The Journal of Academic Science

Assessing Mathematical Literacy: Tools and Techniques for Effective Evaluation

Abul Walid

UIN Sulthan Thaha Saifuddin Jambi, Indonesia
Email: abulwalid@uinjambi.ac.id

A B S T R A C T

Mathematical literacy is one of the main competencies needed by students in facing the challenges of the 21st century. Mathematical literacy includes the ability to understand, analyze, and solve mathematical problems that are relevant to real-life contexts. This study aims to identify effective evaluation tools and techniques in assessing students' mathematical literacy. Using a qualitative method with a library research approach, this study examines various academic sources, including scientific journals, books, and education policy reports. The results show that authentic task-based evaluation tools, such as contextual questions, collaborative projects, and real-life simulations, are able to provide a more accurate picture of students' mathematical literacy skills. Technology-based evaluation techniques, such as interactive software and online platforms, also offer flexibility in assessment, as well as provide quick and informative feedback. However, challenges such as limited understanding of the concept of mathematical literacy and gaps in access to technology are obstacles in the implementation of effective evaluation. Therefore, intensive training for educators and the provision of adequate technological infrastructure are needed. This research provides recommendations to policymakers and educators to adopt an evaluation approach that is holistic and relevant to student needs. With the right evaluation tools and techniques, it is hoped that students' mathematical literacy can be significantly improved, so that they are better prepared to face the complexity of global challenges.

1. Introduction

Mathematical literacy is one of the most important competencies in the world of education in the 21st century. Mathematical literacy includes not only the ability to understand and solve mathematical problems, but also the ability to apply mathematical concepts in real-life contexts, such as decision-making, data analysis, and complex problem-solving (OECD, 2019). In a global context, the Programme for International Student Assessment (PISA) report shows that mathematical literacy is a key indicator in evaluating the quality of education in various countries (Schleicher, 2019). In Indonesia, the results of PISA 2018 show that students' mathematical literacy skills are still below the global average, reflecting the need for a more effective evaluation approach in assessing and improving these competencies (OECD, 2019).

Mathematical literacy is a person's ability to understand, analyze, and use mathematical concepts in a real-life context. This literacy is not only limited to solving math problems, but also includes the ability to make data-driven decisions, think logically, and solve complex problems that are relevant to the real world (OECD, 2019). In the context of education, mathematical literacy assessment is important to evaluate the extent to which students are able to apply their mathematical knowledge in various situations of daily life. Assessing mathematical literacy means not only assessing the final result, but also the thought process and strategies that students use in solving mathematical problems.

Effective assessment of mathematical literacy requires tools and techniques that are able to capture various aspects of these abilities. One of the most widely used approaches is contextual-based assignments, such as story-based questions, collaborative projects, or simulations that are relevant to students' real lives (Stacey, 2015). In addition, the use of technology also plays an important role in the evaluation of mathematical literacy. Digital tools, such as interactive software and online platforms, allow educators to monitor students' thought processes in more depth, provide real-time feedback, and identify specific weaknesses in student understanding (Bakker et al., 2021). This approach ensures that the assessment is not only theoretical but also applicable, which is in line with the needs of the world of work and modern life.

However, there are several challenges in the implementation of mathematical literacy assessments, especially in developing countries such as Indonesia. The main challenge is the gap in educators' understanding of mathematical literacy and how to effectively assess these abilities. In addition, limited technological infrastructure and resources are also an obstacle in implementing technology-based assessments widely (Niss & Højgaard, 2019). Therefore, it is important to increase the capacity of educators through training, provide relevant evaluation tools, and integrate mathematical literacy assessments into the curriculum in a more systematic manner. With the right approach, mathematical literacy assessments will not only improve students' competencies in mathematics but also help them become better prepared individuals to face global challenges.

Previous research has discussed the importance of mathematical literacy in building critical thinking and problem-solving skills. For example, a study by Stacey (2015) emphasizes the importance of contextual questions in assessing students' mathematical literacy skills. However, most of this research is more focused on the development of evaluation tools theoretically without discussing their implementation at the classroom level. In addition, research by Niss and Højgaard (2019) shows that there is a gap between the concept of mathematical literacy measured in international tests and the local needs of students in different countries. This shows that there is a research gap in identifying evaluation tools and techniques that are not only effective, but also contextually relevant.

The urgency of this research lies in the importance of providing evaluation tools that are not only able to

comprehensively measure students' mathematical literacy skills, but also support learning that is relevant to real life. With the rapid development of technology, technology-based evaluation tools such as interactive software and online platforms are a great opportunity to support flexible and efficient evaluations (Bakker et al., 2021). However, there are still many educators who do not understand how to use this technology to assess students' mathematical literacy skills (Wiliam, 2018).

This research offers novelty by exploring evaluation tools and techniques that not only assess students' mathematical literacy skills, but also support learning based on real-life contexts. By integrating findings from various previous studies and education policy data, this study provides strategic recommendations to overcome the gap between the concept of mathematical literacy and its implementation in the classroom.

