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Preservice Mathematics Teachers' Beliefs about Problem-Solving in Culturally Diverse Classrooms

Renán Concha-Zelada [a]
Miguel Friz Carrillo [a]
Hilbert Blanco-Álvarez [b]

[a] Universidad del Bío-Bío, Facultad de Educación y Humanidades, Departamento de Ciencias de la Educación, Programa de Doctorado en Educación en Consorcio, Chillán, Chile
[b] Hilbert Blanco-Álvarez, Universidad de Nariño, Facultad de Ciencias Exactas y Naturales, Departamento de Matemáticas y Estadística, Pasto, Colombia

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ABSTRACT

Background: The beliefs from the area of mathematics teacher training allow us to understand the function that future education professionals assign to mathematical activities, including problem solving, and how in this type of activities it is possible to incorporate the cultural knowledge of the students, when the teaching process takes place in culturally diverse classrooms. **Objective:** To analyze the beliefs of mathematics undergraduate students from a university in the department of Nariño about problem solving and cultural knowledge in culturally diverse classrooms. **Design:** A descriptive methodological complementarity research design was used, since this gives the possibility of understanding and contrasting the quantitative and qualitative information. **Scenario and participants:** The sample consisted of 60 undergraduate students in mathematics. **Data collection and analysis:** The information was collected through a Likert-type questionnaire with 35 statements and 3 open questions, which were analyzed in the SPPS 25.0 and Atlas TI 9.0 software. **Results:** Favorable beliefs are evidenced in the participants to work on solving problems in culturally diverse classrooms and during the development of this activity to integrate the cultural knowledge of students. **Conclusions:** The need to improve mathematics teacher training curricula to develop the teaching process in culturally diverse classrooms is exposed.

Keywords: beliefs, problem solving, cultural knowledge, Ethnomathematics

Corresponding author: Renán Concha-Zelada. Email: renconcha@ubiobio.cl

Creencias de profesores de matemáticas en formación inicial sobre la resolución de problemas en aulas culturalmente diversas

RESUMEN

Antecedentes: Las creencias desde el área de formación de profesores de matemáticas permiten comprender la función que asignan futuros profesionales de la educación a las actividades matemáticas, entre ellas la resolución de problemas y cómo en este tipo de actividades es posible incorporar los conocimientos culturales de los estudiantes, cuando se desarrolla el proceso de enseñanza en aulas culturalmente diversas. **Objetivo**: Analizar las creencias de estudiantes de licenciatura en matemáticas de una universidad del departamento de Nariño sobre la resolución de problemas y conocimientos culturales en aulas culturalmente diversas. **Diseño**: Se utilizó un diseño de investigación de complementariedad metodológica de tipo descriptivo, dado que ello otorga la posibilidad de comprender y contrastar la información cuantitativa y cualitativa. **Escenario y participantes**: La muestra estuvo conformada por 60 estudiantes de licenciatura en matemáticas. **Recopilación y análisis de datos**: La información fue recopilada por medio de un cuestionario tipo likert con 35 enunciados y 3 preguntas abiertas, las cuales fueron analizadas en los softwares SPPS 25.0 y Atlas TI 9.0. **Resultados**: Se evidencian creencias favorables en los participantes para trabajar la resolución de problemas en aulas culturalmente diversas y durante el desarrollo de esta actividad integrar los conocimientos culturales de estudiantes. **Conclusiones**: Se expone la necesidad de mejorar los currículos de formación de profesores de matemáticas para desarrollar el proceso de enseñanza en aulas culturalmente diversas.

Palabras claves: creencias, resolución de problemas, conocimiento cultural, etnomatemática

Crenças de professores de matemática em formação inicial sobre resolução de problemas em salas de aula culturalmente diversas

RESUMO

Enquadramento: As crenças da área da formação de professores de matemática permitem-nos compreender a função que os futuros profissionais da educação atribuem às atividades matemáticas, incluindo a resolução de problemas, e como neste tipo de atividades é possível incorporar o conhecimento cultural dos alunos, quando o processo de ensino ocorre em salas de aula culturalmente diversas. **Objetivo:** Analisar as crenças de alunos de graduação em matemática de uma universidade do departamento de Nariño sobre resolução de problemas e conhecimento cultural em salas de aula culturalmente diversas. **Delineamento:** Foi utilizado um delineamento de pesquisa de complementaridade metodológica descritiva, uma vez que possibilita compreender e contrastar as informações quantitativas e qualitativas. **Cenário e participantes:** A amostra foi composta por 60 alunos de graduação em matemática.

