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**ПОВЫШЕНИЕ ЭФФЕКТИВНОСТИ ОНЛАЙН-ВЗАИМНОЙ
МЕЖКУЛЬТУРНОЙ ПОДГОТОВКИ ПО МАТЕМАТИКЕ:
ПРЕДЛОЖЕНИЯ БУДУЩИХ УЧИТЕЛЕЙ МАТЕМАТИКИ**

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Аннотация. Данное исследование посвящено анализу предложений будущих учителей математики по развитию онлайн-взаимной межкультурной учебной деятельности. В работе использованы письменные отзывы студентов с целью выявления педагогических аспектов, требующих усиленного внимания при проектировании подобных образовательных сред. Методология исследования базировалась на качественном описательном подходе, включающем обработку данных, полученных из ответов на открытые вопросы анкеты, представленных 68 студентами, проходящими подготовку по программе «Обучение математике» в Государственном университете Медана, Индонезия. Аналитика данных осуществлялась через первичное кодирование, организацию в теоретические категории и количественную характеристику по частотам и долям. Важным новшеством работы считается использование предложений студентов как базы для формирования педагогического подхода к улучшению онлайн-взаимной межкультурной математики, а не ограничение исследования прикладными результатами или теоретическими дискуссиями. В результате выявлены шесть взаимосвязанных направления рекомендаций: аутентичные межкультурные математические примеры и контексты из различных культур; структурированное межкультурное взаимодействие и сотрудничество; языковая поддержка и математические знаковые системы; интерактивные и мультимодальные средства обучения; роль преподавателя и его педагогическая активность; рефлексия и расширение глобальных перспектив. Среди них выделяются наиболее актуальные категории: аутентичные межкультурные математические контексты и примеры из различных культур (82,4% участников); организованное межкультурное взаимодействие и сотрудничество (85,0%); а также мультимедийные средства с интерактивными возможностями (66,2%). Подводя итог, можно отметить, что повышение эффективности онлайн-взаимной межкультурной математической подготовки предполагает создание интегрированной педагогической модели, в рамках которой математические идеи рассматриваются через межкультурные перспективы, активируют взаимодействие и диалог, подкрепляются четким языковым и знаковым оформлением, реализуются посредством интерактивных ресурсов, управляются посредством активной педагогической поддержки и дополняются через процессы рефлексии.

Ключевые слова: онлайн-взаимная межкультурная математика; будущие учителя математики; качественное описательное исследование; межкультурное преподавание математики с учетом культурных особенностей; межкультурное

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Introduction

In today's increasingly digital and interconnected higher education environment, learning is no longer confined to mastering subject specific knowledge. Its also involves understanding local, global, and intercultural issues, valuing others' perspectives, and engaging openly, appropriately, and effectively with people from different cultural backgrounds (Sinambela & Savelyeva, 2026). The OECD identifies these abilities as central to global competence, while UNESCO emphasizes that intercultural competence involves navigating diversity, ambiguity, and difference with respect, openness, empathy, and flexibility. In Deardorff's framework, intercultural competence is a developmental process that begins with foundational attitudes such as respect, openness, and curiosity and culminates in the ability to communicate and act effectively and appropriately in intercultural contexts (Deardorff, 2019). For pre-service mathematics teachers (PMTs), this means that academic preparedness in the digital era cannot be separated from the capacity to learn, communicate, and collaborate within increasingly intercultural environments (Deardorff, 2006; OECD, 2019; UNESCO, 2013).

