

## STRATEGIES FOR STRENGTHENING THE NUMERICAL LITERACY OF PROSPECTIVE MATHEMATICS TEACHERS: AN EVALUATION STUDY

Moh. Mahfud Effendi<sup>1</sup>, Hendaro Cahyono<sup>2</sup>, \*Siti Khoiruli Ummah<sup>3</sup>,  
Dian Devita Yohanie<sup>4</sup>

<sup>1-3</sup> Universitas Muhammadiyah Malang, Indonesia

<sup>4</sup> Universitas Nusantara PGRI Kediri, Indonesia

[khoiruliummah@umm.ac.id](mailto:khoiruliummah@umm.ac.id)

**ABSTRACT** The urgency of this research is based on the phenomenon of the Minimum Competency Assessment (AKM), which has so far only involved students and teachers in schools. To date, there has been no national assessment specifically designed for prospective mathematics teachers, even though numeracy literacy is an essential competency for teacher candidates. Therefore, this study aims to describe the strategies for strengthening numeracy literacy among prospective mathematics teachers and to evaluate their implementation outcomes. This study employed a descriptive method with a mixed-methods approach. Quantitative analysis was conducted using literacy and numeracy test results to measure differences between first-year and third-year students, while qualitative analysis was based on interviews with lecturers to explore the strategies previously implemented to strengthen numeracy literacy. The results revealed that lecturers implemented several strategies, including independent project assignments, reading tasks followed by presentations, and exercises to complete incomplete information on lecture topics. Statistical tests indicated a significant difference between the literacy and numeracy skills of first-year and third-year students. The interview findings suggested that this difference was influenced by the higher mastery of basic mathematical concepts and a better understanding of mathematical reasoning among third-year students. This study contributes to the field of mathematics education by offering alternative strategies to enhance numeracy literacy among prospective mathematics teachers as a foundation for developing literacy- and numeracy-based university courses.

**Keywords:** numeracy literacy, prospective mathematics teachers, strengthening strategies, evaluation

**ABSTRAK** Urgensi penelitian ini didasarkan pada fenomena pelaksanaan Asesmen Kompetensi Minimum (AKM) yang selama ini hanya melibatkan siswa dan guru di sekolah. Hingga kini belum terdapat asesmen nasional yang secara khusus ditujukan kepada calon guru matematika, padahal penguasaan literasi numerasi merupakan kompetensi yang

sangat penting bagi mahasiswa calon guru. Oleh karena itu, penelitian ini bertujuan untuk mendeskripsikan strategi penguatan literasi numerasi bagi mahasiswa calon guru matematika serta mengevaluasi hasil pelaksanaannya. Penelitian ini menggunakan metode deskriptif dengan pendekatan *mixed methods*. Analisis kuantitatif dilakukan berdasarkan hasil tes literasi dan numerasi untuk mengukur perbedaan kemampuan antara mahasiswa Tahun I dan Tahun III, sedangkan analisis kualitatif dilakukan melalui wawancara dengan dosen guna menggali strategi penguatan literasi numerasi yang telah diterapkan. Hasil penelitian menunjukkan bahwa dosen menerapkan beberapa strategi penguatan literasi numerasi, antara lain pemberian proyek mandiri, penugasan membaca literatur disertai presentasi, serta tugas melengkapi informasi pada topik perkuliahan yang belum lengkap. Hasil uji statistik menunjukkan adanya perbedaan signifikan antara kemampuan literasi dan numerasi mahasiswa Tahun I dan Tahun III. Berdasarkan hasil wawancara, perbedaan tersebut dipengaruhi oleh tingkat penguasaan konsep dasar matematika dan pemahaman alur berpikir matematis yang lebih baik pada mahasiswa Tahun III. Penelitian ini berkontribusi pada bidang pendidikan matematika dengan menawarkan alternatif strategi untuk memperkuat kemampuan literasi numerasi calon guru matematika sebagai dasar pengembangan kurikulum dan model perkuliahan berbasis literasi numerasi di perguruan tinggi.

**Kata-kata kunci:** literasi numerasi, calon guru matematika, strategi penguatan, evaluasi

## INTRODUCTION

Numeracy plays a crucial role for prospective mathematics teachers because it forms the foundation for understanding mathematical concepts and applying them in real-life situations. However, many prospective teachers still struggle with practical applications, particularly in conceptual understanding, reasoning, and problem-solving (Baking et al., 2023; Wilkins, 2016). This issue can be observed through the habit of memorizing formulas without fully understanding their meaning or applying them inaccurately (Nahdi et al., 2020). In fact, strong numeracy mastery is essential for creating contextual and relevant learning in the 21st century (Syahida & Dewi, 2023). Therefore, strengthening numeracy through contextual, problem-based approaches and innovative learning media is highly recommended to enhance the quality of future mathematics teachers.