Coleta e análise dos dados: As informações foram coletadas por meio de um questionário do tipo Likert com 35 afirmações e 3 questões abertas, que foram analisadas nos softwares SPPS 25.0 e Atlas TI 9.0. **Resultados:** Evidenciam-se crenças favoráveis nos participantes para trabalhar a resolução de problemas em salas de aula culturalmente diversas e durante o desenvolvimento desta atividade para integrar o conhecimento cultural dos alunos. **Conclusões:** Expõe-se a necessidade de melhorar os currículos de formação de professores de matemática para desenvolver o processo de ensino em salas de aula culturalmente diversas.

Palavras-chave: crenças, resolução de problemas, consciência cultural, Etnomatemática

INTRODUCTION

According to Barrantes (2008), Sepúlveda et al. (2009), Schoenfeld (1992), and Concha-Zelada et al. (2022), the beliefs of future mathematics teachers are crucial in problem-solving teaching. These beliefs shape and validate decisions about how teachers plan this activity and the types of mathematical problems that are developed in the classroom, i.e., routine or non-routine (Fonseca Castro & Castillo Sánchez, 2013; Sepúlveda Obreque et al., 2017).

Rojas et al. (2020) highlight the importance of studying these beliefs in culturally diverse classrooms, as a teacher's beliefs about the activity being addressed can shape their ability to incorporate the students' diverse cultural knowledge. Oliveras & Blanco-Alvarez (2016) and Planas (2003) suggest that Ethnomathematics presents an opportunity to delve into the beliefs that emerge in culturally diverse settings. Ethnomathematical attitudes are shaped by beliefs and pedagogical experiences, which can lead to a future math teacher being interested in teaching from an ethnomathematical perspective (Aroca et al., 2016; D'Ambrosio, 2021).

Based on this background, our research objective is to analyze the beliefs of mathematics undergraduate students from a university in the department of Nariño about problem-solving and cultural knowledge in culturally diverse classrooms. This will contribute to the processes of initial teacher training.

BELIEFS ABOUT MATHEMATICAL PROBLEM-SOLVING IN INITIAL TEACHER TRAINING

The international literature provides a broad and detailed definition of the term belief and its relationship with mathematical activities, such as problem-solving (Alabau Gonzalvo et al., 2020; Concha-Zelada et al., 2022). Lester et al. (1989) suggest that beliefs in mathematics play a crucial role in shaping an individual's understanding of themselves, math, problem-solving, and problem-posing. Callejo and Vila (2003) define belief as the "students' ideas about mathematical activities and processes (e.g., exercises, problem-solving, demonstrations) and their approach to mathematical tasks" (p.179). Martínez (2013) expresses similar ideas, highlighting that mathematical beliefs are connected to activities and processes such as exercises, problem-solving, learning, and approaches to mathematical tasks. In contrast, Vilanova et al. (2005) argue that beliefs are the starting point for individuals to approach topics and activities in the math area, influencing how much time, interest, and effort they dedicate to class tasks.

Continuing to contribute to this research topic, Schoenfeld (1992) encountered various beliefs related to mathematical problem-solving during the development of his studies. Thus, he builds a list of beliefs frequently held by pre-service and in-service teachers on this subject, among which we can mention: a) mathematical problems have one and only one correct answer; b) there is only one correct way to solve any problem, and it is usually the rule the teacher recently demonstrated in class; c) ordinary students cannot expect to understand mathematics; they expect to memorize and apply it mechanically without understanding it; d) students who have understood mathematics will be able to solve any problem assigned to them in 5 minutes or less; e) mathematics learned in school has little to do with the real world, and g) formal tests are irrelevant in the process of discovery or invention.

In this same line, Martínez Padrón (2013) has identified some beliefs about mathematics and problem-solving that teachers commonly hold during their initial training, including the following: a) the mathematics teacher must always provide a model example to solve problems; b) the activities that are proposed in the subject of mathematics are never simple, and c) in order to perform the activities in mathematics, we must learn the procedures and concepts to solve a problem.

Fonseca and Castillo (2013), Gómez- Chacón (2000), and Sepúlveda López et al. (2009) express that caution should be taken regarding the beliefs held by student teachers in the initial training processes. These beliefs reflect a series of learning experiences which, at times, are not positive and can generate a rejection or unwillingness to work on specific activities, such as problem-solving, even generating "barriers that are very difficult to break and can seriously hinder students' behavior in this activity" (Rizo Cabrera & Campistrouspérez, 1999, p. 43). On the other hand, Barrantes (2008) and Pérez and Beltrán (2011) emphasized the importance of studying this aspect because understanding the learning experiences that shape students' beliefs can help us predict their performance and effort when solving a problem.

Finally, Schoenfeld (1992,1987), Garofalo, and Lester (1985) suggest that understanding what a belief is not enough. Instead, it is crucial to delve deeper into the beliefs students in initial training develop during the teaching and learning process. According to these authors, beliefs play a crucial role in mathematical activities developed in the classroom, such as problem-solving. Beliefs shape the sense and perception with which a mathematical object will be understood and determine the attitude, possibilities, and limitations pertinent for a future or current mathematics teacher to develop in a classroom activity. In other words, beliefs will affect, even unconsciously, the way a pre-service or in-service teacher plans, organizes, teaches, and the time he or she allocates to activities such as problem-solving and the types of problems (routine or non-routine) that are proposed in the process (Ernest, 1989; Vila Corts, 2001).