This issue is especially important in mathematics education because mathematics cannot be viewed as knowledge that exists entirely apart from social and cultural contexts. From the perspective of ethnomathematics, mathematical activity is always connected to the history, practices, symbols, and ways of life of particular communities. In this sense, culture is not simply a background illustration for mathematics, but medium through which mathematical meaning is formed and understood (D'Ambrosio, 1985). In line with this view, culturally responsive mathematics teaching has emerged as an essential framework for making mathematics learning more meaningful for students from diverse cultural and linguistic backgrounds (Sinambela & Savelyeva, 2026). The synthesis by (Abdulrahim & Orosco, 2020) shows that culturally responsive mathematics instruction requires attention to contextual relevance, student diversity, and inclusive pedagogical approaches. Likewise, (Bonner & Adams, 2012) argue that such teaching depends on understanding students and their contexts, maintaining effective communication, building trusting relationships, and continuously reflecting on and refining pedagogy. This suggests that the quality of mathematics learning depends not only on conceptual precision but also on how well instructional design connects mathematical ideas to authentic and meaningful cultural contexts (Abdulrahim & Orosco, 2020; Bonner & Adams, 2012; D'Ambrosio, 1985).

The growth of online learning has created new opportunities to connect mathematics education with intercultural experiences. Through virtual environments, students can interact, exchange ideas, and compare ways of thinking with others from different cultural backgrounds without relying entirely on physical mobility. However, the educational value of these virtual spaces does not arise automatically. The community of inquiry framework explains that meaningful online learning is shaped by the interaction of social presence, cognitive presence, and teaching presence (Garrison et al., 1999). In teacher education, the review by (Romijn et al., 2021) further indicates that intercultural competence develops more effectively when learning is situated in context, supported by guided reflection, and includes opportunities for enactment or practical application. Therefore, online intercultural learning should not be understood merely as transferring

interaction into digital formats, but as a pedagogical design that intentionally organizes interaction, meaning making, support, and reflection (Garrison et al., 1999; Romijn et al., 2021).

In mathematics learning, this complexity becomes even more visible. Intercultural interaction in mathematics involves not only differences in social experience, but also differences in academic language, symbols, representations, ways of expressing mathematical reasoning, and approaches to linking abstract concepts with concrete cultural contexts. UNESCO stresses the importance of sociolinguistic awareness, the ability to make implicit assumptions explicit, and sensitivity to multilingualism in intercultural communication (UNESCO, 2013). Within mathematics education, these needs directly affect how students understand terminology, interpret notation, build arguments, and make sense of problem-solving strategies. At the same time, culturally responsive mathematics teaching also requires clear communication, supportive learning relationships, and sustained pedagogical reflection (Bonner & Adams, 2012; UNESCO, 2013). Thus, online intercultural mathematics learning cannot simply rely on digital platforms. This process also requires a realistic cultural context, adequate language support and representation, interactive media, a strong role for lecturers in facilitating learning, and a space for reflection that allows students to productively understand differing perspectives (Bonner & Adams, 2012; UNESCO, 2013).

Despite growing attention to intercultural learning, online learning, and culturally responsive mathematics teaching, the existing literature tends to focus on conceptual frameworks, practice syntheses, or general competency development. These studies have not often considered student feedback as a primary basis for improving instructional design. However, research on student voice in higher education has shown that student perspectives can reveal gaps between lecturers' assumptions and their actual learning experiences, providing crucial input for curriculum and instructional development (Brooman et al., 2015). In this context, the perspectives of PMTs are crucial, as they are not only involved as learners but also begin to develop professional sensitivity to pedagogical aspects that need strengthening. The novelty of this study lies in its attempt to ground suggestions from PMTs in an analytical framework for formulating improvements in online intercultural mathematics instruction, rather than simply evaluating learning outcomes or rehashing existing conceptual frameworks. Thus, this study not only describes students' experiences but also positions their responses as a source of pedagogical knowledge for improving instructional design. Therefore, this study aims to describe PMTs suggestions for improving online intercultural mathematics teaching. Specifically, this study answers the following question: What suggestions do PMTs offer to improve online intercultural mathematics learning?

Research Method

This research uses a descriptive qualitative approach (Barada, 2013), to examine PMTs' suggestions for improving online intercultural mathematics learning. To systematically understand the research procedures and data analysis, this research flow is summarized in Figure 1.

As shown in Figure 1, this study involved 68 PMTs. Data was collected through a post-learning questionnaire with 5 open-ended questions. After all data was collected, the researcher began the familiarization phase by repeatedly reading all responses to gain a comprehensive understanding of the data.

