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Research Article

Preservice Mathematics Teachers' Awareness of Sociomathematical Norms

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Abstract

The awareness that pre-service teachers gain during their professional development process can directly affect their future teaching practices. In this context, this research aims to determine the awareness levels of pre-service mathematics teachers regarding sociomathematical norms. In this context, three forms were developed based on teacher-student dialogues that incorporate sociomathematical norms. The research was conducted using a qualitative case study model. The research study group consists of 42 third-grade students enrolled in the middle school mathematics teaching program at a state university in the Central Anatolia Region. Three scenario-based forms and semi-structured interviews were used as data collection tools. The data were analyzed through a three-level rubric. The findings reveal that the sociomathematical norm awareness levels of pre-service teachers are generally moderate. Experimental studies evaluating the impact of training on sociomathematical norms are recommended.

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Introduction

The process of learning and teaching mathematics should not be considered only as a cognitive construction process; this process also includes critical social interactions and activities (Luong, 2022). In fact, the process of students' understanding of mathematical concepts is shaped by social elements, such as classroom discussions, group work, and peer interactions, as well as individual thinking (Webb, 1991). The trend towards considering mathematics education not only as a cognitive process but also as a social and cultural activity is gaining strength (Nunes, 1999).

As researchers emphasize, considering mathematics education as a social and cultural activity brings attention to the role of culture within educational contexts. In this regard, to address the concept of culture in mathematics teaching processes more comprehensively, it

is first crucial to understand the multidimensional structure of culture. Culture is a complex and multidimensional concept consisting of beliefs, values, traditions, and behaviors shared by a society (Lyman, 2008). The iceberg metaphor effectively conveys the multifaceted nature of culture. The small part of the iceberg that remains above water represents the visible elements of a culture, such as art and traditions. The much more significant part of the iceberg that remains below water represents the invisible but essential aspects of culture. These deep layers include the society's basic belief systems, ethical values, norms, worldviews, and social roles (Virtue & Vogler, 2009). In addition to this multilayered structure of culture, smaller groups within a society create and share their microcultures. Microcultures are systems of norms, values, and beliefs that are specific to smaller social groups within a larger culture. For example, the unique rituals and habits of a family, the academic values shared by academics in a university department, or the behavioral patterns of a group of friends are examples of microculture (Roxå & Mårtensson, 2015).

The behaviors of students within a particular classroom, the values they share, and the forms of interaction they create also constitute the classroom microculture (Lopez & Allal, 2007). Classroom microculture refers to the totality of rules, beliefs, norms, values, attitudes, and other habits that emerge as a result of the interaction between students and teachers, or among students themselves, during the learning and teaching process (Toluk-Uçar, 2016). In this context, interactions between teachers and students play a crucial role in shaping the norms within the classroom microculture. These interactions foster a common understanding of rules, expectations, and practices, and classroom norms emerge (Cobb et al., 1992). Norms are a crucial element of the classroom microculture that appears from interactions among class members (Cobb, 1999). Classroom norms are unwritten but shared understandings among class members regarding beliefs, expectations, obligations, and practices. These norms provide guiding principles about what, how, and when individuals should do (Mottier Lopez & Allal, 2007; Toluk-Uçar, 2016; Yackel & Cobb, 1996). "Explaining and justifying solutions," "trying to understand others' explanations," "indicating agreement or disagreement," and "offering alternatives when there is a conflict in solutions" are examples of social norms in the classroom (Cobb & Yackel, 1996).

Social norms generally regulate accepted behaviors and forms of participation in the classroom, shaping general interactions such as listening to others' explanations, expressing disagreements, and justifying solutions. However, sociomathematical norms go beyond

these general participation rules and define how mathematical activities are structured and evaluated. In other words, while social norms guide social interactions within the classroom, sociomathematical norms determine what is considered mathematically meaningful in that context (Yackel & Cobb, 1996). Sociomathematical norms are collectively established rules within the classroom community that specifically govern how mathematical solutions and explanations are assessed. Yackel and Cobb (1996) emphasize the significant role these norms play in classroom mathematical discourse. They determine how mathematical solutions and justifications are assessed and guide students' mathematical thinking processes. For instance, questions such as whether a solution is considered "a different mathematical approach" or what constitutes a "sophisticated" or "efficient" mathematical solution are addressed within the framework of sociomathematical norms. Similarly, what qualifies as an acceptable mathematical explanation is also shaped by these norms. These kinds of norms are interactively developed by both teachers and students within the classroom community and play a crucial role in fostering mathematical autonomy and responsibility. For example, what kind of solution is considered "different" or what is viewed as a "sophisticated" or "effective" solution is determined based on these norms. Sociomathematical norms reveal how mathematical correctness and meaning are constructed through classroom interactions. In this process, teachers and students work collaboratively to define which solutions are valid and meaningful in mathematical discussions. That is, when a teacher asks, "Does anyone have a different way to solve this problem?" students are not merely participating due to social norms; they are also applying sociomathematical norms to assess what qualifies as a different mathematical solution (Yackel & Cobb, 1996).

Literature Review

Studies on sociomathematical norms can be categorized into three main groups. The first category includes studies that aim to determine sociomathematical norms. These studies have contributed to the literature by being conducted at various grade levels, in different mathematical topics, and across diverse learning contexts (Mottier-Lopez & Allal, 2007; Partenen & Kaasıla, 2015; Senger, 2019). The second category focuses on the emergence and sustainability of specific sociomathematical norms in classroom settings. These studies aim to understand how norms are initially formed and how they become established among students over time (Dixon et al., 2009; Morrison et al., 2021; Roy et al., 2014). The third

category comprises research that investigates the relationship between sociomathematical norms and teaching and learning skills (Dini & Maarif, 2022; Siregar & Khusna, 2023).

Studies aiming to determine sociomathematical norms have examined how these norms emerge in different contexts. In this scope, sociomathematical norms have been explored within problem-solving (Gülburnu, 2019; Lopez & Allal, 2007; Muhaimin et al., 2018; Partanen & Kaasila, 2015), problem-posing (Çakır & Akkoç, 2020), technology-enhanced learning environments (Atabaş et al., 2020; Ünlüer, 2021; Akyüz, 2014; Savuran & Akkoç, 2021; Senger, 2019), and inquiry-based learning settings (Akyüz, 2014). Furthermore, studies have also investigated norms within argumentation-based learning environments (Yılmaz-Memiş, 2023). On the other hand, studies on determining socio-mathematical norms reveal how socio-mathematical norms are formed in classes at different levels of education. Studies conducted at the undergraduate level (Dixon et al., 2009; Güven & Dede, 2017; Sanchez & Garcia, 2014; Van Zoest et al., 2012; Yackel et al., 2000; Yackel & Rasmussen, 2002) present essential findings regarding the formation processes of socio-mathematical norms. Additionally, many studies have been conducted at the high school (Partenen & Kaasıla, 2015; Planas & Gorgorió, 2004), middle school (Gülburnu, 2019; Sekiguchi, 2005) and primary school (Lopez & Allal, 2007; McClain & Cobb, 2001; Muhaimin et al., 2018; Yackel & Cobb, 1996) levels. In addition, among the studies on determining socio-mathematical norms, there are studies examining how norms emerge in the context of a specific mathematical subject. In this context, they have focused on different topics such as differential equations (Yackel & Rasmussen, 2002), analysis (Partenen & Kaasıla, 2015), operations on fractions (Öksüz, 2021), linear equations (Sekiguchi, 2005), addition and multiplication operations (Mottier Lopez & Allal, 2007), geometry (Ünlüer, 2021), circle (Akyüz, 2014), and height (Senger, 2019).

The second category includes studies that focus on how socio-mathematical norms are established and maintained within the classroom environment. These studies demonstrate the functionality and continuity of these norms throughout the teaching process. Morrison et al. (2021) and Dixon et al. (2009) demonstrated that social norms promote cooperation in classroom interactions and that socio-mathematical norms play a significant role in shaping students' mathematical reasoning. Roy et al. (2014) emphasize that simply establishing norms is insufficient; these norms must be restructured as course content changes. Tatsis (2013) stated that linguistic and sociological factors play a decisive role in the

construction of norms. Klosterman (2016) stated that norms such as active listening, consistency, and justification support productive mathematical discourse. Van Zoest et al. (2012) highlighted the enduring effects of socio-mathematical norms in teacher education, demonstrating that these norms contribute to long-term professional development. All these studies reveal that consciously structuring social and socio-mathematical norms under teacher guidance creates a strong foundation that supports mathematical learning in the classroom environment.

The third category includes studies examining the relationship between sociomathematical norms and teaching and learning skills. These studies reveal the impact of sociomathematical norms on students' cognitive processes and teachers' attitudes. Siregar and Khusna (2023) and Dini and Maarif (2022) have demonstrated that sociomathematical norms are associated with students' reflective thinking and problem-solving skills. Kang and Kim (2016) and Özdemir-Baki and Kılıçoğlu (2023) have demonstrated that teachers' mathematical beliefs and noticing skills play a decisive role in shaping sociomathematical norms in the classroom environment. Sanchez and García (2014) examined the role of sociomathematical norms in the mathematical identification processes of preservice teachers. Planas and Gorgorió (2004) analyzed the effects of sociomathematical norms in the context of sociocultural differences. These studies demonstrate that sociomathematical norms are a fundamental element shaping both student learning processes and teacher practices.

Purpose and Significance of the Study

In the literature, studies on sociomathematical norms are categorized into three main categories: determining the norms, establishing and sustaining these norms in the classroom environment, and the relationship between these norms and learning and teaching skills. However, there are a limited number of studies examining the awareness of pre-service teachers about these norms (Bayar et al., 2021; Gülburnu, 2024; Toscano et al., 2019). This research aims to fill the gap in this area by examining the awareness of pre-service teachers about sociomathematical norms. It is believed that this awareness can have a profound impact on the professional development of pre-service teachers and their future teaching practices (Gülburnu, 2024; Roy et al., 2014; Sanchez & García, 2014). In this context, the study aims to contribute to both academic literature and practice.