ETHNOMATHEMATICS AND ITS ROLE IN THE INITIAL TEACHER TRAINING PROCESS

Blanco-Álvarez & Nazate Calpa (2022) define ethnomathematics as the "study of mathematical knowledge used in everyday life and produced by various cultures" (p.154 According to their research, ethnomathematics aims to recover the diversity of mathematical thinking and reasoning, characterized by being non-academic in cultural communities, as well as the mathematical thinking that people develop and use during the exercise of their professions to integrate this mathematical knowledge into the school curriculum (Blanco-Alvarez, 2012b; D'Ambrosio, 2013).

Blanco-Álvarez & Nazate Calpa (2022), Schliemann (2002), Carraher et al. (2002), Santillán & Zachman (2011) suggest that ethnomathematics, through the inclusion of extracurricular knowledge, is an excellent method to examine the reasoning, algorithms, and solutions used by groups identified in this process. According to Blanco-Álvarez & Nazate Calpa (2022), every action cited in this field of study presents a valuable opportunity and a significant step forward for the initial training of mathematics teachers. Including ethnomathematics in teacher education enables teachers and students to acknowledge and assess "the recognition and revaluation of the mathematical knowledge and practices of different cultures" (Blanco-Álvarez & Nazate Calpa, 2022, p. 154). According to Planas (2001), problem-solving can uncover the distinct cultural knowledge, reasoning, and mathematical processes students employ to solve mathematical problems in classrooms with diverse cultural backgrounds.

For Planas (2001), one aspect that a future mathematics teacher should bear in mind is that when working on problem-solving, from an ethnomathematical perspective, it is essential to develop non-routine problems since this type of mathematical activity encourages debate and dialogue about a solution (Salinas & Sgreccia, 2017). Conversely, routine problems are characterized by mechanical processes since they only differ in their statement, but their development follows the same patterns as previous ones (Echeñique Urdiain, 2006). Similarly, Planas (2001) suggests that including diverse cultural knowledge from inside and outside the classroom in the teaching and learning process can help math teachers in initial training to develop favorable beliefs toward their pedagogical work, leading to the formation of a reflective teacher in their pedagogical practice (Aroca et al., 2016).

METHODOLOGY

Research design

Our research objective led us to select a descriptive methodological complementarity research design aligned with our pragmatic paradigm. This approach will aid us in comprehending, examining, and exploring the study phenomenon in greater detail (Hernández-Sampieri & Mendoza, 2018; Machado Ramírez & Montes de Oca Recio, 2008) by utilizing both quantitative and qualitative approaches, leading to new areas for investigation. (Bisquerra Alzina, 2009).

Context, scope, study sample and participants

The research was conducted in the city of Pasto, located in the Department of Nariño, Colombia. In this particular territory, the scope of the study was a public university in which a non-probabilistic and intentional sampling was implemented to select the study sample. Doing this allowed us to choose highly relevant participants to the study's objective (McMillan & Schumacher, 2005). These participants included 60 students in semesters III and V of the mathematics bachelor's degree program who had already completed the mathematics education and culture course, which aims to:

> “emphasize that future mathematics teachers have a broad concept of mathematics as a human activity of reasoning based on experience, as well as taking into account in their teaching practice the influence of socio-cultural factors in the teaching, learning, and development of mathematics. They should also consider cultural practices in the classroom and be aware of and respectful of the country's cultural diversity" (Blanco-Álvarez & Marmolejo, 2016, p. 19).

Similarly, in this participant selection process, each participant was informed of the research objectives derived from the doctoral study entitled "Problem-solving in school contexts with a migrant population: beliefs of teachers in educational establishments", approved by the respective ethics committee. The students' concerns were addressed, and those who chose to participate received informed consent, emphasizing the anonymity of the information collected for this study.

Instruments

The information was collected using the Likert questionnaire of Concha-Zelada et al. (2022) as a starting point, which was modified according to the literature reviewed (Blanco-Alvarez, 2023; D’Ambrosio, 2013, 2021; Planas, 2003). Thus, a Likert-type questionnaire was obtained with a total of 35 statements and three reflective open-ended questions. This action allowed for the collection of information on the beliefs of undergraduate math students regarding problem-solving and cultural knowledge in diverse classrooms. Additionally, open-ended questions provided an opportunity to analyze study participants' beliefs and what cultural elements they see necessary to teach problem-solving in diverse culturally classrooms based on their experiences and training.

Data analysis

In order to analyze the information from the 35 statements and three open-ended questions in the Likert questionnaire, the process was organized into three stages, detailed below.