The next stage was initial open coding, the process of assigning codes to units of meaning that included respondents' suggestions, needs, evaluations, and input on online intercultural mathematics learning. Similar codes were then grouped into final categories:

- Context and examples of authentic cross-cultural mathematics,
- Structured cross-cultural interaction and collaboration,
- Language support and mathematical representation,
- Interactive and multimodal media,
- Lecturer facilitation or teaching presence, and
- Reflection and global perspective.

After the final categories were established, the researcher calculated the number of respondents and the percentages in each category as descriptive support for the most dominant

suggestions. The next stage is analytical review, which involves reviewing the relationships between quotes, codes, categories, and themes to ensure interpretations align with the raw data. Through this series of stages, the analysis yields key themes and interpretations of the results, which serve as the basis for formulating implications and recommendations for improving online intercultural mathematics learning.

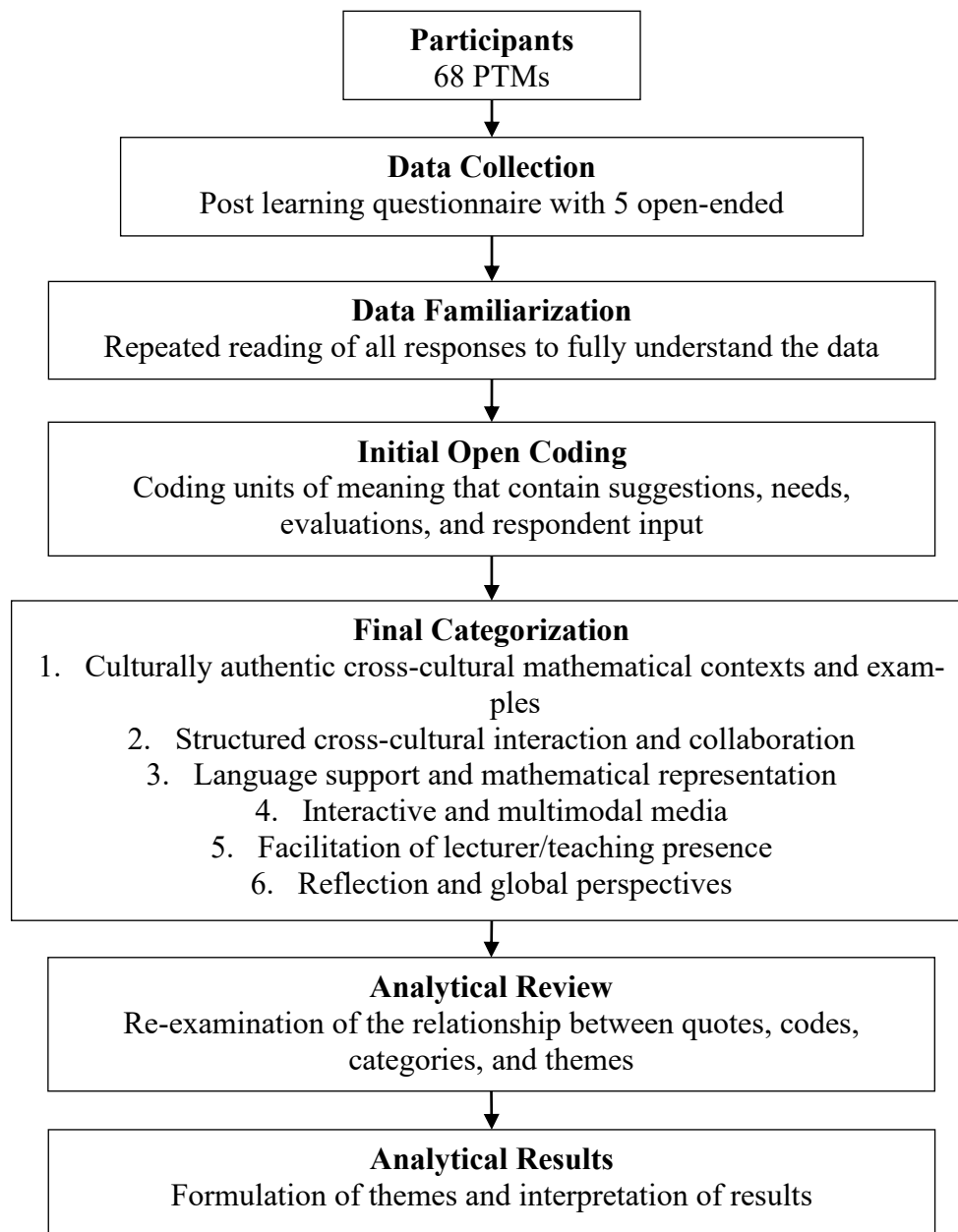


Fig. 1. Qualitative research and data analysis procedures

Results

Based on the qualitative analysis, this study yielded six final categories representing PMTs suggestions for improving online intercultural mathematics learning:

- Culturally authentic cross-cultural mathematical contexts and examples
- structured cross-cultural interaction and collaboration
- language support and mathematical representation
- interactive and multimodal media
- lecturer facilitation or teaching presence, and

- reflection and global perspective.

Although all five open-ended questions were read to understand the context of respondents' experiences, the calculation of the number of respondents and the percentage of suggestion categories focused on responses that directly included suggestions for improvement, namely answers to questions about aspects of learning that need improvement and suggestions for developing learning because each respondent could provide more than one suggestion, a single response could be assigned to more than one category.

Table 1.
PMTs' suggestion categories for enhancing online intercultural mathematics learning

Final category	Number of respondents	Percentage
Culturally authentic cross-cultural mathematical contexts and examples	56	82.4%
Structured cross-cultural interaction and collaboration	51	75.0%
Language support and mathematical representation	17	25.0%
Interactive and multimodal media	45	66.2%
Lecturer facilitation or teaching presence	19	27.9%
Reflection and global perspective	30	44.1%