In Indonesia, numeracy measurement is known as the Minimum Competency Assessment (Asesmen Kompetensi Minimum / AKM), which is designed for elementary, middle, and high school students at specific grade levels. However, there is no equivalent AKM instrument developed for university students, particularly prospective mathematics teachers. Measuring numeracy competency at the tertiary level is crucial for teacher preparation programs, as it directly influences students' future ability to improve numeracy literacy in schools (O'Sullivan, 2020; Rini et al., 2021). Internationally, several instruments have been developed for similar purposes: Italy uses TECO (Test of Competence) (Hall & Zmood, 2019); Australia implements LANTITE (The Literacy and Numeracy Test for Initial Teacher Education Students) (Hilton & Mansfield, 2020); and Germany applies the Berlin Numeracy Test, which targets university students (Cokely et al., 2012). In contrast, in Indonesia, the

AKM serves as a literacy and numeracy assessment (Auliya, 2022; Fauziah et al., 2022; Herman et al., 2022; Hidayah et al., 2021). According to the Ministry of Education and Culture, literacy skills encompass comprehension, the use of strategies, evaluation, and reflection based on texts, while numeracy skills involve the use of mathematical concepts, procedures, and facts to solve problems in various everyday contexts (Prijowuntato et al., 2022). Several studies have provided teacher training on developing AKM instruments (Meriana & Murniarti, 2021; Sulistyani & Kusumawardana, 2022).

The Indonesian numeracy test emphasizes logical thinking and mathematical problem-solving skills. It consists of 25 questions—five story problems with graphs and tables, five infographic-based questions, and fifteen focusing on logical reasoning. Three numeracy processes are assessed: (1) identifying mathematical information and its meaning within real-world contexts, (2) applying mathematical knowledge and problem-solving strategies, and (3) interpreting, evaluating, communicating, and representing mathematical ideas (Hall & Zmood, 2019). Referring to the components of numeracy literacy in Indonesia, these three processes align with the dimensions of content, context, and cognitive level (Rini et al., 2021). The numeracy content includes numbers, measurement, geometry, and data; the context is adjusted to phenomena familiar to students; and the cognitive level emphasizes higher-order thinking and problem-solving abilities.

Numerous studies have examined numeracy literacy measurement. For instance, several researchers have assessed students' numeracy literacy to determine academic achievement using regression analysis (Hall & Zmood, 2019; Prijowuntato et al., 2022; Prince & Frith, 2020). Other studies analyzed numeracy to explore students' problem-solving processes (Hidayah et al., 2021; Saputri & Diana, 2021) and the influence of personality and intelligence on numeracy performance (Cerni et al., 2021). Some researchers also investigated how numeracy relates to students' confidence in solving problems (Wilson & Goff, 2019). However, despite the growing number of studies on numeracy measurement, limited research has specifically focused on the numeracy literacy of prospective mathematics teacher students in Indonesia.

This research addresses that gap by examining the phenomenon of the Minimum Competency Assessment (AKM), which currently focuses only on school students and teachers. To date, there has been no national assessment specifically designed for prospective mathematics teachers, even though mastery of numeracy literacy is fundamental to developing pedagogical competence. Strengthening numeracy literacy at the university level is expected to enhance future teachers' ability to foster numeracy among their students. Moreover, although the results of national assessments such as ANBK (National Assessment based on Competency) have revealed low numeracy levels, few follow-up studies have explored strategies to address this issue (Herman et al., 2022; Hidayah et al., 2021; Ismail & Zakiah, 2021;

Yamtinah et al., 2022). Previous research has mainly focused on teacher training in developing AKM instruments (Meriana & Murniarti, 2021; Murni et al., 2022; Ulyah et al., 2021; Yamtinah et al., 2021), improving students' reading literacy (Ismail & Zakiah, 2021), implementing learning models and media for AKM-type problems (Kustantina et al., 2022; Pulungan et al., 2022), and applying the Merdeka Belajar curriculum design (Hidayatulloh & Rahmadanik, 2022; Lie et al., 2022). These studies have primarily targeted school students and teachers.