From a quantitative point of view, we analyzed the 35 proposed statements according to each participant's degree of agreement or disagreement on a scale of 1 to 5. Subsequently, utilizing the SPSS 25.0 statistical software, a data array was created to obtain descriptive statistics (mean, variance, percentages) and inferential statistics (t student and Tukey tests) (McMillan & Schumacher, 2005) and thus interpret the results obtained at this stage.

On the other hand, from the qualitative scope of the study, the answers provided by the mathematics undergraduate students were entered into the software Atlas TI. 9.0. Thus, through the readings of each account, categories and semantic networks emerged that served to analyze the answers given to the open-ended questions (Blanco-Alvarez, 2012a) and thus achieve a representation of the beliefs expressed by the participants (Bisquerra Alzina, 2009).

Finally, the information from the two previous stages was triangulated from the methodological complementarity. As a result, it was possible to establish, contrast, and deepen the data and accounts collected, thereby generating new aspects that are necessary and relevant to investigate in current and future research (Hernández-Sampieri & Mendoza, 2018; Quintriqueo et al., 2017).

RESULTS

The following tables show the results obtained from applying the Likert-type questionnaire and the respective analyses derived from this instrument with the support of SPPS 25.0 and Atlas Ti 9.0 software.

Quantitative results

Table 1 presents how undergraduate mathematics students have favorable beliefs about mathematical problems as motivating factors for learning new procedures (M=4.28, SD= 0.647) and developing new skills (M=4.22; SD=0.512). The reason is that 90.0% of the participants agreed or strongly agreed with both statements. Likewise, participants showed positive attitudes towards statements that describe problem-solving as a way to learn new concepts (M=4.08; SD= 0.552) and as a strategy to teach mathematics (M=4.02; SD=0.762). Around 91.6% and 78.3% of participants strongly agree or agree with these statements.

Table 1

Characteristics of problem-solving

According to you, mathematical problems are characterized by being:	M	SD	SD %	D %	NAND %	A %	SA %
A learning situation that relates to the student's reality.	3.67	0.870	1.7	11.7	20.0	51.7	15.0
A situation that can motivate to learn new concepts.	4.08	0.552	1.7	3.3	3.3	68.3	23.3
A situation that can motivate to learn new procedures.	4.28	0.647	1.7	1.7	6.7	46.7	43.3
A situation that allows the development of new skills.	4.22	0.512	0.0	3.3	6.7	55.0	35.0
A situation that encourages discussion about a topic involving routine and non-routine mathematical phenomena.	3.98	0.559	0.0	3.3	18.3	55.0	23.3
A situation that provides the	3.98	0.491	1.7	0.0	15.0	65.0	18.3

possibility of making discoveries related to a topic.							
A strategy for teaching mathematics.	4.02	0.762	1.7	3.3	16.7	48.3	30.0
A method for learning mathematics.	3.85	0.74	1.7	3.3	25.0	48.3	21.7

M: Mean, **SD:** Standard Deviation**, SD:** Strongly Disagree, **D:** Disagree, **NAND:** Neither Agree nor Disagree, **A:** Agree, **SA:** Strongly Agree.

Concerning the statements that indicate that a feature of problem-solving is to be an instance that favors discussion about a topic in which routine and non-routine mathematical phenomena are involved (M=3.98; D=0.559) and to be a situation that provides the possibility of making discoveries related to some topic (M=3.98; D=0.491), favorable beliefs are also observed. 78.3% and 83.3% of the participants affirm that they strongly agree or agree, respectively. Finally, the statements expressing that problem-solving is a method for learning mathematics (M=3.85; D=0.740) and a learning situation that relates to the student's reality (M=3.67; D=0.870) obtained a lower valuation but were still positively valued by the participants. 70.0% and 66.7% of the participants strongly agree or agree, respectively.

Table 2 shows that the highest-rated statements were those expressing that the objective of problem-solving in the teaching-learning process is to develop critical reasoning (M=4.20; SD=0.637), to develop logical thinking (M=4.18; SD=0.695) and to activate students' curiosity (M=4.12; SD=0.715). 91.7%, 86.6%, and 85.0% of the participants strongly agree or agree, respectively. Concerning the statements that state that a problem should contextualize different topics of mathematics to give a sense of usefulness to what has been learned (M=4.07; SD=0.673), develop creative thinking (M=4.07; SD=0.945) and should be accessible to all students (M=4.07; SD=0.877), they were positively valued by the students, since 85.0%, 81.7% and 83.3% respectively, indicated that they strongly agree or agree with these statements.

Table 2

Purpose of problem-solving in the teaching-learning process.