The percentage in Table 1 is calculated based on 68 valid respondents. A single respondent may fall into more than one category, so the total percentages do not add up to 100%. Empirically, the most frequently occurring categories was Culturally authentic cross-cultural mathematical contexts and examples, followed by Structured cross-cultural interaction and collaboration, and interactive and multimodal media. However, the categories of findings in this section are presented in conceptual order to facilitate a more systematic interpretation.

Across the responses, the most prominent categories were culturally authentic mathematical contexts and examples from different cultures, followed by structures intercultural interaction and collaboration, and interactive and multimodal media. Even so, the categories in the presentation below are arranged conceptually to make the overall pattern of findings easier to follow systematically.

1. Culturally authentic mathematical contexts and examples across cultures

This was the strongest category, appearing in the responses of 56 out of 68 respondents (82.4%). Most respondents called for a greater use of examples, illustrations, artifacts, patterns, and cultural practices from diverse backgrounds to make mathematical concepts more concrete and relatable.

The prominence of this category shows that respondents did not support an approach to learning that stays limited to formulas and procedures. Instead, they stressed the importance of presenting mathematics through cultural contexts that students can recognize, compare, and interpret meaningfully. In this sense, cultural context was seen as a central way of clarifying mathematical ideas rather than as a purely decorative element.

2. Structures intercultural interaction and collaboration

This category appeared in the responses of 51 respondents (75.0%). Suggestions in this area highlighted the importance of active discussion, group work, strategy sharing, and collaborative projects that would allow students to engage more deeply with different cultural perspectives.

These responses suggest that participants viewed online intercultural mathematics learning as a process that should be designed dialogically. What they wanted was not simply more interaction, but interaction that was more carefully structured, so that comparing strategies, negotiating meaning, and exchanging mathematical ways of thinking could happen productively.

3. Language support and mathematical representations

This category was identified among 17 respondents (25.0%). Participants recommended clearer, simpler explanations, bilingual or multilingual support, and more explicit guidance on understanding the terms, symbols, and mathematical representations used in cross-cultural learning settings.

