a floating reading of the written justifications was carried out to identify discursive regularities, argumentative recurrences, and points of tension in the undergraduates' positions. These regularities were then interpreted in light of the adopted theoretical framework, allowing for the construction of epistemological analytical categories.

Five final analytical categories were defined: (i) expectation of predictability in teaching; (ii) centrality of teacher control; (iii) prevalence of the curriculum; (iv) error as a pedagogical risk; and (v) conditioned creativity and proposal of residual problems. We recognize that the same answer could relate to more than one category, which reflects the non-linear and interdependent nature of epistemological beliefs.

After defining the categories, we selected representative excerpts from the justifications to elucidate the relationships between empirical data and interpretation. The selection focused on excerpts that captured regularities, ambiguities, or tensions identified across the corpus. Due to space limitations, each category includes one excerpt, which is for illustrative purposes only and does not, in isolation, constitute the criterion for constructing the categories. The categories result from an analysis of all justifications, and one answer may relate to more than one line of reasoning. The excerpts are reproduced while preserving the participants' wording, and any omissions are indicated by square brackets with ellipses.

We sought to make the analytical process transparent by explaining the context, the instrument, the categorization steps, and the relationship between justifications, categories, and the theoretical framework (Guba; Lincoln, 1989). Credibility was sought through internal consistency between data, analytical categories, and the theoretical framework. Transferability is supported by the detai-

led description of the context and the case, allowing the results to be interpreted in similar formative contexts.

As Moschkovich (2018) emphasizes, rigor in qualitative research does not stem from the researcher's neutrality, but from the transparency of analytical decisions and the epistemological coherence between theory, method, and interpretation.

4. Results and discussion

In line with the methodological design adopted, the data analysis sought to understand the constructions of meaning mobilized by the pre-service teachers when taking a stance on statements related to exploratory teaching, mathematical tasks and PS/PP. According to the naturalistic paradigm that guides the study, the results are not presented as frequencies or measures of agreement, but as interpretative configurations that emerge from the written justifications, analyzed within the epistemological categories of beliefs constructed in the analytical process.

The five final analytical categories organize the results and make it possible to show how the school mathematics tradition is manifested in the pre-service teachers' conceptions and forms epistemological barriers to understanding the problem as a device for producing knowledge.

The first category highlights a recurring belief in the need for predictability in teaching and learning paths. Although pre-service teachers recognize mathematics as a field of interrelated ideas and value conceptual understanding, their justifications reveal resistance to the unpredictability inherent in investigative practices. A good class is often associated with the teacher's ability to anticipate strategies, difficulties, and outcomes in order to ensure the process runs smoothly.

This tension becomes apparent in the response to Q1, which addressed the unpredictability of mathematical connections. One pre-service teacher affirms:

> The only thing I disagree with is that connections are always unpredictable [...] if we investigate this relationship, we have a prior idea of what we will conclude in the end" (L1, Q1).

The excerpt acknowledges the possibility of investigation and establishing connections but maintains the expectation of anticipating results. It is therefore a hybrid position, in which openness to exploration coexists with a conception of teaching guided by predictability. In light of Ernest (1989), this position shows traces of conceptions that attribute stability to mathematical knowledge and to the process of learning it, making it difficult to fully accept the uncertainty characteristic of problem solving. This configuration is summarized in Table 1, which explains the core of the belief and its implications for PS.

From this perspective, the unpredictability inherent in authentic problem solving tends to be perceived as a threat to lesson organization, which makes it difficult to understand the problem as a legitimate space for mathematical investigation.

The second category reveals the persistence of the teacher's central role as regulator of the learning process, even in discourses that advocate students' active participation. The justifications

Table 1 – Expectation of predictability in teaching

Recurring aspects in the justifications	Analytical interpretation
Emphasis on detailed planning	Education as a predictable path
Rejection of unpredictability	Problem as a risk
The link between control and quality	Uncertainty as a threat

Source: Prepared by the author

analyzed show that student autonomy is often conditioned by the teacher's constant mediation, who must guide, correct, and validate strategies throughout the path.