In the literature, sociomathematical norms have generally been addressed in the context of teachers' classroom interactions. In this context, previous studies have primarily

examined the formation and effects of these norms through the pedagogical practices developed by teachers in classroom environments and the mathematical discussions they establish with students (Kang & Kim, 2016; Özdemir-Baki & Kılıçoğlu, 2023; Zembat & Yaşa, 2015). However, since teacher candidates are not yet fully involved in the professional practice process, they do not have the opportunity to experience these norms directly in real classroom environments. It is believed that examining teacher candidates' awareness of sociomathematical norms will offer a different perspective on the existing literature. Understanding how teacher candidates perceive and internalize these norms during the pre-service period can provide essential insights into how they will shape mathematical interactions in the classroom in the future. Therefore, this study aims to provide a new perspective on how awareness of sociomathematical norms can be developed in the teacher training process.

Although pre-service teachers may not yet have direct experience managing a classroom, they may have encountered various sociomathematical norms through their prior educational experiences and observed instructional practices. These norms can shape their perceptions of mathematics teaching, influence their pedagogical preferences, and inform their expectations regarding classroom interactions. The primary focus of this study is to examine pre-service teachers' awareness of sociomathematical norms. While the investigation does not directly observe how such norms are transferred into the teaching profession, examining pre-service teachers' awareness offers a theoretical foundation and guiding perspective for future studies that aim to explore this transition. Cultivating this awareness at an early stage holds the potential to support pre-service teachers in making more informed decisions during mathematical interactions and in managing learning environments more effectively in the future. In this regard, research focusing on sociomathematical norms within teacher education represents a valuable area of inquiry for supporting professional development and enhancing the quality of mathematics instruction.

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In this study, the awareness of teacher candidates regarding sociomathematical norms was attempted to be revealed through scenarios reinforced with dialogues. Upon examining the relevant literature, it becomes apparent that most studies on sociomathematical norms are long-term and typically limited to a single class taught by a teacher. Although such studies are valuable in providing a deeper understanding of the fundamental interactions and norm-creation processes of teachers in the classroom, they have some limitations in making broader generalizations due to their lengthy duration and limited number of participants. Dialogue-enhanced scenarios can be considered as an alternative method for understanding pre-service teachers' awareness of sociomathematical norms (Toscano et al., 2019; Zembat & Yaşa, 2015). Thus, this study aims to both offer an alternative method to long-term classroom-based studies widely used in the literature and to provide a new perspective on how pre-service teachers' awareness of sociomathematical norms is shaped. Within the scope of this study, the awareness levels of pre-service mathematics teachers regarding sociomathematical norms were examined through scenarios supported by pre-structured dialogues. In accordance with this purpose, the problem statement was determined as follows:

How are pre-service mathematics teachers' awareness of sociomathematical norms shaped in scenarios supported by dialogues?

Method

Research Design

This study aims to examine the awareness of pre-service mathematics teachers regarding sociomathematical norms. The research was designed using a case study approach within the framework of qualitative research to reveal the participants' understanding of sociomathematical norms. In this context, the phenomenon designated as "situation" is the process by which prospective teachers demonstrate their awareness of sociomathematical norms through dialogues supported by scenarios. This situation aims to examine in depth how prospective teachers ascribe meaning to these norms within a specific context (scenario- and dialogue-based interactions). The study was conducted in three stages. In the first stage,

a comprehensive literature review was conducted to determine the sociomathematical norms in the literature. Three sociomathematical norms were selected as a result of the literature review. In the second stage, scenarios were created emphasizing the sociomathematical norms determined in line with the findings obtained from the literature review. In the third stage, these scenarios were presented to the pre-service teachers, and they were asked to respond to the questions about the scenarios in writing. The written feedback received from the pre-service teachers was analyzed to evaluate their awareness levels regarding sociomathematical norms. Following the written data collection process, semi-structured interviews were conducted to examine the awareness levels of the selected pre-service teachers regarding the norms in more depth.

Participants

This study was conducted within the scope of the geometry and measurement teaching course in the middle school mathematics teaching program. The study participants consisted of 42 pre-service teachers enrolled in the course. Thirty-two participants were female, and 10 were male. Since the study was conducted within the context of the course, the convenience sampling method was preferred. Although this method did not guarantee the most representative sample, the fact that all participants had similar academic backgrounds and were studying in the third year of the middle school mathematics teaching program allowed the formation of a homogeneous group suitable for the research problems. This homogeneous structure significantly contributed to the pre-service teachers' awareness of socio-mathematical norms.

Data Collection

Two distinct data collection methods were employed to examine the awareness of Pre-service mathematics teachers regarding sociomathematical norms. Initially, three awareness forms incorporating scenarios enriched with dialogues were administered to assess the participants' levels of awareness. Subsequently, semi-structured interviews were conducted to enable a more in-depth analysis of the data obtained from the written responses.

Awareness Forms

These forms, referred to as the awareness forms, were designed to reveal participants' awareness of sociomathematical norms through pre-structured classroom dialogues. In this study, three forms were prepared to assess the awareness of pre-service teachers regarding

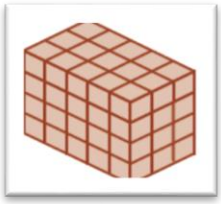
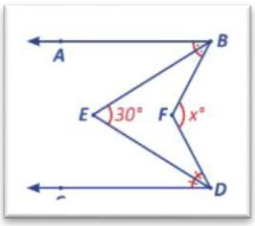
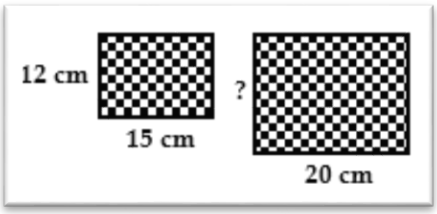
sociomathematical norms. These forms were designed in seven stages. In the first stage, a comprehensive literature review was conducted on sociomathematical norms, and previous academic studies in this direction were examined in detail. The sociomathematical norms reported in the literature were evaluated, and three basic norms that stand out in teaching processes were determined. The consistency of the three selected sociomathematical norms in the literature and their validity in different contexts were meticulously evaluated. In this direction, the relevant norms as defined in the literature and their integration into teaching environments were examined in detail. The contexts in which the norms find correspondence in teaching processes and their functionality in learning environments were taken into consideration when selecting the norms. In the second stage, the learning outcomes were determined by considering the socio-mathematical norms selected in the previous phase and the context of the geometry and measurement teaching course. Care was taken to ensure that these learning outcomes were suitable for writing scenarios related to socio-mathematical norms and supported by dialogues. The forms in the study were structured according to different grade levels and learning outcomes. Table 1 presents the socio-mathematical awareness forms, indicating the grade levels, targeted learning outcomes, the socio-mathematical norms they are based on, and the referenced studies.

Table 1. Overview of socio-mathematical norm awareness forms

Forms	Grade level	Learning outcomes	Socio-mathematical norms	Referenced studies
Form 1	6th	Understands that the number of unit cubes filling a rectangular prism represents its volume and calculates its volume by counting the unit cubes.	offering a different mathematical solution	Yackel and Cobb, 1996; Kozaklı, 2015; Sönmez, 2016; Yılmaz, 2021
Form 2	7th	Identifies corresponding angles, alternate interior angles, alternate exterior angles, and same-side interior angles formed by a transversal with two parallel lines; examines their properties; determines whether the formed angles are congruent or supplementary; and solves related problems.	Not valuing alternative mathematical solutions and expecting the taught method to be used.	Kozaklı, 2015
Form 3	8th	Determines the similarity ratio of similar polygons and constructs congruent and similar polygons to a given polygon	Providing an acceptable mathematical explanation and justification.	Clark et al., 2008; Öksüz, 2021; Pang, 2001; Sönmez, 2016; Yackel and Cobb, 1996; Yaşa, 2015

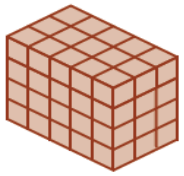
In the third stage, questions were designed in accordance with the selected socio-mathematical norms and learning outcomes. Care was taken to ensure that the questions would encourage teacher-student and student-student interaction and support the formation of a discussion environment. The questions in each form are presented in Table 2.

Table 2. The questions included in the forms

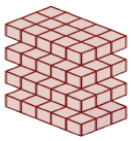
Forms	Questions
Form 1	What is the volume of the rectangular prism made of unit  cubes?
Form 2	In the figure, [BE] and [ED] are angle bisectors, and AB // CD. Accordingly, what is the measure of angle x in degrees? 
Form 3	Eren enlarged the photo by a certain ratio. The width of the original photo was 15 cm, and the width of the enlarged photo became 20 cm. Given that the original was 12 cm, what is the height of the enlarged photo? 

In the fourth stage, interactions and conversations between teachers and students, as well as between students, were written within the framework of a scenario, inspired by the dialogues in studies reporting the selected socio-mathematical norms. The dialogue in Form 1 is presented below.

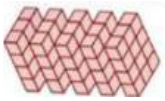
Q: What is the volume of the rectangular prism made up of unit cubes in unit cubes?"



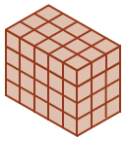
Teacher: Alright, kids. How many unit cubes are there in total in the rectangular prism?
Levent: Teacher, I used the Horizontal Arrangement Approach. First, I considered a horizontal block of the prism. Since the length of this block is 5 and the width is 3, I found that one block contains 5×3 = 15-unit cubes. Then, I noticed that there were 4 of these horizontal blocks stacked on top of each other. Therefore, to calculate the total number of unit cubes, I got 15×4 = 60.
Teacher: Excellent explanation! So, you determined that each horizontal arrangement contains 15 cubes, and by calculating that there are 4 such layers, you obtained a total of 60 cubes. I am exploring alternatives.



