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The utilization of cross-math-based student worksheets in understanding number operations through set materials

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Abstract

This study aims to explore the potential use of student worksheets based on Cross Math, combined with the Realistic Mathematics Education (RME) approach, to enhance students' understanding of number operations through set theory. The research employed a preliminary study with a mixed-method approach. Data were collected through questionnaires distributed to 75 mathematics education students at Universitas Muhammadiyah Bangka Belitung who had taken Basic Mathematics courses, as well as interviews with course lecturers. The questionnaire results revealed that the majority of students considered arithmetic operations as an essential topic to master, with a tendency to understand concepts better when linked to real-life experiences. Most students also perceived that learning media, particularly worksheets, are highly supportive in the learning process. Lecturer interviews further indicated that students often face difficulties in understanding algebra, sets, and geometry, which highlights the need for innovative, interactive, and contextual learning media. Based on these findings, Cross Math-based worksheets with the RME approach have the potential to become an alternative learning medium that can increase motivation, strengthen conceptual understanding, and provide a more meaningful learning experience. This study offers a preliminary foundation for subsequent development stages, specifically the production of Cross Math-based worksheets that are valid, practical, and effective for use in mathematics learning at the higher education level.

Keywords: *cross math; number operation; RME; set theory; worksheet*

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INTRODUCTION

Education is a conscious and planned effort to develop the potential of students, including their ability to think critically and independently (Hidayat et al., 2019). One of the subjects that can foster these skills is mathematics (Ruseffendi, 2006). In the mathematics learning process, students are not only required to memorize formulas but also to understand concepts, methods, and reasoning. Therefore, prospective mathematics teachers must possess a deep understanding of concepts to deliver the material correctly and meaningfully (Rodliyah, 2021). Being a student and thriving in the midst of the pressure of changing academic and social expectations can be a challenging task (Othman

et al., 2019). Mathematics is often considered an abstract and challenging subject by many students. However, the principles and concepts are firmly rooted in real-life applications that span various fields, including engineering, medicine, finance, and everyday problem-solving (Odoh et al., 2021). Mathematics is one of the mandatory subjects taught at all levels of formal education in Indonesia (Sukmawati et al., 2025). One of the basic materials that is a prerequisite for an advanced understanding of concepts is number operations (Asih & Imami,2021). Jarmita (2015) and Sukiyanto et al. (2021) revealed several benefits that can be obtained from learning the concept of integers and counting operations, such as stimulating students to become accustomed to solving simple problems using integers and their calculation operations. In line with what was said by Almaida et al. (2019) and Suwarto (2018), mastery of calculation operation material is an essential aspect for every student. In addition, to support students' ability to complete simple calculation operations, speed in counting is needed to support students' numeracy abilities and skills (Fauzi et al., 2023).

However, field studies reveal that many students, particularly prospective teachers, continue to struggle with understanding basic mathematical concepts, such as number operations, including addition, subtraction, multiplication, and division (Alin & Puguh, 2024). Mistakes that often occur include working on counting operations in order from left to right without paying attention to the rules of operation priority (Noperta, 2023). Similar difficulties arise when students are asked to relate number operations to diagram representations and set concepts; this condition confirms that the two materials are closely related and should be studied integratively. This finding indicates that the conceptual understanding of pre-service teachers remains low and requires further improvement. This difficulty is exacerbated by the use of traditional one-way learning methods, as well as the limitations of interesting and contextual teaching media and materials. Students tend to be passive in lectures, merely listening to lecturers' explanations without actively engaging in the learning process (Oktaviana & Susiaty, 2020). Additionally, the teaching materials used have not fully helped students build their initial knowledge or relate the material to real-life experiences (Putri, 2019).

To address these challenges, innovative, interactive, and engaging learning solutions are necessary. One relevant approach is the Realistic Mathematics Education (RME) approach, which emphasizes learning activities that build knowledge through real

and contextual experiences (Natalia, 2017). This approach is believed to help students build a gradual understanding of concepts through meaningful real-world problems (Cahaya & Karo-karo, 2025). RME also enables students to be more active, creative, and to develop their own mathematical models (Odoh et al., 2021).

