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Number talks: Comparative insight into undergraduate and graduate student literacy

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Abstract

Variations in competence and confidence among higher education students in mathematical literacy, numeracy, and logical thinking are crucial for developing critical reasoning, problem-solving skills, and the application of quantitative knowledge in both academic and real-world contexts. However, limited research has explored how students from different academic disciplines vary in their competence, confidence, and challenges related to these fundamental areas. This gap in the literature highlights the need for a comprehensive examination of such variations across diverse higher education fields. This study aims to compare the levels of mathematical literacy, numeracy, and logical thinking among university students, focusing on their knowledge, confidence, and the challenges they face. A comprehensive survey was employed, covering several dimensions of mathematical literacy, such as real-world applications of mathematics, numeracy comprehension, numerical self-confidence, and the role of emotions in logical thinking. Drawing on responses from Indonesian university students, the study reveals that students generally perceive their abilities as moderate to good, though significant differences are evident across academic disciplines and levels of study. A notable correlation was found between the focus of students' academic programs and their mathematics literacy, with certain disciplines demonstrating higher competency levels. The findings highlight the importance of integrating practical applications and emotional intelligence into mathematics education to foster greater confidence, knowledge, and engagement. This research contributes valuable insights into mathematical literacy and proposes new strategies to improve teaching practices and curricula. The comparative analysis offers a broader perspective, essential for shaping future assessments in mathematics, logical reasoning, and numeracy literacy.

Keywords: Comparative Analysis, Higher Education, Mathematical Literacy, Number Talks

Introduction

The field of mathematics plays a pivotal role in everyday decision-making and problem-solving within the context of the information age, extending well beyond the traditional boundaries of academic disciplines. As such, it is evident that mathematical literacy is not merely a school goal, but an essential competence for navigating the complexities of the twenty-first century. This literacy encompasses the ability to efficiently understand, interpret, analyze, and communicate numerical information, alongside executing mathematical computations. In a world where big data and quantitative analysis are increasingly pervasive, society's functioning relies heavily on the ability to engage with mathematical concepts. An expanding body of scholarly literature underscores the significance of mathematical literacy in contemporary society. Rizki and Priatna (2019) emphasize the escalating complexity of daily challenges, highlighting the need for individuals to cultivate mathematical literacy. This skill set includes mathematical thinking, reasoning, communication, and the application of mathematics to real-world situations. The authors argue that mathematical literacy is essential for becoming an active, engaged member of society, capable of addressing complex problems with thoughtfulness and insight. Moreover, Novita and Herman (2021) examine the role of digital technology in fostering mathematical literacy, particularly within the framework of the 21st-century digital era. Their research investigates the integration of Information and Communication Technologies (ICT) in education, focusing on how digital tools can enhance mathematical knowledge and competencies, a vital aspect of modern literacy. Additionally, Mulyasari et al. (2022) explore the use of Problem-Based Learning (PBL)-based Electronic Student Worksheets (E-LKPD) to advance mathematical literacy among elementary students. Their study highlights the importance of adopting innovative teaching strategies to enhance mathematical proficiency, with a focus on communication, technology, and value-driven approaches to literacy development.

Higher education institutions play a critical role in preparing individuals for a data-driven world, tasked with equipping students with the mathematical skills necessary for success in both professional and personal spheres. This responsibility is increasingly important as workforce demands evolve, requiring higher levels of numerical proficiency and logical reasoning. However, the success of these institutions in fostering mathematical literacy varies significantly, influenced by factors such as curriculum design, teaching methodologies, and the diverse backgrounds of students. Understanding these factors is vital for evaluating the current state of mathematical literacy within higher education. Several studies highlight the role of higher education institutions in equipping students for a data-centric world, particularly with respect to mathematical literacy. Frith (2011) discusses the importance of mathematical or quantitative literacy across university curricula, emphasizing the need to deepen educators' understanding of the mathematical literacy expectations for learners in higher education. This approach is integral to developing the skills required for success in the contemporary workforce. Liu (2011) further underscores the critical role of mathematical literacy in both the intellectual and practical aspects of individuals' lives, highlighting its foundational place in college mathematics education for cultivating literacy. The paper offers strategies for improving

mathematical literacy among college students, stressing the broad-reaching impact of such literacy on overall educational outcomes. Additionally, Steen, Turner, and Burkhardt (2007) note the growing global attention to mathematical literacy, driven by employer concerns regarding the insufficient mathematical proficiency of graduates. They advocate for mathematical literacy as crucial for addressing a range of modern life challenges, reinforcing the empowerment gained from being mathematically literate.