Harun: I multiplied 5 by 3, which gives 15. Then I multiplied 15 by 4, which gives 60.
Levent: (objecting) "Teacher, that is the same solution I gave.
Teacher: Yes, Levent, you are right.
Teacher: (turning to the class) "Different?
Elisa: Teacher, I used the vertical arrangement approach for this prism. I noticed that each vertical stack of cubes is 3 units wide and 4 units long. I multiplied 3 by 4, which gave me 12 cubes in one vertical block. Then I noticed that there are 5 of these vertical blocks placed side by side. So, multiplying 12 by 5 gave me a total of 60 cubes.



Harun: (objecting)
But teacher, that is the same as our solution too!
Teacher (to the class):
Do you think your classmate is right, children?
Class:
Yesss… Nooo…
Teacher: Excellent explanation, Elisa! By looking at the prism as vertical blocks, you have effectively broken down its dimensions into smaller, more manageable parts. Since each block contains 3×4=12 cubes, and there are 5 such blocks side by side, your total of 12×5=60 cubes is spot on. Notice that although Levent and Elisa approached the problem from different perspectives, both methods essentially reached the same result. Now, does anyone else have an alternative approach?
Teacher (pointing to Recep):
Yes? Is it a different approach? Go ahead…
Recep: Teacher, I began by counting the unit squares on the outer surface of the prism. I counted the squares on the three visible faces and got 47. Then, considering that there are three hidden faces at the back, I multiplied 47 by 2, which gave me 94, ensuring that each unit cube's face is counted only once. However, I noticed that the 8 cubes at the corners have 3 faces visible, meaning they were counted three times. To correct this overcounting, I multiplied 8 by 2 (for the extra two counts per corner) and subtracted 16 from 94, resulting in 78. Next, I realized that there are 24 edge cubes (excluding the corners) with two visible faces, which means each of these was counted one extra time. I subtracted 24 from 78, arriving at 54, which represents the cubes on the outer shell of the prism. Finally, I added the 6 cubes hidden inside the prism, and the total came to 60."

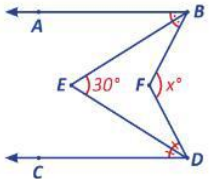


Class: (murmurs) "Oh, that's so different... How did that happen? Teacher, he didn't follow the formula.
Teacher: That's a very detailed and creative approach! You've carefully accounted for the overcounting at the corners and edges to ensure each cube is counted exactly once. While this method is more complex than using the volume formula or the horizontal/vertical arrangement approaches, it still correctly results in a total of 60 cubes. Excellent work in exploring an alternative way to solve the problem!

This dialogue clearly demonstrates how the socio-mathematical norm of "presenting different mathematical solutions" is created and supported in the classroom. The teacher, through the solutions provided by Levent and Elisa, emphasizes that there is not only one way to solve the problem—that different strategies can lead to the same correct outcome. By repeatedly asking "Different?" the teacher encourages students to reassess their methods and

develop alternative problem-solving strategies. In particular, the contrast between Elisa's vertical arrangement approach and Levent's horizontal approach illustrates that mathematical operations can be conceptualized in various ways. Moreover, Recep's more complex, multi-layered solution shows that mathematical concepts are not confined to standard formulas but can be restructured through creative and critical thinking. This norm fosters active participation in mathematical reasoning and supports the idea that mathematics is a socially constructed body of knowledge developed within a collaborative learning environment. The scenario, supported by the dialogues in Form 2, is presented.

Q: In the figure above, [BE] and [ED] are angle bisectors, and AB // CD. Given the information, what is the value of x in degrees?



Teacher: Yes, children, who will solve this problem?

Teacher: (Pointing at Alper) Come on, Alper, let's see.

Alper: (Solving the problem using a method different from the teacher's approach) Teacher, I have solved it. The answer is 60.

Teacher: What did you do here? How did you arrive at the result?

Alper: Teacher, I solved it differently. I saw this shortcut in a book and used it. I multiplied 30 by 2!

Teacher: Oh no! Why didn't you solve it the way I showed you?

Alper: (In a bored tone) Teacher, I did not understand what you were showing. Isn't it acceptable to do it this way? Isn't the value of x just twice 30?

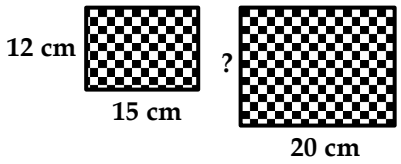
Teacher: Yes, but that's not how I explained it. You were supposed to solve it the way I showed you. I don't want that kind of solution on the exam!

Teacher: Now sit down, then I'll solve it.

In the dialogue, a socio-mathematical norm emerges in which alternative solution strategies are devalued in favor of the method explicitly endorsed by the teacher. Remarks such as "Why didn't you solve it the way I showed you?" and "I don't want that kind of solution on the exam!" exemplify a rigid instructional stance that prioritizes procedural conformity over mathematical reasoning. As a result, although Alper's alternative solution yields the correct answer, it is rejected solely because it deviates from the teacher's prescribed method. This classroom dynamic illustrates a negative sociomathematical norm—defined as a classroom norm that undermines students' deep mathematical thinking, meaning-making, and reasoning by privileging surface-level procedural accuracy over conceptual understanding. While sociomathematical norms are generally understood as shared expectations regarding what constitutes mathematically acceptable explanations, solutions, or strategies in classroom discourse (Yackel & Cobb, 1996), negative forms of these norms—such as discouraging alternative approaches or valuing only teacher-approved methods—

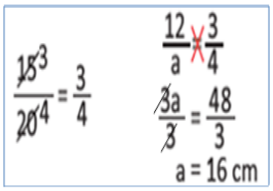
can hinder the development of students' mathematical autonomy, critical thinking, and problem-solving skills.As noted by Akyüz (2014) notes that students may disregard basic mathematical logic when using digital tools and tend to consider their solutions valid only through dynamic verification without mathematical proof. In this case, "dynamic verification" stands out as a negative norm. Similarly, Yaşa (2015) points out that when sociomathematical norms are not effectively established in the classroom environment, students may develop erroneous behaviors in terms of mathematical thinking. For example, generalizing that "the sum of two odd numbers is an even number" only through specific examples (e.g., 5 + 7 = 12, 3 + 5 = 8, 11 + 17 = 28) and supporting this approach by the teacher can lead to the establishment of a false norm in students that "proof in mathematics can be done by giving examples." This type of norm, however, contradicts the very nature of the mathematical concept of proof and is undesirable, negatively impacting the development of students' mathematical reasoning and verification skills. In this context, negative sociomathematical norms can be considered classroom norms that inhibit students' in-depth mathematical thinking, meaning making, and reasoning processes, and encourage superficial, rote, and uncritical learning approaches. The scenario, supported by the dialogues in Form 3, is presented.

Q: Eren has enlarged the photo by a certain ratio. In the first photo, the width is 15 cm, while in the enlarged second photo, it becomes 20 cm. Given this, what will be the height of the second photo if the height of the first photo is 12 cm?



Teacher: Yes, children, what is the answer to the problem?
Doğukan: 15.
Teacher: (addressing the class) Is this answer correct?
Class: (mixed voices) Yes. No.
Doğukan: (suddenly changing his mind) Ah, 16.
Teacher: (asking skeptically) Sixteen?
Doğukan: (changing his mind again) I know, I know—seventeen!
Teacher: (turning to Doğukan) Seventeen centimeters?
Doğukan: No. Teacher, I changed my mind—16!
Teacher: Is that your final decision?
Doğukan: Yes, my final decision is 16.
Teacher: Then why 16?
Doğukan: I think that when I look at the photo, it should be 16…
İsmet: (immediately objecting) In mathematics, you can't answer based on "I think" without performing any calculations!
Teacher: (nodding in agreement with his head bowed) You're right, İsmet!
Teacher: Children, if you cannot explain your answer, you will keep changing it like Doğukan, and I will not accept an answer without justification.
Teacher: (addressing the class) Yes, children, the correct answer is 16. Now, is there anyone who can explain the answer with proper reasoning?
Duru: (showing her solution in her notebook) Is it correct, Teacher?
Teacher: How did you arrive at the result, Duru?

Duru: (in a confident tone) Teacher, here's what I thought: First, I compared the width of the first frame to the width of the second frame. When I simplified 15 divided by 20, it reduced to 3/4. Since the frames are similar, the ratio of the height of the first frame to the height of the second frame must also be 3/4. Therefore, I set up equation 12 divided by an equal to 3/4. By cross-multiplying and solving the equation, I found that a is 16 cm.



Teacher: Hmm. I like it. Your explanation has convinced me, Duru—well done! I accept this!
Teacher: (addressing the class) Children, this is exactly what I expect you to be able to do.

In this dialogue, a socio-mathematical norm is clearly established, emphasizing the importance of providing acceptable mathematical explanations and offering sound justifications for one's answers. The teacher's feedback indicates that merely arriving at the correct answer is insufficient unless it is accompanied by a coherent and logically structured reasoning process. For example, Doğukan's tentative responses—based primarily on intuition and lacking explicit mathematical justification—are criticized by both the teacher and his peers. In contrast, Duru's methodical explanation, which involves comparing the widths of the two photos, simplifying the ratio to 3/4, and then applying proportional reasoning through cross-multiplication, is recognized as a valid and acceptable approach. This norm not only reinforces the idea that mathematical correctness depends on the process as much as on the final result but also encourages students to develop and articulate their mathematical thinking in a precise and justified manner.

In the fifth stage, open-ended questions were prepared to determine the awareness levels of pre-service teachers regarding socio-mathematical norms. In this context, pre-service teachers were asked to identify which socio-mathematical norm was observed in the teacher-student dialogue of a specific classroom microculture—the questions aimed to assess the pre-service teachers' ability to recognize and interpret socio-mathematical norms.