In addition to the approach, learning media plays an important role. The use of appropriate learning media can increase student involvement, motivation, and understanding. According to the research by Shoff et al. (2021), the use of learning media can simplify the material and significantly increase student understanding. This aligns with the view that the learning process is a form of communication that occurs within a system. Hence, learning media occupy an essential position as one of the components of learning. Without media, communication in learning cannot run optimally. According to the research, Wulandari (2023) emphasized that learning media is one of the key components in the learning process. Learning media is one of the tools that can help teachers convey learning materials, thereby sparking children's interest in the presented materials. In fact, according to Juhaevah et al. (2025), the duration of media use interventions also has an impact on learning effectiveness, where the use of short-term structured media can directly increase student involvement and motivation in learning to understand the concept of numbers. One form of media that is relevant and effective in lectures is the Student Worksheet.

According to Andarwati et al. (2021), the student worksheet is a teaching tool systematically prepared to help students build an understanding of concepts through gradual and directed activities. Worksheets are teaching materials that are organized in a way that allows students to study the material independently. In line with the research of Rezeki et al. (2022), it is demonstrated that learning with MFIs is more effective in improving mathematical comprehension skills compared to learning without MFIs. Sipayung (2019) developed a problem-solving MFI for valid and effective number topics. In this context, it is one of the alternative solutions to make learning more interesting and encourage active student involvement.

One form of innovation that can be applied through learning media is the use of educational game-based worksheets. Educational games are not only able to increase learning motivation but also encourage students to think critically. The use of games and simulations in the context of higher education has been proven to have a positive impact,

increasing student motivation and involvement, and supporting the understanding of critical thinking concepts and collaborative learning (Vlachopoulos & Makri, 2017). In addition, research by Ghergulescu et al. (2023) demonstrates that the application of games in students has been proven to improve focus, long-term memory, and students' adaptability in basic mathematics. This research highlights the importance of interactive learning media in facilitating students' understanding of basic mathematical concepts in a fun and efficient manner.

However, studies on Realistic Mathematics Education (RME) at the university level in Indonesia have generally focused on improving students' conceptual understanding and problem-solving abilities through contextual problems or conventional worksheets. For example, Mardhiyana and' Adna (2023) implemented RME in statistics courses, Cahaya and Karo-Karo (2025) examined the effect of RME on students' conceptual understanding, and Sirait et al. (2025) applied RME to enhance mathematical communication skills. None of these studies, however, developed student worksheets that integrate puzzle-based number-operation games such as Cross Math within an RME framework for pre-service teachers. This shows that research combining Cross Math media with RME-based MFIs at the university level has not been reported, indicating a clear research gap. Therefore, it is necessary to conduct a study that develops and explores this innovative learning media for pre-service mathematics teachers. Consequently, it is required to conduct research that explores this innovative learning medium at the student level, particularly among prospective teachers.

This article presents a preliminary study that aims to explore the potential application of cross-math-based MFIs in conjunction with the RME approach for learning set materials. The focus of the research is on identifying students' difficulties in understanding the concept of number operations through sets and exploring the need for learning media that is more interactive, engaging, and contextual.

METHOD

This study represented the initial stage of media development and employed a mixed-method approach. According to Sugiyono (2019), the mixed-method approach is used by combining quantitative and qualitative data to obtain more comprehensive findings. This approach was selected because the study collected two types of data: quantitative data obtained from questionnaires and qualitative data obtained from

interviews. The participants consisted of 75 pre-service mathematics teachers who had completed the Basic Mathematics course, with an explicit focus on the topics of sets and number operations.

The instruments used in this study were a questionnaire and a semi-structured interview guide. The researcher developed both instruments based on the research objectives and the needs analysis stage of the development model described by Thiagarajan et al. (1974), as well as the general principles of educational instrument construction (Arikunto, 2013; Sugiyono, 2019). The questionnaire included four indicators: (1) students' needs for instructional media; (2) difficulties related to number operations and set theory; (3) preferences for types of learning media; and (4) experiences with game-based learning media. The instruments were reviewed and validated by two material experts and one media expert to ensure the appropriateness of the content.