Although this category appeared less frequently than others, it is still important. The responses suggest that challenges in intercultural learning are not limited to cultural context but also involve how mathematical ideas are communicated. Language support and representational clarity were therefore seen as important for helping students interpret concepts, follow explanations, and express their mathematical reasoning more accurately.

4. Interactive and multimodal media

This category appeared in 45 respondents' responses (66.2%). Participants suggested using videos, visual, simulations, and more interactive digital platforms to help connect mathematical concepts with cultural contexts.

This finding indicates that learning media were seen as more than just tools for delivering content. Instead, respondents viewed interactive and multimodal media as resources that can bridge abstract concepts and more concrete forms of representation, making the relationship between symbols, ideas, and cultural contexts easier to understand.

5. Lecturer facilitation or teaching presence

This category was identified among 19 respondents (27.9%). Suggestions in this category emphasized the need for clearer guidance, more consistent support during discussions, more structured explanations, and stronger lecturer involvement in helping students work through different perspectives during the learning process.

This finding shows that respondents did not see online intercultural learning as something that could be left entirely to peer interaction. On the contrary, lecturer presence was still considered essential for keeping learning on track, clarifying its goals, and supporting deeper conceptual understanding.

6. Reflection and global perspectives

The final category appeared in 30 responses (44.1%). Participants suggested that the learning process should offer more opportunities to reflect on the relationships among mathematics, culture, and broader contexts.

This finding suggests that respondents did not only want learning experiences enriched by examples and interaction but also wanted opportunities to make sense of those experiences. Reflection was therefore seen as important for helping students understand how cultural perspectives shape how mathematics is interpreted, while also broadening their awareness of the role of mathematics in social and cultural life.

Discussion

Taken together, the findings suggest that PMTs did not view the enhancement of online intercultural mathematics learning as a matter of adding isolated cultural examples to an otherwise conventional lesson structure. Rather, the coding pattern points to broader expectations of pedagogical redesign in which cultural context, interaction, representation, facilitation, and reflection work in combination. The prominence of the first three empirically strongest categories culturally authentic mathematical contexts and examples across cultures, structured intercultural interaction and collaboration, and interactive and multimodal media indicates that respondents were primarily concerned with how mathematical meaning is constructed, communicated, and negotiated in online intercultural settings, rather than with content coverage alone. This pattern suggests that students' suggestions were oriented towards making mathematical ideas more meaningful, accessible, and dialogically engaging across cultural contexts (D'Ambrosio, 1985; Fouze & Amit, 2023).

The strongest emphasis on culturally authentic mathematical contexts and examples across cultures is especially significant. This finding implies that respondents did not regard culture as a superficial supplement to mathematics instruction, but as an important means of making concepts

interpretable and educationally meaningful. Such a pattern is consistent with ethnomathematical perspectives, which argue that mathematical activity is embedded in cultural practices and that mathematics education should recognize how mathematical ideas emerge through historically and culturally situated forms of knowing. It also aligns with research on culturally responsive mathematics teaching, which shows that meaningful mathematics learning depends not only on conceptual accuracy but also on pedagogical approaches that connect mathematical ideas to learners' cultural and linguistic worlds. From these perspectives, the respondents' calls for more culturally grounded examples can be interpreted as a demand for epistemic relevance: they wanted mathematics to be presented in ways that reveal where and how it lives in diverse cultural settings (D'Ambrasio, 1985; Kabuye Batiibwe, 2024; Sinambela & Savelyeva, 2026).