The growing recognition of the importance of mathematical literacy across various fields—including economics, engineering, social sciences, and healthcare—highlights its crucial role in fostering problem-solving abilities, critical thinking, and workplace success. For example, the study by Heyd-Metzuyanim, Sharon, and Baram-Tsabari (2021) examines the concept of mathematical media literacy during the COVID-19 pandemic, emphasizing its importance in interpreting pandemic-related data, which is vital for public health and safety. Similarly, Güven and Cabakcor (2013) explore high school students' attitudes toward learning mathematics and underline the significance of mathematical literacy in enhancing everyday problem-solving skills, particularly through the establishment of cause-and-effect relationships. This research illustrates how psychological factors, such as interest in and anxiety about mathematics, can significantly influence students' learning experiences and outcomes. Additionally, Hill, Rowan, and Ball (2005) provide evidence on the impact of teachers' mathematical knowledge on student achievement, demonstrating that teachers' mathematical knowledge plays a substantial role in improving student performance in mathematics. This finding reinforces the need for enhancing teachers' mathematical knowledge as a strategy to boost student outcomes.

The importance of understanding the development of mathematical competencies within higher education is further emphasized by various studies advocating for a comprehensive approach to improving educational strategies. Stephens (1982) provides evidence that mathematical competency is a significant predictor of success in statistics courses for both undergraduate and graduate students, highlighting the foundational role of mathematical skills in higher education success. Moreover, Faulkner, Hannigan, and Fitzmaurice (2014) investigate predictors of students' mathematical performance in higher education, proposing that early identification of mathematical competencies can facilitate targeted interventions to support student success. Their findings stress the importance of discriminant analysis in predicting mathematical performance, with the potential to inform educational policy and practice. Ivanov (2020) further contributes to this discourse by assessing mathematical competencies in higher education through structured assessments. Utilizing classification and regression tree methods, Ivanov's study demonstrates the efficacy of these statistical models in evaluating student achievements and competencies, offering a framework for grading and competency assessment.

This research is of significant importance for several reasons. First, it provides valuable insights into the current state of mathematical literacy among higher education students, highlighting both their strengths and the gaps in their learning. This is supported by the findings of Aisyah and Juandi (2022), which demonstrate that varying learning styles among university students are associated with different levels of mathematical literacy. Additionally, a

comparison between undergraduate and graduate programs reveals distinct patterns: at the undergraduate level, individual and institutional factors are found to have a considerable impact on success in developmental mathematics courses (Fong et al., 2015), whereas at the graduate level, the development of research skills follows a more intricate trajectory, often characterized by transformative advancements in understanding and capability (Timmerman et al., 2013).

A second critical aspect of this research is its comparative approach, which offers a nuanced perspective on the progression of mathematical skills across different levels of higher education. By examining both undergraduate and graduate programs, the study contributes to a deeper understanding of how mathematical competencies evolve within academic contexts. Finally, the research plays a crucial role in the broader discourse on educational strategies, curriculum development, and pedagogical practices aimed at improving mathematical literacy. The primary objective of this study is to assess and compare the levels of mathematical literacy, numeracy, and logical-mathematical thinking among higher education students. Specifically, the research seeks to identify the competencies and challenges that undergraduate and graduate students face in applying mathematical concepts to real-world scenarios, their understanding of numeracy and literacy, their confidence in handling numerical information, and the influence of emotional factors on logical reasoning. Through this comprehensive analysis, the study aims to uncover effective educational strategies that can enhance mathematical literacy among future professionals.