Data were collected through questionnaires and semi-structured interviews. The questionnaire data were analyzed descriptively and quantitatively using percentages to identify trends in students' learning needs. Meanwhile, the interview data were analyzed descriptively and qualitatively following the stages of data reduction, data display, and conclusion drawing, consistent with Miles and Huberman's (2014) qualitative analysis framework. These qualitative results were used to support and strengthen the findings obtained from the questionnaire. The use of both data sources aligns with the mixed-method design in which qualitative findings support and strengthen quantitative results (Sugiyono, 2019).

RESULTS AND DISCUSSION

This research is a preliminary study aimed at identifying students' needs for cross-math educational game-based learning media. At this stage, the researcher has distributed a questionnaire to 75 student respondents who have taken the Basic Mathematics course, focusing on the set material, and conducted interviews with lecturers in introductory mathematics courses. The dissemination of this questionnaire aims to determine the extent to which students perceive the need for the development of innovative learning media, as well as assess the potential of cross-math as an alternative medium that can be utilized. The results of this study indicate that most prospective mathematics teachers still experience difficulties in understanding the concepts of sets and number operations. This

finding is consistent with the study by Agustiawan and Faradiba (2022), which reports that students face internal obstacles in understanding problems, transforming problem statements, and solving tasks related to set theory. In addition, the research by Murniasih and Karimah (2024) indicates that students continue to encounter conceptual difficulties with real numbers, including challenges in understanding the fundamental properties of these numbers. Therefore, the findings of the present study reinforce previous evidence that mastering basic mathematical concepts remains a significant challenge for prospective mathematics teachers.

Based on the results of distributing questionnaires to 75 student respondents, some initial findings were obtained, as presented in Figure 1.

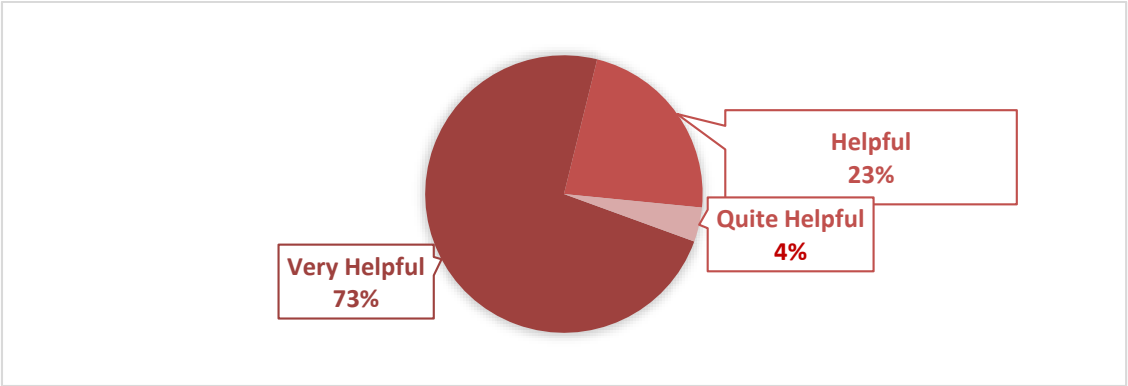

Figure 1. Results of the Questionnaire (How do you think the Media in lectures).

Based on the pie chart presented in Figure 1 above, which shows the responses of 75 respondents regarding the use of media in mathematics lectures, it is known that the majority of students, namely 73.3%, stated that learning media is very helpful in their learning process. 22.7% stated that learning media was quite beneficial, and 4% stated that learning media was helpful. These results demonstrate that learning media play a crucial role and have a positive impact on student understanding in mathematics lectures. These findings underscore the importance of developing engaging, interactive, and contextually relevant learning media to support a more effective learning process. These results demonstrate that learning media play a crucial role and have a positive impact on student understanding in mathematics lectures. This interpretation is supported by previous research, as Laswadi et al. (2022) showed that the use of varied learning media enhances participation and comprehension. Similarly, Putri and Ratu (2020) reported that technology-based media help students of mathematics education better comprehend abstract concepts. The result can be presented in Figure 2.