However, to develop professional mathematics teachers, it is essential to strengthen numeracy literacy competence among prospective teacher students (Ayuningtyas & Sukriyah, 2020; Forgasz et al., 2022; Nadjamuddin & Hulukati, 2022; Prijowuntato et al., 2022; Simamora & Akhiruddin, 2022). The urgency of this study stems from the observed low problem-solving abilities and limited mapping of numeracy literacy within the Mathematics Education Study Program at the University of Muhammadiyah Malang (UMM). Additionally, students still demonstrate insufficient proof and reasoning skills.

Strengthening and evaluating the numeracy literacy of prospective mathematics teacher students represents one of the current challenges for lecturers in designing and implementing numeracy-oriented mathematics learning. Therefore, this study aims to describe and evaluate the strategies used to strengthen numeracy literacy among prospective mathematics teacher students. The findings are expected to provide empirical insights into effective pedagogical practices for developing numeracy literacy in teacher education programs.

## **METHODS**

---

This study aims to describe and evaluate strategies for strengthening students' numeracy literacy. To achieve this objective, a descriptive mixed-methods design was applied to capture both quantitative and qualitative aspects of the research phenomenon. The quantitative component focused on evaluating the effectiveness of the numeracy literacy strengthening strategies through students' test results, while the qualitative component explored students' and lecturers' perspectives through interviews to obtain in-depth information about the implementation and perceived impact of these strategies.

The participants consisted of three lecturers from the Mathematics Education Study Program at a private university in East Java, each with more than ten years of teaching experience, and two cohorts of mathematics education students: 15 students from the 2023 cohort (Batch I) and 32 students from the 2021 cohort (Batch III). The research was conducted from August to November 2023. The research procedure is presented in Figure 1, which illustrates the sequence of activities from the preliminary study to data analysis and reporting.

The research began with a preliminary study carried out during the even semester of the 2022–2023 academic year through observation and document analysis of

students' examination results to identify learning needs related to numeracy literacy. Based on this analysis, a literature review was conducted to develop research instruments consisting of literacy and numeracy test items and interview guidelines. The test items were adapted from the official AKM simulation website ([https://pusmendik.kemdikbud.go.id/an/simulasi\\_akm](https://pusmendik.kemdikbud.go.id/an/simulasi_akm)) for the junior secondary level and modified to reflect contexts relevant to university students. All instruments were validated by senior lecturers with more than ten years of teaching experience to ensure content validity and clarity.

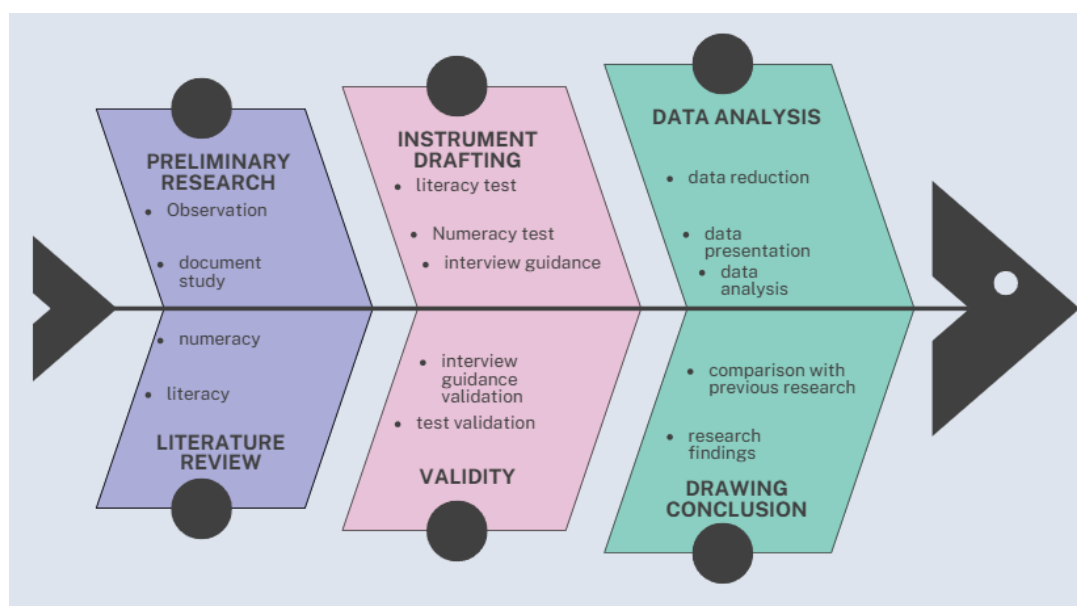


Figure 1. Research Procedure

Data were collected through literacy and numeracy tests followed by semi-structured interviews with lecturers and students. The literacy test consisted of three questions, and the numeracy test comprised five questions administered separately to students enrolled in Calculus, Basic Logic, and Set Theory courses. Interviews with lecturers explored classroom practices and strategies for improving numeracy literacy, while interviews with students focused on their reasoning processes and responses during the tests. All interviews were transcribed and analyzed descriptively.