The second dominant category, structured intercultural interaction and collaboration, further suggests that respondents understood online intercultural mathematics learning as dialogic rather than transmissive process. Their emphasis on active discussion, group work, and collaborative exchange indicates that cultural diversity becomes educationally productive when learners are given structured opportunities to compare strategies, explain reasoning, and negotiate mathematical meaning with others. This interpretation resonates with the community of inquiry framework, which conceptualizes meaningful online learning as the product of an interplay among social presence, cognitive presence, and teaching presence. In this light, the respondents' suggestions imply that intercultural mathematics learning is strengthened not merely by placing students in a shared online space, but by designing tasks and interactions that enable collaborative inquiry. The result is especially important because it shows that students did not simply ask for more participation in general terms. They asked for forms of participation that could deepen mathematical understanding through structured intercultural exchange (Garrison et al., 1999).

Although language support and mathematical representations appeared less frequently than some other categories, their analytical significance should not be underestimated. The respondents' references to simpler explanations, multilingual support, and clearer handling of symbols and representations indicate that intercultural challenges in mathematics learning are also semiotic and linguistic in nature. In other words, difficulties may arise not only from unfamiliar cultural references but also from the ways mathematical ideas are encoded, explained, and interpreted. This finding is consistent with UNESCO's emphasis on sociolinguistic awareness in intercultural communication and with guidance on scaffolding multilingual students' learning in mathematics, which stresses the importance of supporting learners through coordinated use of language, symbols, visuals, and other representational resources. The respondents' suggestions, therefore, point to an important pedagogical insight. Online intercultural mathematics learning requires not only cultural openness, but also explicit support for meaning making linguistic and representational differences across (UNESCO, 2013; Sinambela & Savelyeva, 2026).

The strong presence of interactive and multimodal media in the findings reinforces this interpretation. Respondents did not appear to view digital media as neutral delivery tools. Instead, they positioned them as pedagogical mediators capable of bridging mathematical abstraction and cultural concreteness. Videos, visuals, simulations, and other interactive resources helped students see more clearly the connections among concepts, symbols, and cultural practices. This finding aligns with scholarships showing that online learning becomes more educationally meaningful when educators use the medium to support inquiry, collaboration, and representational access rather than merely transmitting information. Within the present study, the coding pattern suggests that respondents saw multimodality as a means of improving conceptual access in culturally diverse learning environments. In this sense, media use was pedagogical rather than technical (Garrison et al., 1999).

The remaining two categories, i.e., lecturer facilitation or teaching presence and reflection and global perspectives, clarify that respondents did not equate student-centered intercultural learning with the absence of instructional guidance. On the contrary, their suggestions indicate that they still regarded the lecturer as essential for framing tasks, sustaining discussion, clarifying expectations, and helping students navigate differing perspectives. This is consistent with work on

culturally responsive mathematics teaching, which identifies communication, trust, contextual knowledge, and ongoing reflection as central pedagogical cornerstones, as well as with the community of inquiry model, in which teaching presence is integral to the quality of online educational experience. At the same time, the category of reflection and global perspectives suggests that respondents wanted opportunities not only to participate in intercultural encounters, but also to interpret them. This point aligns with review evidence indicating that guided reflection and enactment are important facilitators of intercultural competence development in teacher education. Thus, the two categories together suggest that online intercultural mathematics learning should be designed not only for exposure and participation, but also for guided interpretation and professional meaning making (Bonner & Adams, 2012).

A further point of significance lies in the methodological pattern emerging from the coding itself. The six final categories are analytically distinct, yet the findings show that they are pedagogically interdependent. Respondents who called for more culturally authentic examples often also called for richer interaction or more interactive media, suggesting that these were not perceived as separate improvements but as mutually reinforcing elements of a more coherent learning design. Read in this way, the results do not support a fragmented approach in which culture, technology, language, and facilitation are treated as isolated components. Instead, they point towards an integrated model of online intercultural mathematics learning in which authentic contexts provide meaning, interaction enables negotiation, language and representation support comprehension, multimodal media enhance access, lecturer facilitation sustains direction, and reflection supports deeper intercultural understanding. This reading also strengthens the study's contribution to student voice literature. Rather than offering incidental feedback, the respondents articulated a relatively coherent pedagogical agenda for improving the design of online intercultural mathematics learning (Brooman et al., 2015; Fouze & Amit, 2023).