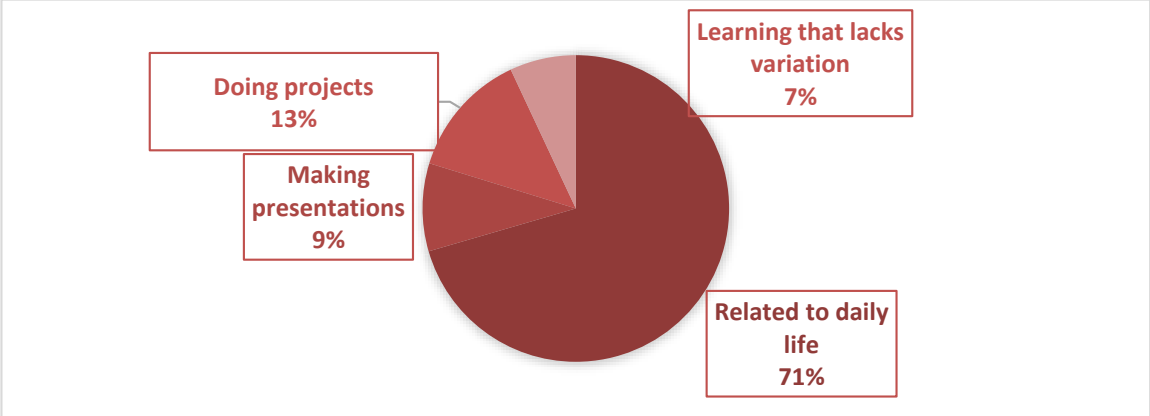

Figure 2. Questionnaire Results (What kind of creative activities do you like in lectures?)

Based on the pie chart presented in Figure 2 above, which illustrates the types of creative activities that students prefer in mathematics lectures, the majority of respondents, as many as 71%, stated that they prefer activities related to daily life. These results indicate that prospective mathematics teacher students are more interested in contextual and applicative mathematics learning that they can directly relate to real-life situations. Previous studies have demonstrated that implementing RME through contextual activities and relevant media is effective in enhancing students' understanding of mathematical concepts. Rahmasantika and Prahmana (2022) emphasized that mathematics learning becomes meaningful when it is connected to everyday life. The RME approach can promote active participation, stimulate interest, and foster students' creativity in education, thereby improving their learning outcomes (Fitriyani, 2024). Therefore, the results of this questionnaire indicate that the application of the RME approach is highly relevant to meeting students' needs in the mathematics learning process, particularly in strengthening their conceptual understanding. The result can be presented in Figure 3.

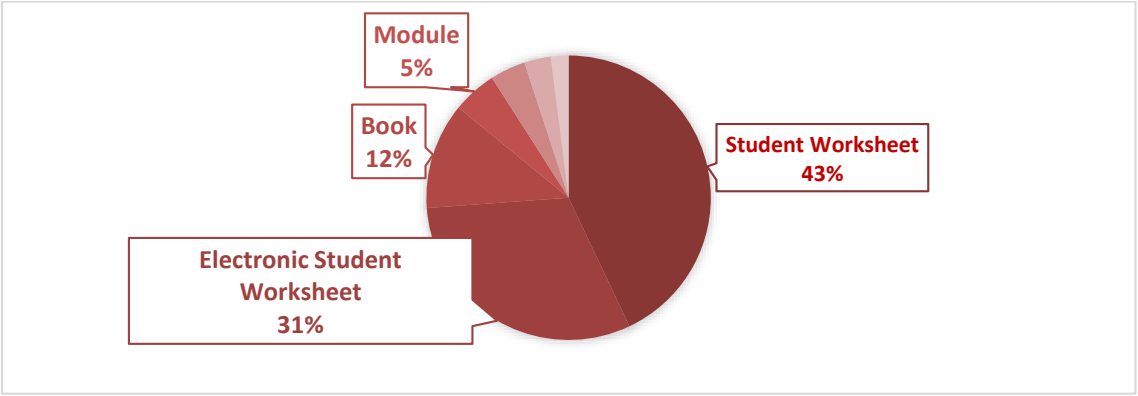

Figure 3. Questionnaire Results (What kind of media do you want in mathematics lectures?)