Quantitative data from the posttest were analyzed using SPSS version 26.0 with a 5% significance level. Normality was examined using the Shapiro–Wilk test, suitable for small sample sizes (Quraisy, 2022). Homogeneity of variances was tested using Fisher's exact test, complemented by Levene's test when necessary (Azis et al., 2021; Minarta & Pamungkas, 2022). If the assumptions of normality and homogeneity were satisfied, an independent-samples t-test was used to compare literacy and numeracy scores between groups; otherwise, the nonparametric Mann–Whitney U test was

employed. A significance value (Sig.)  $< 0.05$  indicated a statistically significant difference between groups.

Qualitative data from the interviews were analyzed through thematic analysis involving data reduction, categorization, and interpretation. Key themes included literacy, numeracy, strengthening strategies, lecture implementation, student understanding, and responses. Quantitative and qualitative findings were then integrated to provide a comprehensive description and evaluation of the strategies for strengthening numeracy literacy among prospective mathematics teacher students.

## FINDING AND DISCUSSION

To begin, this section presents the results of interviews and statistical analyses to describe and evaluate the strategies used to strengthen students' numeracy literacy. The discussion also integrates findings from both quantitative and qualitative data to provide a comprehensive interpretation of the results.

The first interviews in the preliminary study were conducted with three lecturers who taught students from Batch I and Batch III. Each lecturer had more than ten years of teaching experience in the Mathematics Education Study Program at the University of Muhammadiyah Malang. The interview subjects are shown in Table 1.

**Table 1.** Interview Subjects

Lecturer	Years of Teaching	Subject Taught
A	21	Basic Logic
B	27	Integral Calculus
C	13	Set Theory

The open-ended interview questions were as follows:

1. What are your opinions about the literacy and numeracy skills of Batch I and Batch III students?
2. As a lecturer in the mathematics education study program, what strategies do you use to strengthen the literacy and numeracy skills of prospective mathematics teachers?
3. How do you design your courses to reflect literacy and numeracy, and what are the forms of evaluation?
4. How do students respond when you emphasize literacy and numeracy as course outcomes?
5. How has students' understanding of mathematical concepts changed after implementing literacy- and numeracy-focused lectures?

The interview with Lecturer A, who teaches Basic Logic for first-year students, revealed that students' literacy and numeracy skills were relatively low. This was

evident when students were asked to analyze information or data presented in different formats and identify underlying problems. Lecturer A's main strategy for strengthening literacy and numeracy involved assigning reading-based tasks that required students to explore various references related to the lecture topics. The results of these reading activities were presented at the end of each session to assess students' understanding. Student responses indicated that while these tasks encouraged independent learning, they were still challenging. Students attempted to self-evaluate and reflect on feedback during presentations. However, this reading-based reinforcement strategy had not yet shown a significant or rapid improvement in literacy and numeracy performance.

Lecturer B, who teaches Integral Calculus for third-year students, noted a general difference between first-year and third-year students in literacy and numeracy skills, although not a large one. First-year students tended to interpret texts literally and struggled to connect ideas, while third-year students demonstrated more structured reasoning and could link topics across algebra, geometry, and calculus. Nevertheless, third-year students still faced challenges when dealing with real-world problems. To strengthen literacy, Lecturer B assigned tasks that required students to complete fragmented information, thereby encouraging them to synthesize partial data into coherent knowledge. Numeracy skills were enhanced through activities emphasizing estimation, valid computation, and data interpretation in graphs, tables, and verbal forms.

In terms of learning design, literacy was integrated through problem-based learning that promoted open discussion of multiple theories, with evaluations focusing on connecting core material to extension concepts. Numeracy development was encouraged through structured reasoning and logical argumentation. Initially, students felt confused when reading texts beyond the course material, but after exposure to several examples, they began to develop mathematical reasoning in every decision made during problem-solving. Although conceptual change was not measurable in a short period, significant progress was observed in students' understanding of learning purposes. Several students also reported greater confidence and reduced anxiety in expressing opinions, as they could now support their reasoning with relevant references from their readings.