In the sixth stage, the three draft awareness forms developed by the first author were examined and evaluated in detail by the second author and another field expert who has studied socio-mathematical norms, to ensure content validity. In this process, necessary adjustments were made to consider the suitability of the forms for the research purpose, the clarity of the expressions used, and their adequacy for the targeted norms.

In the final stage, the pilot application of the developed awareness forms was conducted with five pre-service teachers during the fall 2022-2023 semester. The forms, prepared in accordance with expert opinions, were sent to the participants electronically after the introductory training was given via Zoom, and the responses were collected

digitally within a week. During the preliminary analysis process, it was determined that some questions contained repetitions and that a student's solution in Form 1 was challenging to understand. Accordingly, the relevant questions were simplified, and the expression of the solution was made more explicit. After the necessary arrangements were made, the forms were finalized and used in the main application.

The data collection process covers the fall and spring semesters of the 2022-2023 academic year. In the fall semester, awareness forms were developed, and a pilot application was conducted after the necessary arrangements were made in consultation with field experts. The forms were finalized in line with the findings obtained from the pilot application. Then, the main participants of the study received a two-hour face-to-face introductory training on socio-mathematical norms, and implementation of the awareness forms began after the training. Participants were given 15 minutes to implement each form.

Semi-Structured Interview

Following the written responses to the open-ended questions in the awareness forms, which were developed to assess the awareness levels of teacher candidates regarding socio-mathematical norms, semi-structured interviews were conducted to examine the obtained data in more detail. These interviews were structured around the open-ended questions directed to the teacher candidates, allowing the candidates' answers to be explored in depth. After completing the preliminary analysis of the data collected in written form, it was decided to conduct semi-structured interviews with seven teacher candidates (approximately 16.7% of the participants), who were identified based on the preliminary analysis results.

During this process, due to the earthquake centered in the Pazarcık district of Kahramanmaraş Province on February 6, 2023, which occurred during the period the study was conducted in our country, education at universities was suspended by the Council of Higher Education's decision. Considering this situation, the semi-structured interviews were conducted online via the Zoom application. Although the duration of the interviews was planned individually with each pre-service teacher as a single 40-minute session, unplanned situations during the interviews necessitated a second session with some participants, and the online interview took longer than expected. With the participants' permission, audio recordings were made during all interviews to prevent potential data loss in the future.

Data Analysis

In this study, qualitative data obtained from three different forms developed to determine the awareness levels of pre-service mathematics teachers regarding socio-mathematical norms were analyzed using holistic rubric. Holistic rubric is an assessment tool that evaluates a performance or response as a whole, rather than breaking it down into separate dimensions. Each level in the rubric represents an overall judgment that reflects the general quality or characteristics of the response based on predefined criteria (Moskal & Leydens, 2000). This approach allows for a comprehensive interpretation of participants' awareness levels, enabling the identification of patterns in reasoning and understanding within a unified framework.

During the rubric development process, the purposes of the open-ended questions in the awareness forms were first considered. A rubric was designed to systematically and structurally evaluate the responses of pre-service teachers on the form. The first of these rubrics was named "Socio-Mathematical Norm Recognition Level Assessment Rubric. In the second step of the rubric development process, criteria based on various indicators were created to determine the awareness levels of pre-service teachers. These criteria were determined in a way that could evaluate the candidates' competence in recognizing, defining, interpreting, and relating norms to discourses. In the third step, three different performance levels were defined to classify the awareness levels of teacher candidates: "Low Awareness, "Medium Awareness," and "Advanced Awareness." Each level was determined with clear and concise expressions to ensure consistency in the evaluation process, supported by observable and distinctive features. Accordingly;

- Low Awareness, Level 1, includes superficial or erroneous evaluations independent of the norm.
- Medium Awareness, Level 2, includes expressions indirectly related to the norm but not clear enough.
- Advanced Awareness, Level 3, expresses correct, clear, and conceptually strong answers regarding the norms.

In the fourth and final step, a field expert was consulted to ensure the content validity of the rubric drafts created. The rubrics were then given their final form by refining the clarity of the criteria and the distinctiveness of the levels. The final versions of the rubric are presented in Table 3.

Table 3. Rubric for assessing the level of recognition of sociomathematical norms

Level of Awareness	Indicators of the Level
Level 1	• Evaluations made independently of the norm. • Incorrect identification of the norm.
Level 2	• Identification of the norm along with other unrelated norms. • Use of similar norms due to an inability to clearly distinguish the characteristics of the intended norm. • Responses that evoke or imply the norm. • Statements that approximate the norm, even if not expressed with entirely accurate terminology.
Level 3	• Responses that refer to the norm as defined in the literature. • Clear and concise descriptions that accurately characterize the norm.

A data analysis template prepared in Microsoft Excel was utilized in the data analysis. In this context, the names of the teacher candidates were coded as PT1, PT2, PT3, …, PT42 to ensure confidentiality within the framework of ethical rules. All data analyses were systematically combined on this template and evaluated in a table. A sample section from the data analysis template is presented in Figure 1.

	A	B	C	D	E
1	No	Preservice Teachers	Awareness Levels of Sociomathematical Norms		
2			Level-1	Level-2	Level-3
3	1	PT1			X
4	2	PT2	X		
5	3	PT3		X	
6	4	PT4		X	
7	5	PT5	X		
8	6	PT6			X
9	7	PT7		X	
10	8	PT8	X		
11	9	PT9		X	
12	10	PT10		X	
13	11	PT11		X	
14	12	PT12		X	
15	13	PT13		X	

Form1 Form2

Figure 1. Data analysis template section

To ensure the reliability of the data analysis, the first author initially evaluated the data. Then, the second author conducted an independent evaluation. The agreement rate between the two evaluators was calculated as 80.29% using the reliability formula suggested by Miles and Huberman (1994) (Reliability = Consensus / (Consensus + Disagreement)). Although this rate met the minimum agreement expectation of 80% in terms of reliability, the points where the evaluators had disagreements were re-evaluated together. In the meeting,

discussions were held on how logical reasoning was made in line with the indicators on the differently coded responses. As a result of these discussions, agreement was achieved between the evaluators.

Findings

In this section, the findings regarding pre-service teachers' levels of recognizing sociomathematical norms are presented under relevant subheadings, based on the scenarios of each form.

Findings derived from Form 1

Table 4 presents the findings regarding the pre-service teachers' level of awareness of the socio-mathematical norm of "offering a different mathematical solution" in Form 1.

Table 4. Pre-service teachers' awareness levels regarding the sociomathematical norm in form 1

Level 1		Level 2		Level 3	
f	%	f	%	f	%
5	11,9	25	59,52	12	28,58

An examination of pre-service teachers' awareness levels regarding the sociomathematical norm of 'offering a different mathematical solution' in Form 1 reveals that the majority of participants (59.52%) are at Level 2. While 12 pre-service teachers (28.58%) were identified at Level 3, 5 participants (11.9%) were classified at Level 1, indicating a low level of awareness. Below are sample responses from pre-service teachers categorized at Level 1 in terms of recognizing the sociomathematical norm of 'offering a different mathematical solution' in Form 1.

"The teacher only approved the student who thought differently. The teacher acted as if only Recep had given the correct answer. However, the teacher did not consider that not all students might be able to understand Recep's method." (PT15)

"Examining the correctness or incorrectness of students' ideas through in-class discussion." (PT1)

"The teacher accepted that Recep's solution was also correct. However, the teacher acted as if Recep's solution was more logical, since Recep had used a non-formulaic method. Those who used the formula found the same result, but due to the teacher's attitude, they may think their method was wrong and that Recep's way was the correct one." (PT12)

An analysis of the responses above reveals that pre-service teachers do not adequately grasp the defining characteristics of sociomathematical norms. As a result, their explanations tend to rely on superficial and generalized expressions rather than conceptually grounded definitions. In addition, it is observed that pre-service teachers evaluate the positive attitudes and approaches of the teacher in the scenario, which actually support

learning and encourage diversity of thought among students, but negatively, disconnected from the normative context. This situation reveals that the Pre-service teachers' conceptual awareness of norms is limited, and they are not at a sufficient level to make a critical analysis based on socio-mathematical norms. In addition, PT15 explained his thoughts as follows during the semi-structured interview.

"To be honest, when I read the dialogue, I tried to put myself in the student's shoes and empathize a little. The teacher consistently says, "something different". It felt like the teacher was solely focused on getting a different answer. That's why I wrote what I did. However, I thought that the teacher wasn't concerned with whether the students understood the topic and was instead focused on presenting a different solution. I entirely placed myself in the students' position, and honestly, I felt a bit bad. I think situations like this can sometimes be problematic in a classroom. When a student eagerly answers a question and doesn't receive the response they were hoping for from the teacher, it can damage their self-confidence. I thought this kind of reaction might lead students to feel like they're not good enough—and I still think that." (PT15)

The pre-service teacher's explanations during the interview significantly deepened the superficial critique presented in the written response. She offered an empathetic and affective evaluation regarding the teacher's impact on student attitudes. The candidate particularly highlights that the teacher's emphasis on an alternative solution method could lead to a loss of self-confidence among other students. However, despite these thoughtful reflections, the candidate's statements lack conceptual clarity in distinguishing and explicitly naming the sociomathematical norms. An analysis of PT15's responses reveals a strong tendency toward empathy, with the scenario being evaluated primarily through the lens of students' emotional reactions rather than from a pedagogical or normative perspective. This has led the candidate to interpret the norm-establishing interaction**,** despite occurring in a generally positive classroom atmosphere**,** as a negative situation. Therefore, although the candidate demonstrates a certain depth of thought, the lack of conceptual awareness regarding sociomathematical norms results in a classification at Level 1 of awareness.

The following responses represent Level 2 awareness of pre-service teachers regarding the sociomathematical norm of 'offering a different mathematical solution' in Form 1.