The role of a mathematical problem in the teaching-learning process is:	**M**	**SD**	**SD %**	**D %**	**NAND %**	**A %**	SA %
To consolidate the knowledge acquired during the class.	3.78	0.870	3.3	6.7	13.3	61.7	15.0
To develop logical thinking.	4.18	0.695	0.0	6.7	6.7	48.3	38.3
To contextualize different mathematical topics with the purpose of giving a sense of usefulness to what has been learned.	4.07	0.673	1.7	3.3	10.0	56.7	28.3
To develop critical reasoning.	4.20	0.637	1.7	3.3	3.3	56.7	35.0
To develop creative thinking.	4.07	0.945	1.7	8.3	8.3	45.0	36.7
To apply concepts addressed in class.	3.97	0.745	1.7	5.0	13.3	55.0	25.0
To encourage the discussion of their possible solution.	3.97	0.846	1.7	6.7	13.3	50.0	28.3
To activate students' curiosity.	4.12	0.715	1.7	3.3	10.0	51.7	33.3
Must be accessible to all students.	4.07	0.877	3.3	3.3	10.0	50.0	33.3
Work collaboratively for its development.	3.80	0.976	5.0	5.0	15.0	55.0	20.0
To reveal students' cultural knowledge.	3.60	1.159	5.0	11.7	20.0	45.0	18.3

M: Mean, **SD:** Standard Deviation**, SD:** Strongly Disagree, **D:** Disagree, **NAND:** Neither Agree nor Disagree, **A:** Agree, **SA:** Strongly Agree.

Likewise, in Table 2, the statements that indicate that problem-solving is to apply concepts addressed in class (M=3.97; SD=0.745) and encourage the discussion of their possible solution (M=3.97; SD=0.846) show favorable beliefs. 80.0% and 78.3% of the participants affirm that they strongly agree or agree, respectively. This situation also occurs with the statements referring to the fact that problem-solving activities allow consolidating the knowledge acquired during class (M=3.78; SD=0.870) and working collaboratively for its development (M=3.80; SD=0.976), where 76.7% and 75.0% of the participants, respectively, affirm that they strongly agree or agree with these proposals. Finally, the statement with the lowest valuation is the one that proposes that problem-solving reveals students' cultural knowledge (M=3.60; SD=1.159), where only 63.3% of the participants affirmed that they strongly agree or agree with this statement.

Table 3 shows that participants hold favorable beliefs about problem-solving, indicating that incorporating different solutions to the same problem is possible (M=4.13; SD=0.592) since 86.7% strongly agree or agree. Concerning the statements that establish the possibility of integrating into problem-solving the students' context (M=3.73; SD=0.843), historical events of a culture (M=3.68; SD=0.898) and geographical characteristics of a culture (M=3.67; SD=0.938), despite obtaining a lower score, the results show positive beliefs, since 68.4%, 66.7% and 63.3% of the participants, respectively, strongly agree or agree with these statements.

Table 3

Incorporation of cultural knowledge in problem solving.

According to you, in a culturally diverse classroom, a mathematical problem makes it possible to incorporate:	M	SD	SD %	D %	NAND %	A %	SA %
Cultural and artistic expressions such as dance.	2.93	1.351	10.0	28.3	31.7	18.3	11.7

Cultural and artistic expressions such as music.	3.10	1.380	11.7	16.7	33.3	26.7	11.7
Cultural and artistic expressions such as paintings.	3.27	1.521	10.0	20.0	18.3	36.7	15.0
Cultural and artistic expressions such as arts and crafts.	3.57	1.504	6.7	15.0	20.0	31.7	26.7
Historical events of a culture.	3.68	0.898	1.7	11.7	20.0	50.0	16.7
Geographical characteristics of a culture.	3.67	0.938	1.7	11.7	23.3	45.0	18.3
Linguistic aspects of a culture.	3.62	0.851	1.7	10.0	28.3	45.0	15.0
The students' context.	3.73	0.843	3.3	5.0	23.3	51.7	16.7
Different solutions to the same problem situation.	4.13	0.592	0.0	5.0	8.3	55.0	31.7

M: Mean, **SD:** Standard Deviation**, SD:** Strongly Disagree, **D:** Disagree, **NAND:** Neither Agree nor Disagree, **A:** Agree, **SA:** Strongly Agree.

A similar situation occurs in Table 3 with the statements that indicate the possibility of integrating linguistic aspects of a culture (M=3.57; SD= 0.851), cultural and artistic expressions such as arts and crafts (M=3.57; SD=1.504), and paintings (M=3.27; SD=1.521) in mathematical problems that are developed in culturally diverse classrooms. 60.0%, 58.4%, and 51.7% of the participants, respectively, strongly agree or agree. Finally, those statements that point out the possibility of incorporating cultural and artistic expressions such as music (M=3.10; SD=1.380) and dance (M=2.93; SD=1.351) obtained low scores, thus reflecting unfavorable beliefs to these proposals since only 38.4% and 30.0% of the participants strongly agree or agree with these statements.