Unlike Lecturers A and B, Lecturer C, who teaches Set Theory to both first- and third-year students, found that students in both cohorts still had relatively low literacy and numeracy skills. The reinforcement strategy used involved assigning students to review scholarly articles and use the results as references during discussions. However, students often struggled to comprehend the research content fully, especially when the findings were incomplete or abstract.

Data on numeracy literacy evaluation were obtained from final exam scores in Calculus and Mathematics Media and Learning Resources courses during the odd semester of 2023–2024. These assessments focused on students' mastery of

fundamental mathematical concepts. The subjects included 15 first-year students and 32 third-year students.

### Normality Test Results

The normality test was performed using SPSS to determine the distribution of the data (Figure 2). Group A represented Batch I students, and Group B represented Batch III students. Since both groups had less than 100 participants, the Shapiro–Wilk results were used. Based on Figure 2, the significance value for Group A was  $<0.001$ , while for Group B it was  $0.067$ . Because both values were below  $0.05$ ,  $H_0$  was rejected and  $H_1$  accepted, indicating that the sample came from a population that was not normally distributed.

Kelompok	Kolmogorov-Smirnov <sup>a</sup>			Shapiro-Wilk			
	Statistic	df	Sig.	Statistic	df	Sig.	
Hasil_Tes							
	Kelompok A	.271	15	.004	.707	15	<.001
	Kelompok B	.182	32	.008	.938	32	.067

a. Lilliefors Significance Correction

Figure 2. Normality Test Results

### Homogeneity Test Results

As the normality test showed that the data were not normally distributed, the Mann–Whitney test was chosen for subsequent analysis. Before conducting the difference test, a homogeneity test was carried out to determine whether the two sample groups had equal variance. Based on the Levene statistic (Figure 3), the significance value obtained was  $0.142$ , which is greater than  $0.05$ . Therefore,  $H_0$  was accepted, indicating that the variances between Groups A and B were homogeneous.

		Levene Statistic	df1	df2	Sig.
Hasil_Tes	Based on Mean	2.236	1	45	.142
	Based on Median	.297	1	45	.588
	Based on Median and with adjusted df	.297	1	25.518	.590
	Based on trimmed mean	1.364	1	45	.249

Figure 3. Homogeneity Test Results

### Mann–Whitney Test Results

To examine the difference between the two groups, a Mann–Whitney test was conducted (Figure 4). The mean rank of literacy and numeracy scores for Group A was 14.13, while Group B had a higher score of 28.63. The significance value obtained was  $<0.001$ , which is less than 0.05. Therefore,  $H_0$  was rejected and  $H_1$  accepted, indicating a significant difference between the literacy and numeracy test results of Batch I and Batch III students.

	Kelompok	N	Mean Rank	Sum of Ranks
Hasil_Tes	Kelompok A	15	14.13	212.00
	Kelompok B	32	28.63	916.00
	Total	47		

### Test Statistics<sup>a</sup>

	Hasil_Tes
Mann-Whitney U	92.000
Wilcoxon W	212.000
Z	-3.378
Asymp. Sig. (2-tailed)	<.001

a. Grouping Variable:  
Kelompok

**Figure 4.** Mann–Whitney Test Results

The statistical results demonstrate a notable difference in literacy and numeracy skills between first-year and third-year students. This difference can be attributed to variations in students' exposure to mathematical concepts and learning experiences. Third-year students had better mastery of calculus, logic, and set theory, which enhanced their literacy and numeracy competence compared to first-year students. The interviews exploring various strategies for strengthening literacy and numeracy revealed similar trends across all lecturers. First-year students' literacy and numeracy skills remain relatively low, particularly in interpreting mathematical concepts. This finding aligns with earlier studies highlighting persistent gaps in mathematical literacy among university students. Research in Australia, for example, emphasized the need for course redesigns to address low mathematical literacy among undergraduate students (Mann, 2022).

The strategies applied by the lecturers in this study—reading assignments, individual projects, and fragmented information tasks—mirror practices observed in the Reading and Mathematics Project (RAMP) in Jordan, which successfully improved students' reading and numeracy levels (Friehat & Al-Khresha, 2021). In the present study, lecturers designed individual reading projects and end-of-course presentations to reinforce both literacy and numeracy competencies.