The tension between autonomy and regulation is explicitly evident in Q5. A pre-service teacher says:

> Obviously, students should be free to create their own questions, but it is important that the teacher guides them so that they do not stray from the focus of the class (L2, Q5).

Student authorship is recognized as desirable, but it remains contingent on the teacher's guidance and definition of the path. The fragment does not reject student participation; rather, it shows regulated autonomy, in which the teacher retains responsibility for setting the limits of exploration. This configuration aligns with the patterns of participation discussed by Skott (2018), in which seemingly participatory forms can coexist with teachers' continued authority over what counts as a mathematically legitimate approach. Table 2 summarizes this configuration.

Table 2 – Centrality of teacher control

Discursive cues	Interpretation
Recurring use of "balance"	Limited autonomy
Emphasis on constant mediation	The teacher as an epistemological authority
Distrust of student initiative	Regulated participation

Source: Prepared by the author

Consequently, students' intellectual agency tends to be limited, reducing the possibilities for exploratory strategies to emerge and weakening the investigative potential of problem solving and problem posing.

The third category concerns the normativity of the prescribed curriculum. The data indicate that pre-service teachers recognize the importance of conceptual understanding but often subordinate it to completing the curriculum. Concern about *delaying content* appears as a recurring justification for limiting exploration of more open-ended problems.

The tension between understanding and curriculum coverage appears in the justification for Q9:

> It's important for students to actually learn; however, it's not feasible to stop covering a lot of content. A balance is needed (L3, Q9).

Learning is explicitly valued, but the conjunction "however" introduces a condition: understanding cannot excessively compromise progress in the program. The recurrence of the idea of "balance"

highlights an ambivalent position, in which the emphasis on conceptual understanding coexists with the normative force attributed to the prescribed curriculum. This interpretation aligns with the tradition of school mathematics discussed by Skovsmose e Penteado (2015), in which the progression of content can serve as an organizing reference for pedagogical decisions. Table 3 shows this tension.

Table 3 – Prevalence of the curriculum

Elements of the justifications	Analytical reading
Valuing understanding "to a certain extent"	Curriculum as a limit
Fear of not completing the program	Disciplinary rule
Content prioritization	Problem as a means, not an end

Source: Prepared by the author

The centrality attributed to compliance with the curriculum suggests that the curriculum operates as a disciplinary norm that regulates pedagogical decisions. In this setting, the time allocated to conceptual exploration and mathematical investigation tends to be subordinated to the need to progress through the planned content, to the detriment of open investigative processes.

The fourth category highlights a particularly relevant belief: that mistakes risk undermining students' confidence and motivation. The justifications reveal an argument in favor of carefully controlled progressions and a preference for starting work with problems considered easy, in order to avoid deadlocks.

This concept can be observed in Q4, which linked the degree of difficulty of the problems to the students' errors and confidence. A pre-service teacher explained:

> I agree with the approach of starting with simpler problems and gradually progressing to more challenging ones. This allows students [...] to gain confidence as they tackle accessible challenges [...] (L4, Q4).

The rationale attributes a role to the controlled progression of difficulty in protecting students' confidence. Although it does not reject exploration, it tends to limit the challenge to situations previously considered accessible. This position emphasizes the non-linear nature of authentic problem-solving processes, in which error, impasse, revision, and reformulation can constitute productive moments of mathematical activity (Rott; Specht; Knipping, 2021). Table 4 summarizes this concept.

Table 4 – Error as a pedagogical risk

Manifestation of the error	Assigned meaning
Initial difficulty	Threat to trust
Frequent error	Academic underachievement
Impasse	Situation to avoid

Source: Prepared by the author

The data suggest that the role attributed to error remains associated with teaching approaches oriented toward reducing situations of impasse, in line with the logic of traditional classes.