Table 4 shows favorable beliefs towards statements that express that when problem-solving takes place in culturally diverse classrooms, it is possible to recognize different strategies to solve a mathematical problem

(M=4.23; SD= 0.623), to discuss about different solutions to the proposed questions (M=4.18; SD=0.491) and to find different solutions to the proposed questions (M=4.18; SD=0.356). 93.4%, 90.0% and 93.4% of the participants, respectively, strongly agree or agree.

Table 4

Developing problem solving in culturally diverse classrooms

According to you, when problem solving takes place in culturally diverse classrooms it is possible:	M	SD	SD %	D %	NAND %	A %	SA %
To incorporate students' cultural knowledge, as this enriches this type of activity.	3.97	0.609	1.7	5.0	6.7	68.3	18.3
To recognize different strategies to solve a mathematical problem.	4.23	0.623	1.7	3.3	1.7	56.7	36.7
To recognize that I feel prepared to develop this type of activities with the students' cultural knowledge.	3.87	0.490	0.0	3.3	21.7	60.0	15.0
To recognize the need to strengthen initial training in topics related to incorporating students' cultural knowledge in these activities.	3.97	0.575	1.7	1.7	15.0	61.7	20.0
To incorporate in the statement of a problem the students' context	3.87	0.660	0.0	8.3	15.0	58.3	18.3

when developing these activities.							
To find different solutions to the proposed questions.	4.18	0.356	0.0	1.7	5.0	66.7	26.7
To discuss about different solutions to the proposed questions.	4.18	0.491	0.0	3.3	6.7	58.3	31.7

M: Mean, **SD:** Standard Deviation**, SD:** Strongly Disagree, **D:** Disagree, **NAND:** Neither Agree nor Disagree, **A:** Agree, **SA:** Strongly Agree.

Similarly, Table 4 shows that participants gave positive evaluations to the statements that indicate that when developing problem-solving in culturally diverse classrooms, it is possible to incorporate the students' cultural knowledge since this enriches this type of activity (M=3.97; SD= 0.609) and also provides the opportunity to recognize the need to strengthen initial training in topics related to incorporating students' cultural knowledge in these activities (M=3.97; SD=0.575). 86.6% and 81.7% of the participants strongly agree or agree with these statements.

Finally, the proposals that consider incorporating in the mathematical statement the students' context (M=3.87; SD=0.660) and recognizing the preparation to develop these activities with the students' cultural knowledge (M=3.87; SD=0.490) also evidence favorable beliefs by the students, since 76.6% and 75.0% respectively, state that they strongly agree or agree.

Table 5 shows statistically significant differences concerning their beliefs according to their gender. Thus, according to their valuations, beliefs in favor of female students in comparison to male students are seen in those statements that express that problem solving is a learning situation that is related to the student's reality ([t (58) =-2.088, p=0.041]) and a situation that provides the possibility of making discoveries related to some topic ([t (58) =-2.127, p=0.038]).

Table 5

Comparison of means according to students' gender

	Group statistics			t-test for equality of means			
	Gender	M	SD	t	df	p(bi)	Direction
A learning situation that relates to the student's reality.	Male	3.49	0.997	-2.088	58	0.041	F>M
	Female	4.00	0.707				
A situation that provides the possibility of making discoveries related to some topic.	Male	3.85	0.709	-2.127	58	0.038	F>M
	Female	4.24	0.625				

M: mean, **SD:** standard deviation, **t:** difference between the means of the two groups, **df**: degrees of freedom, **p(bi)**: Level of significance. **F**: Female, **M:** Male.

Tables 6 and 7 also present the results obtained after performing the one-way ANOVA and Tukey's Post hoc tests in the SPPS 25.0 statistical software. These results show statistically significant differences according to the age of the undergraduate mathematics students, specifically among those who are 24 years old or older (M=5.00) compared to the group between 18 and 19 years old (M=3.81), in the statement that problem-solving is a situation that can motivate them to learn new concepts.

Table 6

One-way ANOVA - Age of students

		Sum of squares	df	Root Mean Square	F	Sig.
	Total	51.333	59			
A situation that can motivate to learn new concepts.	**Between groups**	5.751	3	1.917	4.001	0.012
	Within groups	26.832	56	0.479		
	Total	32.583	59			

Table 7

Post-Hoc Tukey test - Age of students.

Dependent variable	(I) Student age	(J) Student age	Difference in means (I-J)	Deviation Error	Sig.
A situation that can motivate to learn new concepts.	18-19 years old	20-21 years old	-0.396	0.207	0.236
		22-23 years old	-0.385	0.256	0.442
		24 years old or older	-1.185*	0.371	0.012
	20-21 years old	18-19 years old	0.396	0.207	0.236
		22-23 years old	0.011	0.270	1.000
		24 years old or older	-0.789	0.381	0.174
	22-23 years old	18-19 years old	0.385	0.256	0.442

	20-21years old	-0.011	0.270	1.000
	24 years old or older	-0.800	0.410	0.218
24 years old or older	18-19 years old	1.185*	0.371	0.012
	20-21 years old	0.789	0.381	0.174
	22-23 years old	0.800	0.410	0.218

*The mean difference is significant at the 0.05 level.