Furthermore, the learning designs implemented reflected integration of literacy through open discussion, problem-solving, and cross-disciplinary exploration. These findings are consistent with previous research that incorporated virtual reality (McLauchlan & Farley, 2019), ICT-based curricula (Du Toit, 2005), and digital competency frameworks (Sarva et al., 2023) to promote numeracy literacy at the higher education level. Such approaches foster diverse student responses, including increased self-reflection, initial confusion in independent learning, and a heightened sense of responsibility to master content.

The difference in average literacy and numeracy scores between first- and third-year students also reflects cognitive development through increased exposure to higher-level mathematical thinking. Third-year students demonstrated stronger independence and conceptual understanding, as shown by their performance in independent assignments and problem-solving tasks.

However, this study also encountered several limitations. The available data on numeracy literacy strengthening strategies were insufficient to represent all lecturers in the program, limiting the comprehensiveness of the evaluation. Additionally, the test content was restricted to geometry and algebra, which may not fully capture the competencies of students who had completed courses in analytical mathematics. Therefore, future studies are recommended to expand the range of mathematical content and include more participants to produce a broader and more detailed understanding of numeracy literacy development among prospective mathematics teachers.

## **CONCLUSIONS AND RECOMMENDATIONS**

---

The strategies for strengthening literacy and numeracy were implemented differently for first-year and third-year students. These variations were influenced by the level of students' mastery of mathematical concepts and their capacity for independent learning. In the Mathematics Education Study Program, the strategies applied by lecturers included assigning independent projects, reading-based tasks followed by presentations, and exercises requiring students to complete fragmented information from multiple references.

The evaluation results indicated that the differences in literacy and numeracy performance were strongly associated with students' level of study. Statistical tests on fundamental mathematics subjects—Calculus, Set Theory, and Basic Logic—revealed a significant difference between the literacy and numeracy abilities of first-year and third-year students. This difference is likely due to the higher mastery of mathematical concepts among third-year students, who have greater experience integrating mathematical reasoning, literacy, and problem-solving skills.

Future research is recommended to develop and test innovative lecture models designed to enhance literacy and numeracy competencies among prospective mathematics teachers. Expanding the scope of participants and incorporating more

diverse mathematical content would also help produce a more comprehensive understanding of how literacy and numeracy can be effectively strengthened in teacher education programs.

## REFERENCES

- Auliya, P. K. (2022). The implementation of minimum competency assessment (AKM): Opportunities and challenges for English teachers. *Didaktika: Jurnal Pemikiran Pendidikan*, 28(2). <https://doi.org/10.30587/didaktika.v28i2.3809>
- Ayuningtyas, N., & Sukriyah, D. (2020). Analisis pengetahuan numerasi mahasiswa matematika calon guru. *Delta-Pi: Jurnal Matematika dan Pendidikan Matematika*, 9(2). <https://doi.org/10.33387/dpi.v9i2.2299>
- Baking, R. D., Ibarra, F. P., & Mukminin, A. (2023). Predictive analysis of cognitive skills achievements in mathematics along seven logical operations among elementary pre-service teachers. *Edelweiss Applied Science and Technology*, 7(1). <https://doi.org/10.55214/25768484.v7i1.332>
- Cerni, T., Di Benedetto, A., & Rumiati, R. I. (2021). The contribution of personality and intelligence toward cognitive competences in higher education. *Frontiers in Psychology*, 12. <https://doi.org/10.3389/fpsyg.2021.621990>
- Cokely, E. T., Galesic, M., Schulz, E., Ghazal, S., & Garcia-Retamero, R. (2012). Measuring risk literacy: The Berlin numeracy test. *Judgment and Decision Making*, 7(1). <https://doi.org/10.1017/s1930297500001819>
- Du Toit, I. (2005). The effect of ICT curriculum support on the measured skills levels of learners of two sub-projects of the Khanya Project. *Proceedings of the 8th IFIP World Conference on Computers in Education (WCCE 2005)*.
- Fauziah, N., Roza, Y., & Maimunah, M. (2022). Kemampuan matematis pemecahan masalah siswa dalam penyelesaian soal tipe numerasi AKM. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, 6(3). <https://doi.org/10.31004/cendekia.v6i3.1471>
- Forgasz, H., Hall, J., & Robinson, T. (2022). Evaluating pre-service teachers' statistical literacy capabilities. *Mathematics Education Research Journal*. <https://doi.org/10.1007/s13394-022-00438-6>
- Friehat, R. H., & Al-Khresha, A. (2021). The role of RAMP initiative (Reading and Mathematics Project) in raising the level of students in the basic stage in reading and numeracy skills. *International Education Studies*, 14(5). <https://doi.org/10.5539/ies.v14n5p109>
- Hall, J., & Zmood, S. (2019). Australia's literacy and numeracy test for initial teacher education students: Trends in numeracy for low- and high-achieving students.