"The teacher persistently asks students whether there is an alternative solution method, encouraging them to think. Additionally, although Levent and Elisa seem to approach the problem differently—one vertically, the other horizontally—it is emphasized that this does not change the outcome of the multiplication, thus highlighting the commutative property. Recep, on the other hand, introduces a different perspective to the classroom by proposing his method." (PT4)

"The evaluation of different solution methods by both the teacher and students within the classroom. Helping students realize that a problem can be solved even without using a formula." (PT18)

"The norm of presenting developed (alternative) solution strategies in the classroom. Reaching a discussion point by analyzing and debating the necessary mathematical data during the lesson. Emphasizing that mathematical understanding is not limited to formulas alone." (PT35)

An analysis of the responses indicates that all three pre-service teachers demonstrate Level 2 awareness of sociomathematical norms. PT4 recognized the teacher's encouragement of alternative solution methods and the emphasis on the commutative property, yet was unable to define the norm; instead, it offered mainly observation-based descriptions clearly. PT18 highlighted the evaluation of different solution strategies in the classroom and the realization that problems can be solved without relying on formulas. Although this implies the presence of a norm, it was not sufficiently distinguished at a conceptual level. PT35 emphasized the development of alternative solution strategies and a culture of discussion in the classroom, noting that mathematical understanding is not limited to formulas. However, the expressions she uses tend to explain the norms with expressions close to the norms rather than defining them directly. In this context, while the pre-service teachers' responses include norm-related discourse, their inability to articulate the defining characteristics of sociomathematical norms places them within the scope of Level 2 awareness. Following the written responses, the explanations provided by the pre-service teachers during the interview process for the corresponding form are presented below.

"The teacher's primary focus is to encourage students to consider an existing situation from different perspectives. The teacher attempts to gather diverse ideas from students, essentially enabling them to think critically. The fact that the teacher repeatedly asks if anyone has a different solution, and that Recep eventually comes up with his method after two similar solutions have been shared, made me sense the presence of this norm." (PT4)

"The teacher's aim here is to help students grasp the conceptual meaning of volume rather than just its procedural aspect, even though almost all of them gave the correct answer. The teacher tries to get students to think about how they perceive the concept of volume—whether it's simply the multiplication of length, width, and height, or rather the amount of space something occupies. Recep's response also helps the teacher and the whole class realize that a problem can be solved without relying solely on formulas." (PT18)

"So, there's a question here, and that question has one answer—but there are multiple ways to reach that answer. The teacher is trying to reveal those different paths by asking the students." (PT35)

An analysis of the interview data reveals that the awareness of sociomathematical norms demonstrated by the pre-service teachers in their written responses was similarly reflected in their interview explanations. PT4 deepened the idea of 'encouraging students to

think' mentioned in the written response by emphasizing that the teacher encouraged students to approach an existing situation from different perspectives. PT18 highlighted the importance of conceptual understanding of the volume concept, underlining that mathematical thinking is possible even without using formulas. PT35 noted that the same result could be reached through different methods. It stated that the teacher aimed to elicit these methods in the classroom, thus reinforcing the emphasis on 'developed solution strategies' in the written response. These statements confirm that although the candidates had difficulty in explicitly naming the norms, they expressed their thoughts using norm-related discourse and therefore demonstrated Level 2 awareness."

The following are the responses of pre-service teachers categorized at Level 3 regarding the socio-mathematical norm of 'offering a different mathematical solution' in Form 1.

"To resolve a problem with different solutions and to discuss these alternative solutions." (PT7)

"Solving a problem using multiple solution methods." (PT11)

"Helping students realize that a problem can have more than one solution." (PT17)

An analysis of these responses in Form 1 reveals that the pre-service teachers demonstrated Level 3 awareness of sociomathematical norms. The candidates emphasized the importance of addressing a problem through various solution paths and engaging in classroom discussions around these methods, thereby articulating the essence of the norm clearly and concisely. Statements such as 'solving a problem using different solution strategies' and 'helping students realize that a problem can have more than one solution' directly correspond to the norm of 'supporting multiple solution strategies' as defined in the literature. In this respect, the candidates not only conceptually identified the norm accurately but also expressed it through explanatory and precise language, thus meeting the criteria for Level 3 awareness.

Findings derived from Form 2

Table 5 presents the findings regarding the pre-service teachers' level of awareness of the socio-mathematical norm of "not valuing alternative mathematical solutions and expecting the taught method to be used" in Form 2.

Table 5. Pre-service teachers' awareness levels regarding the sociomathematical norm in form 2

Level 1		Level 2		Level 3	
f	%	f	%	f	%
3	7,15	20	47,61	19	45,24

An examination of pre-service teachers' awareness levels regarding the sociomathematical norm of 'not valuing alternative mathematical solutions and expecting the taught method to be used' in Form 2 reveals that the majority of candidates (47.61%) are at Level 2. At Level 3, there are 19 pre-service teachers (45.24%), while only three candidates (7.15%) fall into Level 1, indicating a low level of awareness. These findings suggest that a significant portion of the candidates used expressions that evoke the norm yet were unable to distinguish its defining characteristics clearly. However, the notable proportion of candidates at Level 3 indicates that there are also pre-service teachers who were able to define the norm in a clear and literature-consistent manner.

The following are sample responses from pre-service teachers categorized at Level 1 in terms of recognizing the sociomathematical norm in Form 2.

"In this scenario, there is a norm of disregarding the student's inadequacy of mathematical knowledge." (PT3)

"A norm of abstracting the problem from a different perspective and a stereotyped expression norm." (PT39)

In the dialogue, Alper attempts to solve the problem using a different method and arrives at an incorrect answer. Instead of encouraging him to reflect on his mistake and guiding him toward the correct solution through questioning, the teacher does not accept Alper's method and insists on adopting the teacher's method. The proper solution is presented without addressing or questioning the error." (PT21)

An analysis of the responses indicates that the pre-service teachers demonstrate Level 1 awareness of sociomathematical norms. In the responses of the Pre-service teachers, there is no direct and correct definition regarding the basic characteristics of the norms, and the evaluations are mostly made outside the normative framework and based on pedagogical observations. For example, expressions such as "the norm of disregarding the inadequacy of the student's mathematical knowledge" indicate incorrect norm determinations that do not directly correspond to the concept of socio-mathematical norm. Similarly, definitions such as "the norm of stereotyped expression" also express the norm incorrectly. In the comment made regarding directing the student to the correct method without directly intervening in his wrong solution, the teacher's attitude is brought to the forefront instead of the nature of

the norm. Such answers show that the Pre-service teachers either define the norms incorrectly or make evaluations independent of the norm, and therefore are evaluated within the scope of level 1 awareness.

The following are the responses of pre-service teachers categorized at Level 2 regarding the socio-mathematical norm in Form 2.

"A norm of not accepting different solutions in the classroom, or a norm of not requiring justification for a solution—also associated with reliance on rote memorization." (PT14)

"Reaching the result through a single solution path or being unable to justify the given mathematical expression." (PT17)

"In this example, we are faced with negative sociomathematical norms. 1. Norm: Teaching based on the memorization method. 2. Norm: The teacher accepts only his method without seeking another student's opinion. Additionally, he does not go back and repeat it, even if the student says they did not understand. 3. Norm: Teaching students with fear of exams" (PT11)

According to the answers provided, it is evident that the pre-service teachers' awareness of socio-mathematical norms is at level 2. The pre-service teachers stated that rote-learning approaches in the classroom, as well as not accepting different solutions, and not providing explanations based on justification, indicate negative norms. However, it is noteworthy that they have difficulty in defining the norms clearly and generally use discourses that are close to the norms but lack conceptual clarity. For example, expressions such as "rote-learning method norm, "using only one solution, or "student insisting on their idea" do not directly define socio-mathematical norms but contain connotations related to this norm. In addition, the fact that the pre-service teachers expressed more than one norm together shows that they have difficulty in distinguishing between norms. Therefore, the pre-service teachers' answers are evaluated within the scope of level 2 because they do not exactly correspond to the norm but show awareness close to the norm. Following the written answers, the explanations given by PT14 during the interview process regarding the relevant form are presented below.

"There is actually a negative norm here. Because the teacher is focusing on only one solution, a problem can have multiple solutions. Actually, there is a norm that is opposite to what we just discussed. The teacher does not accept different solutions." (PT14)

When the interview data are examined, it is evident that the teacher candidate, coded as PT14, continued to evaluate the norm of "not accepting different solutions" as expressed in his written response. The candidate stated that the teacher only focused on his solution

method, did not consider alternative solutions, and that this situation created a negative norm in the classroom environment. This explanation supports the evaluation of PT14 in his written response that evokes the norm; however, it does not reflect sufficient depth in clearly defining the norm in accordance with the literature and distinguishing it from other norms. Therefore, the candidate's level was classified as level 2 in accordance with the criteria.

The following are the responses of pre-service teachers categorized at Level 3 regarding the socio-mathematical norm in Form 2.

"Here, there is a norm of not accepting alternative solutions and making students accept that there can only be one solution." (PT18)

"Believing that there is only one solution when reaching a mathematical solution, closing oneself to differences." (PT24)

"The norm of not going beyond what the teacher tells" (PT16)

An analysis of the responses indicates that the pre-service teachers demonstrate Level 3 awareness of sociomathematical norms. PT18 clearly referred to the norm of not accepting alternative solutions in the classroom environment. PT24 defined the norm clearly and plainly by emphasizing an approach that is closed to differences and a single solution approach. The other Pre-service teacher directly drew attention to the reflection of the norm in the classroom by stating that the teacher does not accept solutions different from his method. The statements of all the pre-service teachers show that the norm is both in accordance with its definition in the literature and is expressed conceptually clearly; in this context, the awareness levels of the Pre-service teachers are evaluated as level 3. Following the written answers, the explanations given by PT18 and PT24 during the interview process regarding the relevant form are presented below.