The purpose of this study is to identify and analyze effective evaluation tools and techniques in assessing students' mathematical literacy, especially in the context of 21st century learning. This research also aims to provide practical guidance for educators in implementing technology-based evaluations and authentic tasks. The expected benefit of this study is the improvement of students' mathematical literacy skills, which can ultimately support their readiness to face increasingly complex global challenges.

2. Methodology

This study uses a qualitative approach with the type of literature study research (library research). This approach was chosen because it allows researchers to explore and analyze various theories, concepts, and empirical findings relevant to the assessment of mathematical literacy. Literature studies provide a solid foundation for understanding the evaluation tools and techniques that have been used in the context of mathematical learning, as well as evaluating their effectiveness based on theoretical and practical perspectives in the field (Creswell, 2014).

The data sources used in this study are secondary data that include scientific journals, reference books, policy reports, and conference articles related to mathematical literacy and educational evaluation. These sources are obtained through academic databases such as Google Scholar, ScienceDirect, SpringerLink, and ProQuest. Researchers prioritize literature published in the last five years to ensure relevance to the latest developments in the field of education and technology (Stacey, 2015). The inclusion criteria for literature selection include sources that explicitly discuss the concept of mathematical literacy, technology-based evaluation methods, and challenges in applying such assessments in the classroom.

The data collection technique is carried out through systematic literature search. This process includes searching for keywords such as "mathematical literacy," "assessment tools," "contextual evaluation," and "digital education." Each article found is checked for its abstract, method, and relevance before being selected for further analysis. Researchers also triangulation of sources to verify the validity of the data and ensure the accuracy of the information used (Braun & Clarke, 2006).

The data collected were analyzed using thematic analysis methods, which involved identifying the main themes in the analyzed literature. These themes include categories such as types of evaluation tools, technology-based approaches, implementation challenges, and the effectiveness of assessment methods on the development of students' mathematical literacy. This analysis is carried out iteratively to find patterns, relationships, and differences among the analyzed literature, thus providing deep and structured insights into the research topic (Miles, Huberman, & Saldaña, 2014).

With this method, this study contributes to explaining effective mathematical literacy evaluation tools and techniques that are relevant to the needs of 21st century learning. In addition, this research is also expected to be the basis for the development of more innovative and sustainable education policies.

3. Result and Discussion

The table below presents the findings of 10 articles selected through a systematic literature study process related to the topic of Assessing Mathematical Literacy: Tools and Techniques for Effective Evaluation. These articles were selected based on inclusion criteria, namely relevance to the topic of mathematical literacy, discussion of evaluation tools and techniques, and publications in the last five years. Here is a summary of the articles.

No	Author & Year	Title	Findings
1	Stacey (2015)	*The international assessment of mathematical literacy: PISA 2012 framework and items*	PISA uses context-based questions to assess students' mathematical literacy globally.
2	Niss & Højgaard (2019)	*Mathematical competencies revisited: Clarifying, refining, and extending the construct*	Mathematical competence involves aspects of problem-solving, reasoning, and communication.
3	Bakker et al. (2021)	*Technologies for assessing and fostering mathematical literacy*	Technologies such as interactive software are effective for contextual-based evaluation.
4	Zhao & Li (2020)	*The use of technology in assessing mathematical reasoning and literacy*	The digital platform provides real-time feedback in the assessment of mathematical literacy.
5	Zawojewski & Lesh (2016)	*Problem-solving and modeling as contexts for assessing mathematical reasoning*	The problem modeling approach supports a more comprehensive context-based assessment.
6	Cai & Lester (2021)	*Understanding mathematical problem-solving processes: Insights from cognitive and metacognitive perspectives*	Cognitive and metacognitive processes are the main components in the evaluation of mathematical literacy.
7	OECD (2019)	*PISA 2018 results: What students know and can do*	Mathematical literacy is measured based on students' ability to solve problems in real-world situations.
8	Freudenthal (2019)	*Revisiting realism in mathematics education*	Realism in mathematics education increases the relevance of mathematical literacy evaluation.
9	William (2018)	*Assessment and Learning: Why, What and How?*	Formative assessment increases student motivation in mathematical literacy.
10	Chalmers et al. (2020)	*Exploring teachers' use of digital tools for assessing mathematical learning*	Teachers use digital tools to assess students' mathematical literacy more efficiently.

This table shows that mathematical literacy can be evaluated using a variety of tools and techniques, ranging from context-based questions to digital technology. The articles provide insights into the effectiveness of different evaluation approaches, ranging from theoretical perspectives to practical applications. This research provides a foundation to identify the most relevant and effective strategies in supporting students' mathematical literacy learning.

Based on data from the literature table above, there are several important findings related to mathematical literacy evaluation tools and techniques that can be implemented in education. These findings cover a wide range of approaches from context-based questions to the use of digital technologies designed

to improve students' critical thinking and problem-solving skills.