The notion of error as a pedagogical risk reveals the persistence of a school culture guided by correction and the elimination of deviations. However, in authentic problem-solving processes, error and impasse are fundamental to producing knowledge, since they trigger review, reformulation, and negotiation of meanings. When error is predominantly interpreted as failure, the possibilities for heuristic exploration tend to be reduced, limiting the investigative and formative potential of working with problems.

The fifth category reveals a conditional acceptance of creativity and the proposition of problems. Although pre-service teachers recognize the value of multiple strategies and question formulation, these practices appear to be complementary, peripheral, or dependent on external factors, such as the time available or the students' level.

The conditionality attributed to problem posing appears directly in Q5. In a jointly filed statement of reasons, the pre-service teachers state that:

> In certain subjects, we believe that we can easily propose the creation and resolution of questions [...] In other subjects, this proposal would probably not work (L5–L6, Q5).

The excerpt acknowledges the possibility of students asking questions but restricts this practice to certain content or circumstances. Problem posing thus appears as a possibility, and not yet as a constitutive practice of school mathematics. This position contrasts with perspectives that understand problem formulation as a process that involves exploration, establishing connections, and generating and reflecting on new problem situations (Cai; Rott, 2024). Table 5 summarizes this configuration.

Table 5 – Constrained creativity and residual problem posing

Constraints mentioned	Implications
"It depends on the content"	Epistemological limitation
"It is not always possible"	PP as an exception
Creation at the end of the process	Loss of investigative character

Source: Prepared by the author

The data indicate that problem posing is still not recognized as a central epistemological practice, but as an ancillary activity, which limits the integrated understanding of problem solving and problem posing as investigative practices.

The conditional acceptance of creativity indicates that PP is still not recognized as a constitutive practice of school mathematics, but as a complementary or occasional activity. This position suggests that students' mathematical authorship remains subordinated to the logic of solving previously defined tasks. This configuration limits the understanding of "PP as a practice linked to PS and as a space for mathematical authorship.

The integrated analysis of the categories confirms the suitability of the qualitative case study and the naturalistic paradigm adopted. The beliefs identified do not present themselves in a homogeneous or linear way, but as hybrid configurations marked by ambiguities and constraints, whose understanding requires attention to the formative context and the participants' interpretations. Table 6 summarizes the categories and their implications for PS/PP.

Table 6 – Summary of analytical categories and epistemological implications

Category	Implication for PS/PP
Expectation of predictability	Restriction of investigation
Teachers' control	Reduction of student agency
Curriculum	Subordination of the problem
Error as risk	Elimination of the productive impasse
Conditioned creativity	Emptying the PP

Source: Prepared by the author

In line with the criteria of credibility and internal coherence defined in the methodology, the results suggest that the stated familiarity with investigative approaches does not eliminate beliefs related to predictability, teacher control, and compliance with the curriculum, but rather deeply rooted epistemological beliefs, produced and reproduced in participation patterns associated with the school mathematics tradition.

Taken together, the results suggest that the stated appreciation of inquiry-based approaches coexists with beliefs about predictability, teacher control, and adherence to the curriculum, and is associated with participation patterns historically present in the school mathematics tradition.

Taken together, the categories reveal a tension between the stated appreciation of inquiry-based practices and the persistence of conceptions that prioritize the predictability of the path, the centrality of the teacher, compliance with the curriculum, the reduction of errors, and restricted forms of student authorship. These positions do not correspond to an explicit rejection of problem solving or problem posing. Rather, they reveal forms of conditional acceptance, in which the openness characteristic of investigative work is allowed as long as it remains subject to certain limits of control, time, content, and difficulty.