''There is a norm of not accepting alternative solutions and making students accept that there can only be one solution. Because the teacher always expects the students to give him the solution he made. This is, of course, wrong. This also causes students to worry about whether they are doing something wrong and focus on the solution the teacher has given, even if they are doing what they think is right, for example, on a test. In other words, it is a wrong attitude." (PT18)

''I think the teacher has discouraged the students here once. He only wants the questions to be solved with the solution he shows. He has displayed a rather strict attitude. He should not have approached the students with this language. He may be acting this way to maintain his authority. He has brushed them off without communicating with the students too much. We can give this attitude a norm name as the teacher insisting on the solution path he explains, or wanting the student not to solve it differently." (PT24)

When the interview data are examined, it is evident that the awareness of the norm of "not accepting alternative solution methods," expressed in the written answers of the teacher candidates coded as PT18 and PT24, is consistently reflected in their verbal expressions. PT18 supports his written answer by emphasizing that the teacher's only valid solution method can negatively affect the students' thinking processes. Similarly, PT24 evaluated the teacher's attitude of directing students only to their method from a norm-based perspective, stating that the teacher's strict and one-sided approach undermines the students' motivation. These explanations demonstrate that both candidates clearly define the relevant norm in accordance with the literature; thus, they reinforce their level 3 awareness in a manner consistent with the written data.

Findings derived from Form 3

Table 6 presents the findings regarding the Pre-service teachers' level of awareness of the socio-mathematical norm of "providing an acceptable mathematical explanation and justifications" in Form 3.

Table 6. Pre-service teachers' awareness levels regarding the sociomathematical norm in Form 3

Level 1		Level 2		Level 3	
f	%	f	%	f	%
5	11,9	15	35,72	22	52,38

An examination of pre-service teachers' awareness levels regarding the sociomathematical norm of 'providing an acceptable mathematical explanation and justifications' in Form 3 reveals that the majority of candidates (52.38%) are at Level 3. There are 15 pre-service teachers (35.72%) at Level 2, while five candidates (11.9%) are categorized at Level 1, indicating a low level of awareness. This distribution suggests that a significant portion of the candidates were able to define the norm clearly and, in a manner, consistent with the literature.

The following are sample responses from pre-service teachers categorized at Level 1 in terms of recognizing the sociomathematical norm in Form 3.

"Gaining awareness to the whole class based on an event. Turning mistakes into an advantage." (PT35)

"Mathematical ratios cannot be determined by eye." (PT23)

"Negative socio-mathematical norm: Passing over a student's incorrect answer without explaining the reason and humiliating the student and not telling the result." (PT31)

An analysis of the responses indicates that the pre-service teachers demonstrate Level 1 awareness of sociomathematical norms. The statements of the pre-service teachers are based on pedagogical observations and personal interpretations rather than a conceptual view based on norms. For example, statements such as "raising awareness in the whole class based on an event" or "turning mistakes into advantages" do not directly correspond to socio-mathematical norms but are more related to general classroom management or teaching strategies. Similarly, the statement "mathematical ratios cannot be determined by eye" is also far from the normative context. The third Pre-service teacher emphasized the teacher's attitude towards the student's mistake, but focused on the teacher's communication style. In this context, since the Pre-service teachers' evaluations were independent of the norm or based on incorrect norms, they are evaluated within the scope of level 1 awareness. Following the written answers, the statements given by PT35 during the interview process regarding the relevant form are presented below.

"The teacher did not answer the question or did not want to answer it. First, he asks the students for the answer but does not tell them how to find it. He also tries to correct the students' wrong attitudes by warning them while answering. In this way, he raises awareness in the students.'' (PT35)

PT35 explained the expression "raising awareness based on an event," which he had stated in his written answer. PT35 noted that the teacher made the students think instead of answering directly and corrected their wrong attitudes by warning them. Although PT35 evaluated the teacher's approach positively, his explanations focused on describing the teacher's general classroom behaviors rather than directly expressing socio-mathematical norms. This situation indicates that the candidate struggled to develop a normative perspective and remained at the level of 1 awareness during the interview process, as evident in his written answer. The following are the responses of pre-service teachers categorized at Level 2 regarding the socio-mathematical norm in Form 3.

"Accepting logical explanations based on justifications. Students discuss among themselves and see and complete each other's deficiencies (with teacher support). Creating an alternative situation from an incorrect solution and making it advantageous." (PT15)

"The solution of a mathematical problem must be scientific. A problem cannot be solved based on personal opinion." (PT24)

"Inability to justify the information learned, making connections between the information learned, questioning the solutions or answers, explaining the answer with concrete mathematical operations." (PT12)

An analysis of the responses indicates that the pre-service teachers demonstrate Level 2 awareness of sociomathematical norms. Although PT15 made statements that were far from the norm, such as students discussing and developing each other's ideas in class and making alternative inferences from wrong solutions, she used expressions close to the norm in her first sentence. PT24, on the other hand, drew attention to the necessity of producing scientific solutions, but could not sufficiently separate the definition of norm within the conceptual framework. The other pre-service teacher touched upon essential concepts such as justification, association, and questioning. Still, these statements remained at the level of discourses that evoked the norm rather than a clear definition of the norm. Although these candidates expressed thoughts close to the norm, they could not clearly define the distinguishing features of the norm; therefore, they were evaluated at the level of 2nd-level awareness. Following the written answers, the explanation given by PT24 during the interview process regarding the relevant form is presented below.

"I think the teacher wants the students not to comment without finding a solution or having a clear idea. In my answer on the form, I wanted to give a slightly more impressive answer :) I aimed to make it look more scientific." (PT24)

When the interview data are examined, it is evident that PT24 continues to elaborate on the norm they expressed in their written answers in their verbal explanation. PT24 stated that the teacher expects explanations based on thought rather than unfounded opinions from the students; he noted that the emphasis on "scientific solutions" in his written answer was preferred to make a striking impression. This explanation indicates that their awareness of the norms is not yet established at the conceptual level. This situation supports the conclusion that the candidate demonstrates level 2 awareness, consistent with the written data

The following are the responses of pre-service teachers categorized at Level 3 regarding the socio-mathematical norm in Form 3.

"The teacher's failure to accept an answer to a question without justification may be in the form of the norm of "basing mathematical solutions on logical answers". In addition, Doğukan's constant changes in the answer, not being sure about it, and İsmet's response to this, that there is no such answer as "in my opinion" in mathematics, also supports this norm." (PT4)

"In this class, the norm that every answer given, every solution made, must be justified is dominant." (PT18)

"The norm of explaining the answer by providing a mathematical justification." (PT6)

The responses provided by the teacher candidates demonstrate a strong understanding of the norm of offering an acceptable mathematical explanation and justification. PT4 clearly describes how the teacher's refusal to accept an answer without justification reflects this norm. Furthermore, it supports this by citing examples of student interactions, such as rejecting the phrase "in my opinion" in a mathematical context. This shows an accurate interpretation of how the norm operates in classroom settings. PT18 also emphasizes the importance of justifying every answer and solution in the classroom, conveying the essence of the norm directly and explicitly. Similarly, PT6 defines the norm concisely as the act of explaining answers through mathematical reasoning. All three candidates identify the norm in a meaningful way. These responses indicate a high level of awareness and conceptual understanding of the sociomathematical norm in question. Following the written responses, the interview explanations provided by PT18 regarding the corresponding form are presented below."

"I think the norm is that 'it is important and necessary to justify every answer given and every solution made.' The teacher argues that students should explain why whether they answer wrongly or correctly." (PT18)

When the interview data are examined, it is seen that PT18 clearly and consistently maintained the "justification" norm she stated in her written answer in her verbal explanation.

Discussion and Conclusion

This study aims to determine the awareness levels of pre-service mathematics teachers regarding sociomathematical norms. In this context, the responses of the candidates to forms containing teacher-student dialogues reflecting a specific classroom microculture were analyzed. In this study, the awareness of sociomathematical norms among pre-service teachers was examined within the framework of three different scenarios. The findings indicate that the participants' awareness varied according to the scenarios. In general, most pre-service teachers were able to recognize sociomathematical norms only to a limited extent. Many of the participants responded with statements that suggested the norms but lacked clarity and consistency. This indicates that the participants had an intuitive understanding of the norms. However, this understanding was not sufficiently clear at a theoretical level. On the other hand, the data related to the third scenario are noteworthy. Compared to other norms, the pre-service teachers demonstrated a higher level of awareness regarding the sociomathematical norm of *providing an acceptable mathematical explanation and*

justification. Overall, pre-service teachers possess a basic awareness of sociomathematical norms. However, this awareness has not yet developed into a clear, well-reasoned, and pedagogically informed understanding that aligns with the definitions found in the literature. In this section, the findings are discussed and compared with the literature. Thus, the level of awareness of pre-service teachers regarding sociomathematical norms that influence mathematics teaching was evaluated in the context of the literature.

In this study, pre-service teachers' awareness of the sociomathematical norm, defined as *not valuing alternative solutions and expecting the taught method to be used* (as presented in Form 2), was examined. This sociomathematical norm pertains to the acceptance of only a single solution method as correct in the classroom. Alternative methods are disregarded. This situation hinders students from developing diverse ways of thinking and simultaneously restricts their freedom of expression (Kozaklı, 2015). Therefore, this norm can be considered a negative sociomathematical norm. Kozaklı (2015) clearly articulated the sociomathematical norm as "*not valuing alternative solutions and expecting the taught method to be used*. In the present study, it was found that the participating pre-service teachers emphasized the use of only the mathematical rules and formulas they presented and did not incorporate alternative solution methods. In particular, during a classroom interaction related to the topic of definite integrals, when a student solved a problem using an alternative solution method, the pre-service teacher deemed this approach invalid and demanded that the student use only the method demonstrated by the teacher. This reveals that the pre-service teacher adopted an approach that excludes alternative strategies and restricts students' forms of mathematical expression. Consequently, this norm is regarded as a negative sociomathematical norm that reduces diversity in learning environments, limits students' independent thinking skills, and hinders the development of mathematical creativity (Kozaklı, 2015).