Methods

The methodology employed in this study is a quantitative survey research design. A structured survey instrument was utilized to collect data, specifically designed to assess various aspects of mathematical literacy. The survey captures a broad spectrum of responses, including self-assessments of competencies, confidence in handling numerical information, and the influence of emotional factors on logical reasoning. The instruments were rigorously evaluated by subject matter experts to ensure their validity and effectiveness in accurately measuring the intended constructs. Kimberlin and Winterstein (2008) provide a comprehensive discussion on the validity and reliability of research measurement tools, highlighting the importance of minimizing measurement error.

The instruments refer to the questionnaires used in the research to collect data. Prior to field deployment, these instruments underwent thorough scrutiny by experts with extensive knowledge in the relevant domain. This expert review process evaluates the tools against established quality criteria, such as validity (ensuring the instrument measures what it is intended to measure), reliability (assessing the consistency of the instrument's results over time), and usability (verifying the clarity and practicality of the instrument for intended administration). During the review, experts also evaluate the content of the instruments to ensure that they comprehensively cover all relevant aspects of the concept being measured. Additionally, the process includes pilot testing, wherein the instrument is administered to a small, representative sample to identify potential issues related to the clarity of questions or the structure of the instrument. Based on feedback from this pilot phase, adjustments are made to

refine the instrument as necessary. Once experts have confirmed that the instrument is theoretically sound, practically feasible for use, and capable of producing reliable and valid data, it is considered suitable for application in the study. This endorsement from experts enhances the credibility and integrity of the data collection process, ensuring confidence in the validity of the gathered information.

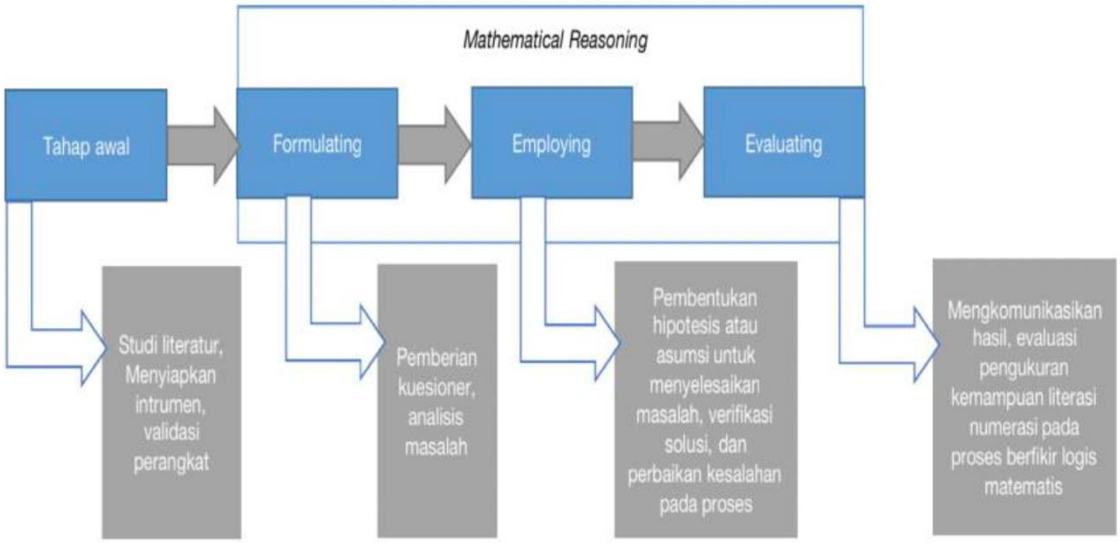

Figure 1. Research Flow

The non-test research instrument employed in this study was a questionnaire designed to measure several key aspects of mathematical literacy. These aspects included: the ability to connect mathematical concepts to real-world situations; understanding of literacy and numeracy; analysis of numerical information, particularly in relation to difficulties encountered when interpreting numerical data such as tables and graphs; self-confidence in mathematics; motivation and enthusiasm towards mathematics; decision-making based on numerical data; error identification and problem-solving skills; and conceptual ability in logic and mathematical proof. The questionnaire comprised 20 items, with response options on a 5-point Likert scale ranging from "" to "strongly agree." The instrument underwent validation by two experts, who concluded that the questionnaire was feasible for use, contingent upon certain revisions.