- Australian Journal of Teacher Education*, 44(10).  
<https://doi.org/10.14221/ajte.2019v44n10.1>
- Herman, Shara, A. M., Silalahi, T. F., Sherly, & Julyanthry. (2022). Teachers' attitude towards minimum competency assessment at Sultan Agung Senior High School in Pematangsiantar, Indonesia. *Journal of Curriculum and Teaching*, 11(1).  
<https://doi.org/10.5430/jct.v11n2p1>
- Hidayah, I. R., Kusmayadi, T. A., & Fitriana, L. (2021). Minimum competency assessment (AKM): An effort to photograph numeracy. *Journal of Mathematics and Mathematics Education*, 11(1), 14.  
<https://doi.org/10.20961/jmme.v11i1.52742>
- Hidayatulloh, K. S., & Rahmadanik, D. (2022). Implementation of Kampus Mengajar 3 as an effort to improve literacy and numeracy capabilities of students. *Jurnal Pendidikan dan Teknologi*, 1(1).
- Hilton, A. L., & Mansfield, C. (2020). "In LANTITE, no one can hear you scream!" Student voices of high-stakes testing in teacher education. *Australian Journal of Teacher Education*, 45(12). <https://doi.org/10.14221/ajte.202v45n12.4>
- Ismail, S., & Zakiah, Q. Y. (2021). Policy analysis of implementation of minimum competency assessment as an effort to improve reading literacy of students in schools. *Paedagoria: Jurnal Kajian, Penelitian dan Pengembangan Kependidikan*, 12(1), 83–91.  
<http://journal.ummat.ac.id/index.php/paedagoria/article/view/3925>
- Kustantina, V. A., Nuryadi, N., & Marhaeni, N. H. (2022). Improving the students' numerical literacy skills by using interactive mathematical comics on Pythagorean theorem. *Jurnal Ilmu Pendidikan Muhammadiyah Kramat Jati*, 3(1).  
<https://doi.org/10.55943/jipmukjt.v3i1.24>
- Lie, D., Ekana Nainggolan, L., & Triapnita Nainggolan, N. (2022). Improving literacy and numeracy of students in elementary and junior high school through Merdeka Belajar Kampus Merdeka (MBKM). *International Journal of Community Service*, 2(3). <https://doi.org/10.51601/ijcs.v2i3.117>
- Mann, G. (2022). "There's a reason for all the numbers": Using a literacy framework in enabling education to bridge the gap between low adult numeracy levels and undergraduate mathematics. *Student Success*, 13(2).  
<https://doi.org/10.5204/ssj.2326>
- McLauchlan, J., & Farley, H. (2019). Fast cars and fast learning: Using virtual reality to learn literacy and numeracy in prison. *Journal for Virtual Worlds Research*, 12(3).  
<https://doi.org/10.4101/jvwr.v12i3.7391>
- Meriana, T., & Murniarti, E. (2021). Analisis pelatihan asesmen kompetensi minimum. *Jurnal Dinamika Pendidikan*, 14(2).