On the other hand, negative sociomathematical norms have also been reported in various other studies. Akyüz (2014) noted that students tend to neglect the fundamental principles of mathematical logic when using digital technologies. As a result, students are inclined to accept their results as valid solely through dynamic verification, without engaging in any mathematical proof processes. The study emphasized that the practice of dynamic verification has become established as a negative sociomathematical norm among students and that this norm contradicts the epistemological nature of mathematical

validation. Similarly, Yaşa (2015) noted that students may develop erroneous behavioral patterns in their mathematical thinking within the classroom environment. For instance, the generalization that the sum of two odd numbers is an even number is based solely on specific examples (e.g., 5 + 7 = 12, 3 + 5 = 8, 11 + 17 = 28). The teacher's endorsement of such an approach may lead to the formation of a false norm among students that "mathematical proof can be carried out by providing examples." Such a norm contradicts the essence of the concept of mathematical proof and constitutes an undesirable condition that adversely affects students' mathematical reasoning and validation skills. In this context, negative sociomathematical norms can be described as classroom norms that hinder students' deep mathematical thinking and reasoning processes while promoting superficial, rote, and uncritical learning approaches. Additional examples of negative sociomathematical norms are also found in the literature. These include students who consider reaching the correct answer sufficient without focusing on the problem-solving process (Sönmez, 2016) and those who accept mathematical explanations without providing any justification (Öksüz, 2021). Furthermore, attitudes such as interpreting geometric figures solely based on visual features and not feeling the need to learn alternative solution methods when mathematical problems can be solved using previously learned strategies are also cited as examples of negative sociomathematical norms (Yılmaz-Memiş, 2023).

In Form 2, unlike the other forms, the study investigated how pre-service teachers identified a negative sociomathematical norm, namely, *not valuing alternative solutions and expecting the taught method to be used.* The data obtained indicate that the majority of participants were able to define the norm either directly or indirectly. It was observed that pre-service teachers could recognize the sociomathematical norm based on the dialogue presented in the scenario. The frequent occurrence of statements suggestive of the norm and references to similar norms demonstrates that the participants possessed a certain level of awareness regarding this sociomathematical norm. However, a small number of participants appeared to assess the norm only superficially or based on general teaching observations. This suggests that some pre-service teachers did not fully understand the norm and that their awareness in this regard needs to be further developed. The ability of pre-service teachers to recognize the sociomathematical norm presented in Form 2 is thought to be associated with pedagogical and psychological factors. Accordingly, this finding will be

examined within the context of pedagogical and psychological factors and discussed in detail in the following paragraphs in light of the relevant literature.

The sociomathematical *norm of not valuing alternative solutions and expecting the taught method to be used* can be seen as a consequence of a teacher-centered approach. This is because teacher-centered approaches accept only a single solution or method as correct within the classroom environment. Such an approach inhibits students from experimenting with different ways of thinking and problem-solving. Nardelli (2007) demonstrated that when teachers label any solution outside of their own as incorrect, students are also led to perceive alternative methods as wrong. This situation results in the establishment of rigid and restrictive norms in the classroom. Similarly, Pang's (2000, 2001) studies demonstrate that teacher-centered expectations limit students' thinking and narrow the range of shared sociomathematical norms. Such negative norms render students' mathematical reasoning skills superficial and hinder their creative thinking, thereby diminishing the quality of the learning environment. Kang and Kim (2016) noted that rigid mathematical beliefs held by teachers reinforce and propagate negative norms. Furthermore, Lim and colleagues (2023) argued that exam-focused systems push collaborative thinking and solution-generation processes into the background, prioritizing instead the pursuit of quick and superficial approval. As a result, students tend to adopt standard solutions, which contributes to making negative norms more prominent within the classroom.

In this study, it is believed that the negative sociomathematical norm of *not valuing alternative solutions and expecting the taught method to be used*—emerging from a teacher-centered approach—was identifiable by pre-service teachers because it contradicted their own student-centered experiences. Since 2005, a student-centered approach has been adopted in Turkey. Accordingly, curricula and textbooks have been designed with a student-centered perspective, and teachers have been expected to conduct instruction in alignment with this approach. Courses offered in the faculties of education have been delivered from a student-centered instructional perspective (Acat & Dönmez, 2009). Student-centered instructional models have provided pre-service teachers with a learning culture that promotes collaboration and encourages alternative solutions. Therefore, the epistemological narrowing and emotional discomfort caused by the imposition of a single method in the scenario directly conflict with their expectations of the instructional process. This automatically draws attention to the negative norm. Consequently, the expectations that pre-

service teachers hold—based on student-centered instructional principles and classroom practices—stand in sharp contrast to the one-method approach imposed in the scenario. This pedagogical and emotional dissonance may have enabled the participants to more clearly recognize this negative sociomathematical norm, which contradicts their own experiences.

On the other hand, the reason why pre-service teachers were able to recognize the norm of *not valuing alternative solutions and expecting the taught method to be used* can also be explained within the context of attentional tendencies toward negativity, as discussed in the psychology and neuroscience literature. People tend to focus more on negative or extreme behaviors than on positive or ordinary ones—a phenomenon known as negativity bias (Fiske, 1980). Within this framework, pre-service teachers may have been more likely to notice the norm presented in the scenario due to both its contradiction with their student-centered experiences and the emotional discomfort caused by the imposition of a single correct method. As seen in social media and political communication, emotional and negative content is particularly effective in capturing human attention (Xie, et al. 2022). Brain research also demonstrates that negative stimuli—especially those evoking fear or disgust—capture attention quickly and intensely (Carretié et al., 2003). These psychological and neuroscientific effects may have contributed to the pre-service teachers' ability to more readily identify negative sociomathematical norms that conflict with their student-centered expectations.

In addition, this study also examined pre-service teachers' awareness of sociomathematical norms from the perspective of two positive sociomathematical norms. In this context, the significance of these sociomathematical norms in the literature and their relevance for pre-service teachers were first discussed. Subsequently, the pre-service teachers' awareness of these norms was analyzed in light of the relevant literature.

One of the positive sociomathematical norms examined in this study, in terms of pre-service teachers' awareness, is *offering a different mathematical solution* (as in Form 1). This sociomathematical norm encourages students not only to reach the correct answer but also to develop alternative methods for the solution process. It represents a classroom culture in which students are expected to propose mathematically distinct strategies during problem solving, rather than merely replicating previously presented methods (Mottier-Lopez & Allal, 2007). In this context, students are guided to generate approaches that alter the mathematical structure of the solution and involve different modes of thinking, rather than

offering a mere variation of the existing solution. Cobb and Yackel (1996) noted that in classrooms where this norm is established, students know which solution strategies are considered mathematically different and apply this understanding in their interactions. This fosters a shared conceptualization of mathematical differences within the classroom. Similarly, Partanen and Kaasila (2015) revealed the development of norms that validate students' use of graphical, numerical, and verbal approaches, rather than relying solely on symbolic representations. Such norms support multifaceted thinking by opposing the pressure of traditional symbolic representation. Öksüz and Gürefe (2023) define this norm as a classroom practice that enables students to develop alternative strategies without being confined to a single solution method, thereby fostering flexibility in mathematical thinking. The development of pre-service teachers' awareness of the norm of *offering a different mathematical solution* is of great importance for practical and student-centered mathematics instruction. To foster a classroom culture that promotes diverse ways of thinking, it is expected that pre-service teachers will cultivate an awareness of the need to understand students' solution processes, support diversity, and incorporate these processes into classroom discussions. Therefore, pre-service teachers' level of awareness regarding this norm is considered a key factor in shaping the quality of future learning environments (Cobb & Yackel, 1996; Yaşa, 2015).

Another positive sociomathematical norm examined in this study, in terms of pre-service teachers' awareness, is the norm of *providing an acceptable mathematical explanation and justification*. This sociomathematical norm is a critical one that directly influences the quality of students' mathematical thinking and understanding processes (Çakır, 2021). It emphasizes that merely presenting the result of a mathematical solution or listing procedural steps is insufficient; instead, it expects students to offer explanations supported by conceptual reasoning about the solutions they construct through mathematical thinking (Yılmaz-Memiş, 2023). Such explanations require clarifying how mathematical relationships are established and articulating their underlying rationale (Gülburnu, 2019; Öksüz, 2021). At the heart of this process lies the teacher's crucial role in guiding students. Teachers support students in reorganizing their mathematical beliefs and values by asking them to explain their thinking and provide justifications for their claims (Çakır, 2021; Gülburnu, 2019; Sönmez, 2016). Students, in turn, recognize that their explanations must be both sufficient and understandable, not only for themselves but also for others in the classroom, and they begin

to engage in conceptual explanations (Çakır, 2021). The norm of *providing an acceptable mathematical explanation and justification* is a fundamental component of mathematics learning, as it fosters mathematical reasoning, deepens understanding, and supports higher-order cognitive activities (Çakır, 2021; Sönmez, 2016; Yılmaz-Memiş, 2023). Moreover, it underpins other sociomathematical norms such as presenting mathematical differences or effective solutions (Öksüz, 2021). This norm has been observed in studies spanning from elementary to university levels and has also been identified in various contexts such as virtual learning environments and gifted student classrooms (Çakır, 2021; Sönmez, 2016; Yackel & Cobb, 1996). In this context, pre-service teachers' development of awareness regarding the norm of *providing an acceptable mathematical explanation and justification* not only enhances their instructional competence but also enables them to create learning environments that deepen their students' conceptual understanding. Pre-service teachers who internalize this norm can foster a classroom culture of inquiry, explanation, and justification, thereby contributing to the construction of classroom practices that reflect the nature of mathematical thinking.