Qualitative results

Table 8 shows the categories that emerged after the analysis carried out in Atlas TI. 9.0 to each of the three open-ended questions proposed in the questionnaire, presented below.

Table 8

Open-ended questions and emerging categories

Question	Description	Emerging category
What aspects should be considered to incorporate problem-solving and cultural knowledge in culturally diverse classrooms?	Based on their beliefs, students mention the aspects necessary to incorporate problem-solving and cultural knowledge in culturally diverse classrooms.	Knowledge, respect and appreciation Dialogue

What didactic-mathematical knowledge is necessary for articulating cultural and school mathematical knowledge in culturally diverse classrooms?	Students express their beliefs about the didactic-mathematical knowledge necessary to articulate cultural and mathematical knowledge.	Didactic approach contextualized to the students' characteristics.
What didactic resources would you use to teach mathematics in culturally diverse classrooms?	In this category, students express their beliefs about the didactic resources they would use to teach mathematics in culturally diverse classrooms.	Manipulative or Digital Material

Tables 9, 10, 11, and 12 below present some of the most striking responses to each open-ended question proposed in the questionnaire. With these answers, it was possible to go deeper into the beliefs of the undergraduate mathematics students in their initial training process, which we have named E1, E2, and E3.

Regarding question 1, Table 9 indicates that participants believe teachers must understand their students' cultural knowledge to incorporate it into math problem-solving in culturally diverse classrooms. This understanding will enable teachers to integrate cultural knowledge into planned classroom activities. Similarly, the participants' beliefs indicate that cultural knowledge should be respected and valued when teaching problem-solving or other math activities in culturally diverse classrooms, as it holds significant value for the students' cultural groups.

Table 9

Beliefs about the aspects that students think are necessary to work in culturally diverse classrooms. Category: Knowledge, respect and appreciation.

Question 1: What aspects should be considered to incorporate problem-solving and cultural knowledge in culturally diverse classrooms? Category: Knowledge, respect and appreciation		
Account E1	**Account E2**	**Account E3**
"The different types of mathematical knowledge that students have according to their culture should be taken into account so that the problem posed is related to daily life, which should also be respected and valued in this process"(E1).	*"I consider that first of all, the teacher who goes to a site should learn about the culture of the locality, and once he/she knows what the culture is, he/she should talk about it in class and refer to the culture, obviously without denigrating it, but rather engaging their interest in learning mathematics and also without leaving their culture behind, that is, valuing and respecting each culture and its knowledge" (E2).*	*"It is necessary for the teacher to know the cultural knowledge of his students so that he can relate or correspond with other cultural knowledge or activities that can be designed, which undoubtedly must be valued and respected to give true meaning to this knowledge." (E3)*

E1: Student 1, E2: Student 2, E3: Student 3.

Table 10 also shows that another aspect that must be considered to incorporate the students' cultural knowledge in problem-solving is to develop a respectful dialogue with the students from culturally diverse classrooms. This communication process facilitates a deeper understanding and exploration of students' cultural knowledge and how they use it in problem-solving within their contexts.

Table 10

Beliefs about the aspects that students are required to work in culturally diverse classrooms. Category: Dialogue.

Question 1: What aspects should be considered to incorporate problem-solving and cultural knowledge into culturally diverse classrooms? Category: Dialogue		
Account E1	**Account E2**	**Account E3**
"It is essential to appreciate diversity, learn about students' cultural context, include cultural examples and perspectives in mathematical problems, encourage intercultural dialogue, and use diverse materials and resources. Doing so promotes an inclusive and enriching environment that enables students to learn meaningfully and develop academic and cross-cultural skills."(E1)	*"One should take into account what students think and find solutions to what they present for each subject." (E2)*	*"You could do a round table, where each student mentions what their culture is based on. With that, problem solving is incorporated and embodied for everyone, thus sharing and listening to each culture with everyone else in a respectful way." (E3)*

E1: Student 1, E2: Student 2, E3: Student 3.

Regarding question 2, Table 11 reveals that students believe contextualized didactic knowledge is a didactic-mathematical knowledge necessary to articulate cultural and school mathematical knowledge in culturally diverse classrooms. Considering students' context-specific characteristics, such as cultural knowledge, can add greater meaning and significance to problem-solving in mathematical activities.