Figure 2 presents two examples from the questionnaire, designed to examine how students perceive the influence of their logical reasoning on their behaviors and how personal preferences shape their logical thinking. These items sought to evaluate the interaction between rational decision-making and subjective factors, thereby providing insights into the students' cognitive processes and behavioral tendencies.

The target population for this survey included undergraduate and graduate students from Universitas Ahmad Dahlan and Universitas Siber Muhamadiyah, representing a diverse range of academic disciplines and study levels. The sampling strategy appears to have been inclusive, encompassing both undergraduate and graduate students from various fields of study, in order

to facilitate a comprehensive analysis of mathematical literacy within the context of higher education. In total, the study involved 121 participants.

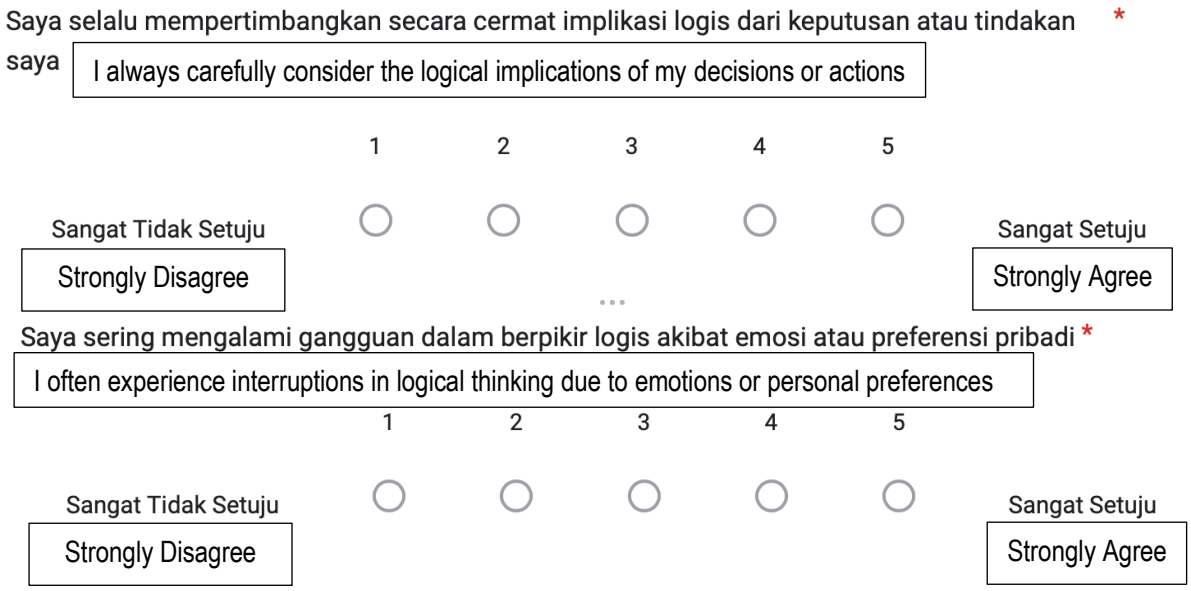

Figure 3. Questionnaire Sample Test

Quantitative data analysis techniques were employed to assess the survey responses (Freund, 1979; Creswell, 2007). These techniques likely involved statistical methods to evaluate the self-assessed levels of mathematical literacy among the student populations. The analysis aimed to identify differences in mathematical literacy between undergraduate and graduate students, as well as across various academic disciplines, suggesting a comparative approach. Moreover, the investigation into proficiency levels among students from specific academic programs implies the use of correlation analysis to examine the relationship between curriculum focus and mathematical literacy outcomes. The rating scale, based on Zhao et al. (2017), was utilized for this study, with response options ranging from: (1) Strongly Disagree, (2) Disagree, (3) Neutral, (4) Agree, and (5) Strongly Agree.