Overall, the discussion indicates that the respondents' suggestions extend beyond request for minor instructional adjustments. They point instead to the need for a more deliberately designed pedagogical environment in which mathematical concepts are contextualized across cultures, explored through structured interaction, supported through linguistic and multimodal scaffolding, and consolidated through lecturer guidance and reflection. In this respect, the findings position PMTs not merely as recipients of instruction, but as informed participants capable of identifying the pedagogical conditions under which online intercultural mathematics learning can become more meaningful and conceptually productive (Abdulrahim & Orosco, 2020; D'Ambrosio, 1985).

Conclusion

This study examined PMTs' suggestions for enhancing online intercultural mathematics learning. The findings indicate that six interconnected areas need meaningful improvement: culturally authentic mathematical contexts and examples across cultures, structures intercultural interaction and collaboration, language support and mathematical representations, interactive and multimodal media, lecturer facilitation or teaching presence, and reflection and global perspectives. Among these areas, PMTs placed the strongest emphasis on culturally authentic contexts, structured intercultural collaboration, and interactive multimodal media.

Taken together, these findings suggest that educators cannot strengthen online intercultural mathematics learning by adding cultural content only at a superficial level. Instead, lecturers and course designers need to develop a more coherent pedagogical design. In this design, educators contextualize mathematical concepts across cultures; students explore these concepts through purposeful interaction; lecturers support learning through clear language and representation; online resources mediate learning through interactive materials; lecturers guide the learning process through active facilitation; and students deepen their understanding through reflection. In practical terms, lecturers and course designers should prioritize culturally grounded mathematical materials, intentionally structured intercultural exchange, clearer representational support, and more meaningful use of multimodal media in online learning environments.

This study contributes to the field by positioning PMTs suggestions as a substantive source of pedagogical insight for improving online intercultural mathematics learning. Rather than treating students as passive recipients of instructional design, this study shows that students can reveal the conditions under which mathematics learning becomes more meaningful, culturally grounded, and conceptually productive across diverse contexts.

This study was delimited to written responses to open-ended questionnaire items, which enabled the systematic capture of a broad range of student suggestions. Future researchers may extend this foundation through interviews, cross-context comparisons, or implementation-based inquiry.

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ENHANCING ONLINE INTERCULTURAL MATHEMATICS LEARNING: PRE-SERVICE MATHEMATICS TEACHERS' SUGGESTIONS

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Abstract. This study examined pre-service mathematics teachers' suggestions for improving online intercultural mathematics learning. It draws on students' written reflections to identify the pedagogical dimensions that need greater attention in the design of such learning environments. The research adopted a qualitative descriptive approach, using data from open-ended questionnaire responses collected from 68 pre-service mathematics teachers enrolled in mathematics education study program at State University of Medan, Indonesia. Data analysis involved initial open coding, theoretical categorization, and descriptive quantification through frequencies and percentages. The study's novelty lies in treating pre-service mathematics teachers' suggestion as a meaningful analytical foundation for strengthening online intercultural mathematics learning, rather than focusing only on learning outcomes or broad theoretical discussions. The findings revealed six interconnected categories of suggestions: culturally authentic mathematical contexts and examples from different culture; structured intercultural interaction and collaboration; language support and mathematical representations; interactive and multimodal media; lecturer facilitation or teaching presence; and reflection and global perspectives. Among these, the most dominant categories were culturally authentic mathematical contexts and examples from different cultures (82.4% of respondents); structured intercultural interaction and collaboration (85.0%); and interactive and multimodal media (66.2%). Overall, the study shows that improving online intercultural mathematics learning requires a more

integrated pedagogical design in which mathematical concepts are situated across cultural contexts, explores through purposeful interaction, supported by clear language and representation, delivered through interactive resources, guided by active lecturer facilitation, and enriched through reflection.

Keywords: online intercultural mathematics learning; pre-service mathematics teachers; qualitative descriptive study; culturally responsive mathematics teaching; intercultural learning; students' suggestions

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