Table 11

Beliefs associated with the didactic-mathematical knowledge of teachers in initial training

Question 2: What didactic-mathematical knowledge is needed to articulate cultural knowledge and school mathematical knowledge in culturally diverse classrooms? **Category: Didactic approach contextualized to the students' characteristics**		
Account E1	**Account E2**	**AccountE3**
"A didactic approach that is sensitive and adapted to the students' characteristics and experiences is required."	*"There is a need to relate mathematical knowledge to everyday life activities to make it easier for students to understand."*	*"The didactic-mathematical knowledge that I consider necessary is for the teacher to take ownership of the reality of his students and have previous mathematical knowledge of the required social context."*

E1: Student 1, E2: Student 2, E3: Student 3.

Table 12 shows that in question 3 of the questionnaire, students indicate that the didactic resources they would use to teach mathematics in culturally diverse classrooms are manipulative or digital material. The study participants expressed that this resource is more meaningful and appealing to students because it allows them to explore and investigate it and thus establish mathematical relationships pertinent to the class objective.

Table 12

Beliefs regarding didactic resources in mathematics teaching.

Question 3: What didactic resources would you use to teach mathematics in culturally diverse classrooms? Category: Manipulative or digital material		
Account E1	**AccountE2**	**Account E3**
"Manipulative resources such as the abacus, dice, pirinola, and even the various resources that can be presented depending on the area in which it is located so that students feel more engaged".	*"The didactic resources I would use to teach mathematics are calculators, rulers, games such as playing cards, dice, educational tickets, virtual platforms, educational games and videos that draw students' attention."*	*"Some manipulative and concrete and digital materials that are visually appealing and allow students to explore and experiment with mathematical concepts. These materials may include tokens, fruits, coins, videos, platforms, or other objects that are recognizable and relevant to the students' cultural context."*

E1: Student 1, E2: Student 2, E3: Student 3.

CONCLUSIONS

For Fonseca and Castillo (2013), Gómez- Chacón (2000), and Sepúlveda López et al. (2009), the beliefs of future teachers expose their different learning experiences in their training process. These beliefs, which can be of a positive or negative nature, will considerably determine the willingness to develop the activities they plan or propose in the teaching process, which in this research were focused on problem-solving and cultural knowledge present in culturally diverse classrooms.

Based on the results of the Likert-type questionnaire, participants believe that a problem in a learning situation is related to the student's reality (M=3.67). The process reveals students' cultural knowledge (M=3.60) and enriches mathematical activities (M=3.97) by incorporating it. According to the students' beliefs, it is crucial to thoroughly understand the cultural knowledge of culturally diverse classrooms so it can be incorporated into problem-solving, respected, and valued equally to school knowledge. This aspect, observed from ethnomathematics, is fundamental for future teachers to be able to recognize and revalue the extracurricular knowledge of other cultural groups and integrate it into the teaching process (Blanco-Alvarez & Nazate Calpa, 2022; D'Ambrosio, 2013).

Similarly, future mathematics teachers state that when problem-solving is developed in culturally diverse classrooms, it is necessary to dialogue with the students about the mathematical problem being addressed and not only to specify a result or answer. This activity makes it possible to recognize the different strategies for solving a mathematical problem (M=4.23) and discuss different solutions to the proposed questions (M=4.18).

On a different note, the results indicate that undergraduate mathematics students believe a contextualized didactic approach is crucial for developing problem-solving skills in culturally diverse classrooms. This action will allow the students' context (M=3.87), historical events (M=3.68), and geographical characteristics (M=3.67) of a culture to be incorporated into the statement of a mathematical problem. Thus, students from culturally diverse classrooms can use their cultural knowledge to develop alternative solutions to problems, highlighting the value of incorporating ethnomathematics in problem-solving teaching (Blanco-Álvarez, 2023; Planas, 2001).

Future teachers express that working on problem-solving in culturally diverse classrooms is a situation that provides the possibility of making discoveries related to some topic (M=3.98). However, for this proposal to be effective, some manipulative or digital material is required, allowing students to discover through experimentation how school and out-of-school mathematics allow solving everyday problems in different contexts.

Finally, the research results indicate that undergraduate students have positive beliefs about incorporating the students' cultural knowledge into problem-solving in culturally diverse classrooms. Therefore, favorable attitudes are reflected toward the proposals established by ethnomathematics to work this type of activity (Aroca et al., 2016; Blanco-Alvarez, 2023; D'Ambrosio, 2021; Oliveras & Blanco-Alvarez, 2016). Consequently, more research on ethnomathematics is required and should be given importance by mathematics teacher educators in the teaching process.

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AUTHOR CONTRIBUTION STATEMENT

Each author contributed to the tabulation, analysis, interpretation, and conclusion of the data and accounts analyzed in each table presented.

DATA AVAILABILITY STATEMENT

The documents used in this research are available at: https://drive.google.com/drive/folders/1MaP3-qRFBzZ-_bMWwwh4c5WNFhJiTOAY?usp=sharing

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