- Murni, V., Nendi, F., Jundu, R., Men, F. E., Pantaleon, K. V., Jehadus, E., & Jeramat, E. (2022). Pelatihan penyusunan instrumen asesmen kompetensi minimum (AKM) di SMK Bina Kusuma Ruteng. *Jurnal Kreativitas Pengabdian kepada Masyarakat (PKM)*, 5(8). <https://doi.org/10.33024/jkpm.v5i8.6031>
- Nadjamuddin, A., & Hulukati, E. (2022). Kemampuan literasi numerasi mahasiswa dalam menyelesaikan masalah matematika. *Jurnal Basicedu*, 6(1). <https://doi.org/10.31004/basicedu.v6i1.1999>
- Nahdi, D. S., Jatisunda, M. G., Cahyaningsih, U., & Suciawati, V. (2020). Pre-service teachers' ability in solving mathematics problems viewed from numeracy literacy skills. *Elementary Education Online*, 19(4). <https://doi.org/10.17051/ilkonline.2020.762541>
- O'Sullivan, K. A. (2020). 'Prepare yourself': Testing the literacy skills of graduating teachers. *Australian Journal of Language and Literacy*, 43(2). <https://doi.org/10.1007/bf03652053>
- Prijowuntato, S. W., Widharyanto, B., & Julie, H. (2022). The influence of literacy and numeracy skills on the success of college students in the Faculty of Teacher Training and Education. *Jurnal Pendidikan Ilmu Sosial*, 32(2). <https://doi.org/10.23917/jpis.v32i2.20338>
- Prince, R., & Frith, V. (2020). An investigation of the relationship between academic numeracy of university students in South Africa and their mathematical and language ability. *ZDM—Mathematics Education*, 52(3). <https://doi.org/10.1007/s11858-019-01063-7>
- Pulungan, S. A., Wanhar, F. A., Fatmawati, F., & Arianto, D. (2022). Pelatihan pembuatan bahan ajar berbasis literasi, numerasi dan karakter bagi guru SMP Swasta PAB se-Kabupaten Deli Serdang. *Empowerment: Jurnal Pengabdian Masyarakat*, 1(5). <https://doi.org/10.55983/empjcs.v1i5.245>
- Rini, T. A., Cholifah, P. S., Nuraini, N. L. S., & Margetts, K. (2021). Readiness of elementary teachers in minimum competency assessment: Teachers' competence in arranging literature and numeration tests. *Profesi Pendidikan Dasar*, 8(2). <https://doi.org/10.23917/ppd.v8i2.16157>
- Saputri, V., & Diana, H. A. (2021). Development of HOTS problem-based test instruments to measure level 4 numeracy capabilities using Rasch model. *Jurnal Ilmiah Mandala Education*, 7(4). <https://doi.org/10.36312/jime.v7i4.2371>
- Sarva, E., Lāma, G., Oļesika, A., Daniela, L., & Rubene, Z. (2023). Development of education field student digital competences—Student and stakeholders' perspective. *Sustainability*, 15(13). <https://doi.org/10.3390/su15139895>
- Simamora, E. W., & Akhiruddin, A. (2022). Analisis kemampuan literasi numerasi mahasiswa ditinjau dari gaya kognitif reflektif dan impulsif. *Jurnal Magister*

*Pendidikan Matematika (JUMADIKA)*, 4(2), 89–95.  
<https://doi.org/10.30598/jumadikavol4iss2year2022page89-95>

Sulistiyani, N., & Kusumawardana, A. S. (2022). Pendampingan pengembangan instrumen berciri literasi numerasi dalam menyiapkan AKM pada guru SD. *Jurnal Masyarakat Mandiri*, 6(1).

Syahida, H., & Dewi, L. (2023). Identifying 21st-century skills in the “Kurikulum Merdeka” at the elementary level numeracy aspect: A literature review. *International Conference on Elementary Education*, 5(1).

Ulyah, S. M., Sediono, S., Ana, E., Sholihah, N., & Niswatin, K. (2021). Improving the competency of high school teachers in understanding and designing questions based on minimum competency assessment in Babat Lamongan District. *MUST: Journal of Mathematics Education, Science and Technology*, 6(1).  
<https://doi.org/10.30651/must.v6i1.7773>

Wilkins, L. (2016). The role and positioning of numeracy in Australian universities—Does it matter? *Journal of Academic Language and Learning*, 10(1).

Wilson, A., & Goff, W. (2019). “Hopefully, I will gain confidence”: Hope in pre-service teachers’ mathematics and numeracy testing. *Australian Journal of Teacher Education*, 44(10). <https://doi.org/10.14221/ajte.2019v44n10.4>

Yamtinah, S., Utami, B., Masykuri, M., Mulyani, B., Ulfa, M., & Shidiq, A. S. (2022). Secondary school science teacher response to minimum competency assessment: Challenges and opportunities. *Jurnal Penelitian Pendidikan IPA*, 8(1). <https://doi.org/10.29303/jppipa.v8i1.1075>

Yamtinah, S., Utami, B., Mulyani, B., Masykuri, M., & Ulfa, M. (2021). Pendampingan penyusunan instrumen asesmen kompetensi minimum (AKM) sebagai upaya penguatan kemampuan guru. *Seminar Nasional Kimia dan Pendidikan Kimia XIII*.