The primary objective of this study was to assess and compare the state of mathematical literacy, including numeracy and logical reasoning, among higher education students in Indonesia. By identifying patterns and correlations within the data, the research sought to highlight areas of strength and potential gaps in current educational practices related to mathematical literacy. This methodology provides a robust foundation for understanding the nuances of mathematical literacy across diverse educational contexts, offering valuable insights that can inform curriculum development and teaching strategies in higher education.

Results and Discussion

The assessment of mathematical literacy, numeracy, and logical-mathematical thinking is based on eight indicators: the ability to relate mathematical concepts to real-life situations (Afriansyah et al., 2020; Astuti, 2017); comprehension of literacy and numeracy, specifically the challenges

associated with interpreting numerical information in tables and graphs (Rahmawati et al., 2023; Anjani et al., 2022); self-assurance in mathematics (Anjani et al., 2022; Astuti, 2017); motivation and enthusiasm toward mathematics (Afriansyah et al., 2020; Astuti, 2017); decision-making based on numerical information (Anjani et al., 2022; Astuti, 2017; Rahmawati et al., 2023); the identification of errors and troubleshooting (Afriansyah et al., 2020; Rahmawati et al., 2023); and the ability to reason logically and provide proofs in mathematics (Astuti, 2017; Afriansyah et al., 2020; Anjani et al., 2022).

The survey contains questions assessing respondents' ability to relate mathematical concepts to practical situations, their understanding of literacy and numeracy, and the difficulties encountered in interpreting numerical data from tables or graphs. Additional questions address logical decision-making, problem-solving, and the emotional influences on logical reasoning. These responses are quantified using a numerical scale (Zhao et al., 2017), which reflects varying levels of agreement or self-assessment. The statistical summary for each survey question, categorized by the number of respondents assigning each score (ranging from 1 to 5), is as follows:

Initially, questions on confidence, understanding, and engagement reveal that a majority of respondents exhibit confidence in relating mathematical concepts to real-world scenarios and possess a solid understanding of literacy and numeracy. Most respondents provided scores ranging from 3 to 5 (neutral to strongly agree). This trend is also evident in their confidence in handling numerical data, making logical decisions, and taking a proactive approach to problem-solving that requires complex reasoning, with higher frequencies of marks 4 and 5 (agree and strongly agree).

In contrast, when addressing challenges in understanding numerical information and problem-solving, a substantial number of respondents reported difficulties in interpreting numerical data from tables or graphs, reflected by a higher frequency of marks 2 and 3 (disagree and neutral). Respondents also expressed concerns about feeling uneasy or lacking confidence when presenting mathematical ideas or encountering mathematical challenges, with a notable portion selecting marks 1 and 2 (strongly disagree and disagree).

Regarding motivation and decision-making, responses to questions on motivation, enthusiasm, and the tendency to make decisions without careful consideration were diverse, indicating varying levels of engagement and impulsivity among respondents. Additionally, questions regarding attention to numerical details and the emotional impact on logical reasoning yielded mixed responses, suggesting individual differences in experiences and perceptions.

Finally, in terms of deep understanding and confidence in skills, a segment of respondents demonstrated a strong grasp of mathematical concepts and confidence in solving challenging problems, though some indicated difficulties. This analysis reveals a broad range of experiences and self-assessments among respondents concerning their mathematical literacy, numeracy, and logical thinking abilities, highlighting both strengths and areas for improvement.

The overall mean score across all survey questions is approximately 3.07, suggesting that, on average, respondents exhibit a moderate level of agreement or self-assessment across the various dimensions of mathematical literacy, numeracy, and logical-mathematical thinking

assessed in the survey. The mean scores for individual questions, reflecting the average level of agreement or self-assessment, are as follows:

Table 1. The Average Level of Self-Assessment Across Respondents

No	Respondent's Self-Assessment	Mean
1	Ability to connect mathematical concepts with real-life situations	3.76
2	Understanding of literacy and numeracy	3.68
3	Difficulty understanding numerical information in tables or graphs	2.49
4	Feeling awkward or lacking confidence in simple calculations	2.23
5	Motivation and enthusiasm in reading mathematical information	3.64
6	Attention to numerical details in decision-making	3.58
7	Difficulty identifying mistakes in one's own mathematical problem-solving	2.71
8	Lack of confidence in facing numeracy tests or tasks	2.75
9	Lack confidence in math tests/tasks	2.66
10	Quick and accurate in simple calculations	3.55
11	Making decisions without considering logical or mathematical evidence	2.35
12	Difficulty in organizing logical steps for complex mathematical problems	2.91
13	Struggle to understand the reasons or basis of logical statements	2.63
14	Deep and clear understanding of logical mathematical thinking concepts	3.22
15	Confidence and ability in situations requiring logical analysis	3.44
16	Tendency to avoid or delay solving complex mathematical problems	2.74
17	Enthusiasm and readiness for tasks requiring logical thinking in math context	3.43

These scores represent the average responses, with higher scores typically indicating greater confidence, comprehension, or positive attitudes toward mathematical literacy and logical reasoning, while lower scores suggest difficulties or negative perceptions in these areas.

The mean scores for the survey questions highlight variability in the perceptions and self-assessments of mathematical literacy, numeracy, and logical thinking among students from Universitas Ahmad Dahlan (UAD), regardless of their status as graduate or undergraduate students. Similarly, responses from students at Siber Muhammadiyah University (SiberMu) exhibit variations in their perspectives on the survey questions. The findings of this survey offer valuable insights into how students from UAD and SiberMu engage with and approach mathematical reasoning and logical problem-solving. By utilizing a carefully standardized dataset to ensure equitable comparisons, the analysis provides a comprehensive understanding of student competencies and challenges in these areas.

Regarding questions on connecting mathematical concepts to real-life situations, understanding literacy and numeracy, and other facets of mathematical literacy and logical reasoning, students from both universities demonstrated a solid understanding and confidence,

with mean scores typically exceeding 3.0. Specifically, students from SiberMu generally scored slightly higher on most questions compared to their counterparts from UAD. For example, in understanding literacy and numeracy, SiberMu achieved an average score of 3.88, while UAD scored 3.58. This suggests that SiberMu students exhibited a marginally higher level of proficiency across the majority of surveyed areas, which may be attributed to effective teaching strategies or a curriculum design emphasizing practical applications. Nevertheless, UAD students also displayed notable proficiency, with mean scores consistently above the 3.0 threshold, indicating a strong understanding of mathematical concepts and logical reasoning.

These results underscore UAD's commitment to developing critical thinking and analytical skills among its students. The influence of teaching methodologies and curriculum design on enhancing students' mathematical literacy and numeracy is well-documented in educational literature. For instance, Goos, Geiger, and Dole (2014) emphasize how the integration of numeracy strategies across the curriculum, especially through real-life contexts and critical perspectives on mathematics, plays a crucial role in fostering numeracy skills. Hill, Rowan, and Ball (2005) highlight the significant relationship between teachers' mathematical knowledge for teaching and student achievement in mathematics, reinforcing the importance of strong subject-matter knowledge in educational practices. Thornton and Hogan (2004) examine how teachers' confidence and willingness to incorporate mathematics across the curriculum can shape students' numeracy outcomes. Furthermore, Beeli-Zimmermann (1970) investigates how teachers' prior experiences influence their beliefs about teaching numeracy, thereby shaping their instructional approaches. Evans (2017) explores how literacy, including numeracy, facilitates access to the broader curriculum for students with diverse learning needs, noting that numeracy encompasses more than just mathematical content—it also serves as the foundational language of education. These studies collectively suggest that a multifaceted approach to curriculum design and teaching practices is essential for enhancing students' understanding of mathematical concepts, boosting their confidence in literacy and numeracy, and facilitating the application of mathematics in real-world contexts. Thus, these findings highlight the significance of innovative teaching methodologies and curriculum designs centered on practical application in advancing students' proficiency in mathematical literacy and numeracy.

The responses to questions regarding difficulties in understanding numerical information in tables or graphs, as well as the influence of emotions or personal preferences on logical thinking, revealed differences between the two universities, with students from SiberMu reporting slightly higher difficulties on average. However, in areas such as motivation and enthusiasm toward mathematical texts, confidence in problem-solving, and careful consideration of the logical implications of decisions, both universities showed positive responses, with mean scores around or exceeding 3.5. This comparison suggests that, on the whole, students from both institutions exhibit a moderate to strong level of mathematical literacy, numeracy, and logical reasoning, with minor variations across specific areas. Notably, students from SiberMu displayed marginally higher averages in several surveyed aspects compared to their peers at UAD.