In light of Ernest (1989), the set of justifications shows traces of Platonic and instrumentalist conceptions even when the pre-service teachers express appreciation for student participation and conceptual understanding. This coexistence indicates that beliefs are not necessarily organized as homogeneous or mutually exclusive positions. Participants can recognize principles associated with investigative practices and, at the same time, draw on teaching approaches that preserve previously defined paths, teacher-centered validation, and priority given to curriculum progression. In this sense, the data reinforce the importance of understanding beliefs as situated and sometimes hybrid configurations.

The perspective of Skott (2015, 2018) helps broaden this interpretation by preventing such positions from being treated exclusively as stable individual dispositions. The justifications are consistent with participation patterns historically associated with school mathematics, in which expectations regarding who proposes, who validates, how progress is made in the content, and what place can be attributed to error and uncertainty are stabilized. Thus, the status assumed by the problem depends not only on the characteristics of the proposed task, but also on the conceptions of teaching, learning, and participation that guide its use.

This reading helps us understand why the presence of problems does not ensure investigative practice. A problem can be approached as a previously navigated path or, in another configuration,

as a space for exploration, strategy formulation, confrontation of ideas, validation, and knowledge production. The tensions identified in the justifications therefore suggest that expanding the formative potential of problem solving and problem posing requires discussing not only procedures or types of tasks, but also the conceptions that govern openness to uncertainty, error, autonomy, and students' mathematical authorship.

Finally, the analysis of the written justifications revealed conditioned and ambivalent positions that could not be grasped solely through the choices made on the scale. Expressions such as "it depends," "to a certain extent", and other forms of qualification assume, in this context, analytical relevance because they highlight tensions between adherence to investigative principles and the preservation of references consolidated by school experience. It is precisely in this coexistence, rather than in a simple opposition between traditional and investigative conceptions, that one of the main results of the study lies.

Final Considerations

The study presented in this article aims to analyze the beliefs about teaching and learning mathematics expressed in the written reasoning of pre-service teachers when taking a stance on statements related to PS and PP, and to discuss their implications for understanding the problem as a space for research and knowledge production. The results show that the stated appreciation of inquiry-based practices coexists with expectations of predictability, the centrality of teacher control, subordination to the curriculum, an understanding of error as risk, and limited recognition of problem posing. These tensions can limit the understanding of the problem as an open space for investigation, authorship, and the production of mathematical knowledge.

From the perspective of initial teacher education, the results indicate that introducing PS and PP as a didactic approach cannot be limited to presenting methodologies, tasks, or examples of good practices. It is necessary to promote educational spaces that explicitly challenge prospective teachers' epistemological beliefs, through experiences that confront predictability, control, and curriculum normativity. Creating these spaces involves organizing practical courses and supervised practicums as research spaces, in which uncertainty, error, and authorship are experienced as constitutive elements of mathematical learning.

In addition, initial teacher education should foster new patterns of participation in mathematics classes, in which teachers can interpret processes, support cognitive demands, and make pedagogical decisions in unpredictable contexts. In this sense, PS and PP can be understood not only as teaching approaches but also as formative practices that challenge beliefs and foster transformations in teachers' professional constitution.

Finally, we acknowledge that the research is limited to a single educational context and a small group of participants, which limits the scope of its conclusions. Considering the naturalistic paradigm, the results are not aimed at statistical generalization, but at an in-depth understanding of a situated case and the production of analytically transferable knowledge. Future research could expand this discussion

through longitudinal studies, observations of teaching practices, and analyses of formative processes that track potential changes in beliefs throughout initial education and entry into professional practice.

Although the study contributes to our understanding of epistemological beliefs related to problem solving and problem posing in initial teacher education, some limitations warrant consideration. The research is limited to a single formative context and a small number of participants, characterizing a situated case study. However, given the naturalistic paradigm adopted, these characteristics are not methodological weaknesses but conditions inherent to research aimed at gaining an in-depth understanding of educational phenomena in specific contexts. Thus, the results presented are not intended for statistical generalization, but rather to produce analytical and theoretically transferable knowledge.

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