In this study, two forms were developed to assess pre-service teachers' awareness of the sociomathematical norms for *offering a different mathematical solution* and *providing an acceptable mathematical explanation and justification*. The scenarios included in both forms exemplified learning environments aligned with these sociomathematical norms. Upon examining the findings, it was found that a small number of pre-service teachers (11.9%) were unable to recognize these two sociomathematical norms. These pre-service teachers either made assessments entirely unrelated to the sociomathematical norms or misidentified the norm. In this context, it can be stated that these individuals were inadequate in recognizing the sociomathematical norms and tended to make either unrelated or superficial interpretations. In contrast, the pre-test results from the study conducted by Aydoğan-Yenmez and Çelik (2021) revealed that, prior to the intervention, pre-service teachers had a significantly more limited understanding of sociomathematical norms. In that study, only 17% of the pre-service teachers responded correctly in the pre-test, indicating that 83% struggled to identify sociomathematical norms. This lack of awareness was attributed to the participants' perception of the concept as abstract, their lack of prior hands-on experience with such norms, and their difficulty in connecting classroom interactions to pedagogical and psychological principles. When the findings of both studies are considered together, it

becomes evident that the pre-service teachers in the present study demonstrated a higher level of recognition of sociomathematical norms compared to those in the pre-intervention phase of Aydoğan-Yenmez and Çelik's (2021) study. Possible explanations for this difference may include the pre-service teachers in the present study having previously encountered sociomathematical norms either directly or indirectly, or possessing a relatively more developed level of intuitive awareness regarding these norms.

When examining the other findings regarding pre-service teachers' awareness of the sociomathematical norms of *offering a different mathematical solution* and *providing an acceptable mathematical explanation and justification*, certain similarities and differences in their levels of recognition become evident. In both sociomathematical norms, a significant portion of the pre-service teachers were found to be at Level 2. At this level, the participants' responses did not directly define the norm but included statements that were related to or suggestive of similar norms. This suggests that, although the participants had a certain level of intuitive awareness of the norms, their understanding lacked conceptual clarity. Nonetheless, a notable number of pre-service teachers were also placed at Level 3 for both norms, demonstrating the ability to articulate the sociomathematical norm clearly and accurately. Awareness at Level 3 was more prominent for the norm of *providing an acceptable mathematical explanation and justification*. In this context, it can be inferred that this norm was found to be more clearly recognizable and definable by pre-service teachers. On the other hand, there was a greater concentration at Level 2 for the norm of presenting a different mathematical solution. This finding suggests that while pre-service teachers struggled to define this norm explicitly, they possessed a certain degree of intuitive familiarity with it.

When the pre-service teachers' awareness of the three sociomathematical norms addressed in this study is examined holistically, it is observed that their awareness tends to concentrate mostly at Level 2. This suggests that, although the participants struggled to explicitly define the norms, they were able to develop statements that were suggestive of, related to, or closely aligned with the norms. In other words, the pre-service teachers had developed a certain level of intuitive awareness regarding sociomathematical norms; however, this awareness had not yet attained theoretical depth and clarity. Similarly, in the study conducted by Aydoğan-Yenmez and Çelik (2021), it was found that although pre-service teachers incorporated certain sociomathematical norms into their designed activities, their use of these norms remained at a superficial level. Gülburnu (2024) also revealed that

while pre-service teachers struggled to provide conceptual explanations of sociomathematical norms, they were not entirely unfamiliar with them. As in those studies, the findings of the present study also show that, although norms are recognized intuitively, pre-service teachers' ability to define them within a theoretical framework remains limited.

On the other hand, the presence of a noteworthy number of participants at Level 3 awareness indicates that some pre-service teachers were able to define sociomathematical norms clearly and accurately and could articulate related concepts in a pedagogically coherent manner. These candidates expressed sociomathematical norms not only intuitively but also consciously and theoretically. This finding is promising in that it demonstrates a degree of awareness of sociomathematical norms among a subset of pre-service teachers. It also represents a level that is relatively less frequently reported in the literature. In a study conducted by Toscano, et al. (2019), it was found that some pre-service teachers possessed a conceptual perspective and were able to consciously define certain norms. In the same study, among the five socio-didactic norms identified based on participants' statements, some reflected a more advanced pedagogical understanding. In this context, the presence of a limited number of candidates with Level 3 awareness in our study also suggests that these individuals demonstrated not only intuitive but also theoretical development, thereby reflecting the potential of teacher education programs.

Conversely, the fact that only a limited number of pre-service teachers were at Level 1 suggests that, in general, pre-service teachers were not entirely unfamiliar with sociomathematical norms; however, a small number of participants either misidentified these norms or made unrelated assessments. This finding is consistent with the study by Gülburnu (2024), which reported that while most pre-service teachers were not entirely unfamiliar with the norms, their explanations regarding them were limited. Similarly, in the study by Aydoğan-Yenmez and Çelik (2021), although certain norms were visible in the activities, the complete absence of others indicated that, even if the norms were not entirely unfamiliar, there could be incomplete or incorrect representations.

Within the scope of this research, it was also found that the aspects of the scenarios pre-service teachers focused on while identifying sociomathematical norms varied. This diversity in focus contributed to differences in their levels of awareness regarding the norms. While attempting to identify sociomathematical norms, pre-service teachers concentrated on mathematical processes, social interactions, or instructional methods. These findings align

with similar studies in the literature. For instance, in a study conducted by Toscano and colleagues (2019), the discourse of pre-service teachers during dialogue-based tasks was analyzed, and various sociomathematical norms were identified based on this discourse. In this context, it was noted that the pre-service teachers' focus areas included themes such as mathematical knowledge, the role of the teacher, and classroom interactions.

On the other hand, some pre-service teachers focused on the social interaction dimension of the dialogues, emphasizing the emotional states of the teacher and students. This focus made it difficult for them to evaluate the normative structures impartially and holistically. Another group of pre-service teachers concentrated on the instructional methods presented in the scenarios and, by focusing on the applicability of these methods in classroom practices, interpreted the norms as instructional strategies. Similarly, the study conducted by Bayar, et al. (2021) reported that some pre-service teachers were able to define sociomathematical norms within the framework of social expectations and relate them to pedagogical justifications.

Another notable finding that emerged in this study is that the majority of the norms identified by the pre-service teachers fell under the category of social norms rather than sociomathematical norms. In other words, the participants tended to define the normative structures in the dialogues not within a mathematical context but rather in terms of general classroom interactions, which align more closely with social norms. According to Yackel and Cobb (1996), interaction patterns that influence learning processes and are observed across all subjects in the classroom are considered social norms. In contrast, normative structures specific to the culture of the mathematics classroom are defined as sociomathematical norms. In this context, the norms identified by pre-service teachers that were not directly associated with mathematical concepts or content cannot be considered consistent with the definition of sociomathematical norms. Indeed, Zembat and Yaşa (2015) also emphasized that social norms are independent of mathematics, while sociomathematical norms arise exclusively within a mathematical context. Similarly, in Gülburnu's (2024) study, the views of pre-service teachers on sociomathematical norms were evaluated through both individual (e.g., beliefs, attitudes) and social (e.g., teacher-student interaction, classroom atmosphere) frameworks. In this regard, it was concluded that the processes by which pre-service teachers identify and interpret norms varied, and that these differences could be attributed to their educational backgrounds and pedagogical orientations.

On the other hand, it is believed that individual differences among pre-service teachers influence their awareness of sociomathematical norms. The varying learning styles, cultural backgrounds, and prior experiences of pre-service teachers are thought to affect how they perceive sociomathematical norms. An examination of the interpretive framework developed by Cobb and colleagues (1996) reveals that sociomathematical norms are not limited to in-class social interactions but instead possess a multilayered structure that includes the cultural and individual backgrounds of classroom members. In this context, it can be stated that sociomathematical norms, shaped within the microculture of the mathematics classroom, have a cultural dimension and that the cultural capital of classroom members may play a determining role in how these norms are formed and perceived (Kang & Kim, 2016). Indeed, in the present study, it was observed that some pre-service teachers interpreted the teacher-student interactions presented in the scenarios from a socio-cultural perspective and made comments regarding the sociomathematical norms accordingly.

The findings of this study reveal the awareness of pre-service teachers regarding sociomathematical norms. However, certain limitations should be taken into consideration when evaluating the data obtained. Pre-service teachers may have had difficulty reading and understanding the scenarios in a limited time. This process may have negatively affected the perception of norms by causing distraction and cognitive load. Additionally, the study's reliance on third-year pre-service mathematics teachers constitutes a significant limitation. A similar study carried out with fourth-year pre-service teachers or recent graduates might yield different results due to their increased teaching experience. This is because the professional knowledge base and classroom practice experience of pre-service teachers can directly influence their awareness of sociomathematical norms. Therefore, the limited level of experience of the participant group may be considered a factor that restricts the generalizability of the findings.

In line with the findings of this study, various suggestions can be made for both teacher training institutions and future research. Firstly, it is recommended that more practice-based activities be incorporated into pre-service education processes, allowing teacher candidates to develop an awareness of sociomathematical norms in their classroom practices. In this context, introducing examples of in-class practices related to sociomathematical norms to teacher candidates or having them watch videos of these practices will contribute to both increasing the awareness levels of the candidates and

reinforcing their conceptual knowledge. Additionally, this study was conducted exclusively with third-year teacher candidates in the context of geometry and measurement. Therefore, conducting similar studies with teacher candidates in different subject areas and grade levels will enable the examination of the development of awareness regarding sociomathematical norms within a broader framework. Developmental studies conducted using longitudinal designs, particularly with teacher candidates from first to fourth grade, can reveal changes in awareness levels over time. Ultimately, this research is a descriptive case study designed to assess the current awareness levels of teacher candidates. In the future, providing systematic and comprehensive training to pre-service teachers on sociomathematical norms and conducting experimental studies examining the effects of this training on their awareness levels will make significant contributions to the literature.

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