Despite the observed strengths, challenges remain, particularly in fostering greater confidence and alleviating difficulties in comprehending numerical information presented in tables or graphs. Both universities exhibit potential areas for curriculum development, particularly in enhancing practical applications and addressing emotional intelligence in problem-solving to mitigate the impact of personal preferences or emotions on logical reasoning. Several studies highlight the challenges of understanding numerical information and the role of emotional intelligence in mathematical problem-solving. For example, Ludewig et al. (2019) demonstrated that basic numerical skills, such as number line estimation and subtraction, along with conceptual knowledge, significantly predict graph reading performance, beyond general cognitive abilities. This finding underscores the relevance of foundational numerical skills for real-life problem-solving in secondary education. Additionally, Bottge et al. (2001) found that students in remedial math classes could match the problem-solving performance of pre-algebra students when engaged in rich problem-solving environments. This supports the potential for curriculum enhancements that emphasize practical applications, which could improve students' comprehension and performance in mathematical contexts.

In addition, Mercer and Miller (1992) describe instructional components and curricula that assist students with learning difficulties in mathematics in acquiring, understanding, and applying basic mathematical facts. Their work emphasizes the importance of pedagogical strategies in enhancing mathematical competencies. Hidayah et al. (2017) found that teacher stimulation plays a critical role in helping students achieve competencies in mathematical reasoning and problem-solving, highlighting the significance of teacher-led interventions in supporting students' problem-solving abilities. Guberman and Leikin (2013) suggest that the use of Multiple-Solution Tasks (MSTs) in teacher education can alter teachers' perspectives on the interest and difficulty levels of mathematical tasks, potentially influencing curriculum development to foster creativity and interest in problem-solving among students. Amri et al. (2020) emphasize the positive impact of self-confidence, self-efficacy, and emotional intelligence on students' abilities to solve mathematical problems, suggesting that these psychological factors could be targeted for curriculum enhancement. Furthermore, research by Özcan and Gümüş (2019) underscores the importance of metacognitive experiences in directly improving students' mathematical problem-solving performance, with self-efficacy, motivation, and anxiety indirectly influencing performance through their effect on self-efficacy. Maryani et al. (2019) highlight the influence of emotional intelligence on students' mathematical problem-solving abilities, indicating the need to incorporate emotional intelligence into problem-solving strategies. Collectively, these studies point to the need for a multidimensional approach to curriculum development that addresses not only cognitive skills but also emotional intelligence and affective factors to support students in overcoming challenges in mathematical problem-solving. As we move forward in a world increasingly shaped by technology and data, nurturing a mathematical mindset becomes even more critical.

The insights derived from this comparative study not only illuminate the current state of mathematical literacy among university students but also lay the groundwork for innovative educational strategies. Emphasizing real-world applications, problem-solving skills, and

emotional resilience in mathematical reasoning will be essential for empowering the next generation of thinkers and leaders. Given the critical importance of mathematical literacy for both UAD, SiberMu, and the broader educational community, several key considerations emerge as follows:

1. **Curriculum Development**: Both institutions should consider continuous review and enhancement of their curriculum to ensure that it remains relevant and engaging. This could involve integrating real-world problems that require mathematical solutions, thus fostering a deeper understanding of mathematical concepts and their practical applications.
2. **Professional Development**: Invest in regular professional development for educators to keep them abreast of innovative teaching strategies and methodologies in the field of mathematical literacy and logical thinking. Encouraging teachers to share best practices and learn from each other can lead to improved teaching outcomes.
3. **Technology Integration**: Explore the use of digital tools and resources to aid in teaching mathematical concepts. This could range from interactive simulations to software that helps visualize complex mathematical problems, catering to various learning styles and enhancing student engagement.
4. **Cross-disciplinary Collaboration**: Encourage collaborations between the mathematics department and other faculties to demonstrate the interdisciplinary nature of mathematics. This can help students appreciate the role of mathematics in fields such as the sciences, engineering, economics, and social sciences.
5. **Student Support Services**: Establish support systems for students who may struggle with mathematical literacy. This could include tutoring programs, peer mentoring, and workshops that focus on problem-solving strategies and dealing with math anxiety.
6. **Research and Feedback**: Conduct regular research to assess the effectiveness of teaching methods and curriculum changes. Use feedback from these studies to make data-driven decisions about further improvements in teaching mathematical literacy.
7. **Community Engagement**: Involve the community in understanding the importance of mathematical literacy. Hosting events, open lectures, and workshops can help in building a culture that values and supports mathematical education.
8. **Emotional Intelligence Training**: Since emotional factors can impact learning, include training that helps students manage emotions and stress. This can increase their resilience and improve their performance in mathematical problem-solving.
9. **Foster Curiosity and Inquiry**: Encourage students to develop a questioning mindset that propels them to explore mathematical concepts deeply. Activities that stimulate curiosity can lead to a greater appreciation and understanding of mathematics.
10. **Recognize and Celebrate Success**: Acknowledge and celebrate both student and teacher achievements in the area of mathematical literacy. This can boost morale and motivate all involved to strive for continued excellence.

By implementing these strategies, UAD, SiberMu, and similar institutions can play a pivotal role in advancing mathematical literacy and logical thinking among students. The results

from this initial phase of our broader research initiative underscore the importance of developing a conceptual framework that connects numeracy literacy with the process of mathematical logical thinking. In the subsequent research phase, the development of a numeracy literacy assessment will be identified as a key objective, aiming to enhance students' mathematical logical thinking abilities. Furthermore, this framework will serve as a valuable reference for universities seeking to design curricula that integrate technology into mathematics education. By aligning curriculum development with numeracy literacy principles, institutions can foster more effective and innovative approaches to teaching and learning mathematics, ultimately equipping students with the essential skills required for academic and professional success.

Conclusion

This study has highlighted the significant relationship between the development of mathematical literacy and logical thinking skills. It underscores the pivotal role of institutions like UAD and SiberMu in fostering these competencies through their commitment to enhancing the quality of education. The findings suggest that integrating real-life applications of mathematics into curricula, offering ongoing professional development for educators, and utilizing digital tools to create diverse and engaging learning environments are essential strategies for improving mathematical outcomes. Additionally, promoting interdisciplinary collaborations and providing robust student support services are critical in helping students build confidence and competence in mathematics. Encouraging curiosity, celebrating achievements, and utilizing feedback for continuous improvement in teaching practices will contribute to a culture of excellence and innovation in mathematical education.

However, this study has several limitations that must be acknowledged. The sample was drawn from only two universities within a single province in Indonesia, which restricts the generalizability of the findings. Furthermore, the research relied solely on questionnaire data, without incorporating random sampling or interviews to gain a deeper understanding of the underlying reasons for the observed differences. While these limitations restrict the scope of the conclusions, the findings offer valuable insights into the factors influencing mathematical literacy and logical thinking, and they provide a foundation for further research in this area. Future studies should aim to include a more diverse sample, encompassing multiple provinces and a broader range of institutions, to validate and expand upon these results.

Future research should also focus on several key areas to advance our understanding of mathematical education. Longitudinal studies are needed to assess the long-term effects of educational interventions on students' mathematical skills. Investigating the effectiveness of different teaching methods and the integration of digital tools, including AI and gamification, is essential for identifying best practices in the field. Additionally, exploring the impact of cultural and social factors on students' perceptions and achievements in mathematics, as well as the relationship between emotional intelligence and math anxiety, would provide valuable insights into how to support diverse student populations. Further studies should also examine the influence of teacher training on pedagogical content knowledge, the development of

interdisciplinary curricula that connect mathematics with real-world problem-solving, and the creation of innovative assessment methods that accurately reflect students' mathematical competencies. These research directions are crucial for informing policies and practices aimed at improving mathematics education outcomes.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been covered completely by the authors.

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