Based on the pie chart presented in Figure 3 above, which shows students' preferences for the type of media they want in mathematics lectures, most respondents, namely 43%, chose the Student Worksheet as the most desired learning medium. These results indicate that students prefer learning media that are structured and applicable, both in print and digital form, which can help them understand mathematics material more independently and systematically. The result can be presented in Figure 4.

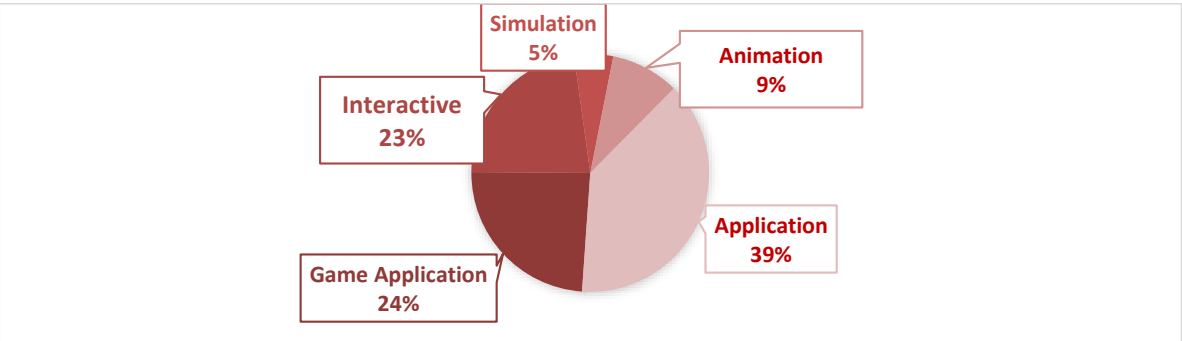

Figure 4. Questionnaire Results (What kind of technology do you prefer for math learning?)

Based on the pie chart presented in Figure 4 above, which shows the type of technology that students prefer for learning mathematics, most respondents, namely 38.7%, chose applications. Specifically, 24% of respondents chose game applications. These results indicate that students have a high interest in integrating technology into mathematics learning, especially when it is interactive and game-based, as it is considered to increase learning motivation and conceptual understanding more engagingly and practically.

Based on initial observations of the questionnaire distributed to 75 respondents regarding their views on material considered essential in mathematics, it was found that 15 respondents (20%) explicitly chose arithmetic operations as the most important material. However, upon further examination, several respondents chose other materials that are conceptually closely related to computational operations, such as multiplication, division, numbers, and basic mathematical concepts. Each of these options was chosen by 1 to 2 respondents. These results indicate that more than a quarter of respondents consider computational operations and related materials to be fundamental components in mathematics learning.

This finding suggests that strengthening prospective teachers' understanding of arithmetic operations is still necessary. In the context of needs analysis, student learning needs are legitimately obtained from the students themselves, as their reported perceptions, experiences, and difficulties are important indicators for identifying areas that need improvement in the learning process (Sugiyono, 2019; Arikunto, 2013). The needs assessment literature also emphasizes that self-reported needs by students complement predetermined curriculum competencies, ensuring that instructional development aligns with actual learning challenges. Therefore, efforts to develop learning media that support the understanding of computational operations in a more contextual and engaging manner, such as MFI based on cross-math educational games, are seen as relevant and strategic in addressing the learning needs of these materials.

Based on interviews with lecturers in introductory mathematics courses, it was found that, in general, the learning process in the classroom proceeded smoothly without any problems. The model used so far is quite varied, namely through lectures, discussions, practices, and assessments. According to the interview results, the model encourages students to be more active in interaction and discussion; however, in practice, students still face difficulties in understanding certain materials. The lecturer said that the materials considered essential and difficult for students are algebra, sets, and geometry. This indicates that students' understanding of basic concepts still needs to be strengthened, particularly in the operation skills of counting numbers, which form the foundation for advanced materials. To help students, lecturers usually provide additional guidance by adjusting the approach to each student, but there has been little use of innovative learning models such as RME. This information reinforces the urgency of MFI development based on cross-math educational games with the RME approach. Educational games can increase motivation while creating a more enjoyable learning environment, and the RME approach allows students to understand the operation of counting through real and meaningful contexts.

This article demonstrates that the use of cross-math-based student worksheets in conjunction with the RME approach has the potential to be an effective alternative for improving students' understanding of number operations through the topic of sets. This effectiveness is evident in the questionnaire results, which indicate that most student teachers consider arithmetic operations to be significant material for understanding. This

is because at this initial stage, the questionnaire is used to identify the student teachers' perceived learning needs rather than to measure mastery through test items. The instrument is designed to capture the views, difficulties, and priorities of student teachers as part of the needs analysis process. These results are in line with interviews with lecturers who emphasized that one of the essential materials in introductory mathematics courses is number material. The interview results also confirmed that one of the materials that student teachers face is sets. The lecturer also noted that one of the most effective solutions to help students is to provide repeated practice questions. This finding is strengthened by the fact that student teachers require more contextual, interactive, and innovative learning media to help overcome difficulties with basic mathematics material.

The tendency of students to prefer activities associated with daily life, as illustrated in the questionnaire results (70.7%), shows that students understand the material better when it is linked to authentic experiences. According to Rahmasantika and Prahmana (2022), learning mathematics becomes meaningful when it is related to daily life. Cross Math, as an educational game, has succeeded in addressing this need. Another similar study by Jagust et al. (2017) in Croatia also found that the use of digital-based math lessons with gamification elements, such as games on tablets, significantly increased student engagement and motivation by incorporating logic and strategy challenges in solving computational operations.

Additionally, the interview results revealed that lecturers had never employed the RME approach in their lectures. This suggests that there is an opportunity for the development of cross-math educational game-based media using the RME approach, as this approach has proven effective in research. Cahaya & karo-karo (2025) confirm that the application of RME can improve students' understanding of concepts. Recent research also supports the effectiveness of RME in enhancing knowledge of mathematical concepts. Mardhiyana & Adna (2023) implemented RME based on the local cultural context and achieved a significant increase in students' concept comprehension scores, from 70 to 80-85.33. In addition, Sirait et al. (2025) found that RME can strengthen conceptual understanding compared to conventional methods.

Previous research has also supported these findings. Jagust et al. (2017) in Croatia found that digital-based mathematics learning with gamification elements can increase student engagement through logic and strategy challenges. Similarly, Ghergulescu et al.

(2023) show that the use of game-based learning can improve students' focus, long-term memory, and adaptability to basic math materials.

This article continues to focus on exploring student needs through questionnaires and interviews. However, the integration of the quantitative and qualitative results of these findings provides a solid foundation for the next stage of development, where cross-math-based MFIs with the RME approach will be linked through set materials. In this way, number operations are not only understood separately, but also placed in a broader context, i.e., sets. It is hoped that this will strengthen students' overall understanding. As expressed by Andriani (2019), mastery of number operations is crucial for understanding the set material as a whole.

All of these results and findings indicate that the use of cross-math-based MFIs is an effective learning strategy to overcome problems in learning number operations, especially for prospective teacher students. Therefore, this study has significant importance because it demonstrates that cross-math-based MFIs with an RME approach can serve as a more engaging and effective alternative to traditional mathematics learning. This study implies that cross-math-based MFIs can serve as an alternative to traditional mathematics learning, offering a more engaging and practical approach, while also enhancing students' understanding of number operations.

CONCLUSION

The use of Cross Math–based Student Worksheets in understanding number operations through set theory for prospective mathematics teachers is expected to help them overcome conceptual difficulties, particularly in linking number operations to set representations. The findings of this study indicate that students continue to face challenges in comprehending the concepts of number operations and have a strong need for learning media that are interactive, contextual, and engaging. This study contributes to the understanding of students' learning needs by mapping their learning requirements and identifying gaps in the use of learning media related to set theory and number operations.

From a scientific standpoint, the results demonstrate that developing Cross Math–based LKM with an RME approach has the potential to serve as a more meaningful and effective learning medium, and it may also be applied to other fundamental mathematical

topics. However, this study is limited to the needs-analysis stage and does not include the development or testing of the instructional media. Therefore, future research should focus on the design, validation, and effectiveness testing of the media to provide stronger empirical evidence regarding its impact on improving the conceptual understanding of prospective mathematics teachers.

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