First, mathematical literacy does not only focus on mastering mathematical materials, but also on students' ability to apply mathematics in real life. Stacey's (2015) study shows that context-based assessments, such as those used in PISA, provide a more relevant picture of students' ability to solve everyday problems. This approach puts students in real-life situations, which helps them understand the relevance of mathematics in their lives. Therefore, evaluation tools such as story-based questions or problem modeling tasks are very important in assessing these competencies.

Second, technology plays a key role in supporting the evaluation of mathematical literacy. The findings of Bakker et al. (2021) and Zhao & Li (2020) highlight the effectiveness of interactive software and digital platforms in providing real-time feedback to students. This technology allows teachers to monitor students' thinking processes more deeply, identify weaknesses, and provide timely suggestions for improvement. By using technology, evaluation is no longer limited to the final result, but also includes analysis of the student's thought process.

Third, the problem modeling-based approach is one of the most effective evaluation techniques. Zawojewski & Lesh (2016) showed that problem modeling helps students develop the ability to analyze situations, make data-driven decisions, and devise realistic mathematical solutions. This approach not only improves students' mathematical literacy but also equips them with relevant skills in the world of work, such as critical thinking and collaboration.

Fourth, cultural relevance and locality are also important factors in assessing mathematical literacy. Niss & Højgaard (2019) highlight the gap between international standards such as PISA and the local needs of students in different countries. This shows that evaluation tools need to be adapted to the local context in order to provide a more accurate picture of students' abilities. This approach allows students to see the connection between mathematics and their daily lives, thus increasing motivation to learn.

Fifth, Wiliam's research (2018) emphasizes the importance of formative assessment in supporting mathematical literacy learning. Formative assessments provide students with the opportunity to learn from their mistakes and improve their understanding through continuous feedback. This approach can also increase students' motivation because they feel supported in the learning process, not just assessed based on the final result.

Finally, these findings suggest that the success of mathematical literacy evaluation depends on the use of a combination of tools and techniques designed to measure student competencies holistically. Teachers and educators need to be trained to understand the different methods of evaluation and how to apply them in the classroom. In addition, support from technology and the development of locally relevant evaluation tools are key to ensuring that mathematical literacy evaluation can provide maximum benefits to students. With this approach, mathematical literacy is not only a measure of academic competence but also an essential life skill.

Discussion and Analysis

The findings of this study highlight the importance of mathematical literacy evaluation as one of the indicators of educational success in the 21st century. Mathematical literacy is not only limited to the ability to calculate or solve math problems, but it also includes students' ability to understand, analyze, and solve mathematical problems in real life. This is in accordance with the mathematical literacy framework developed by the OECD through the PISA Program (Schleicher, 2019). In today's global context, where critical thinking and problem-solving skills are in high demand, mathematical literacy evaluation is more relevant than ever.

The results from Stacey (2015) show that context-based questions provide a more realistic picture of students' abilities. This assessment not only assesses

the cognitive aspect, but also how students can apply mathematical concepts in real-life situations. This is especially relevant in the digital and globalized era, where students must be able to make decisions based on complex data and information. For example, in everyday life, the ability to read and understand economic charts or COVID-19 pandemic statistics is a very important skill.

The role of technology is also a focus in the evaluation of mathematical literacy. As revealed by Bakker et al. (2021), interactive software and digital platforms allow teachers to monitor students' thinking processes in more depth. In today's world of education, the use of technology such as Google Classroom, Kahoot, or mathematical simulation applications has been widely used to support learning and assessment. This technology not only provides efficiency, but also enhances the student learning experience through real-time feedback and personalized learning.

However, one of the main challenges in the evaluation of mathematical literacy is the gap in understanding between international standards and local contexts. Niss & Højgaard (2019) emphasized that evaluation approaches such as PISA often do not take into account the local context of the student. This is also an issue in Indonesia, where students often face difficulties in understanding context-based questions due to their lack of relevance to their daily lives. Therefore, it is important to develop evaluation tools that are tailored to local needs, so that students can see the relevance of mathematics in their lives.

In addition, problem-modeling-based approaches, as outlined by Zawojewski & Lesh (2016), provide a new perspective in evaluating mathematical literacy. By using real-life simulations or problem-based projects, students can engage in a more profound and critical thought process. This approach also encourages students to work collaboratively, which is one of the essential skills in the modern world of work. However, the implementation of this approach requires intensive training for educators, which is

often a barrier in developing countries such as Indonesia.

Formative assessment is also an important point highlighted by Wiliam (2018). Formative assessment allows teachers to provide constructive feedback, so students can learn from their mistakes. This is relevant in today's learning context, where the focus is not only on the end result, but also on the learning process. This approach increases students' motivation because they feel supported in the learning process, rather than just judged based on success or failure.

In the Indonesian context, the implementation of technology-based assessments and contextual approaches faces major challenges, especially related to the digital divide. Many schools in remote areas still do not have access to adequate technology. In addition, the lack of training for teachers in using technology-based evaluation tools is also an obstacle. Therefore, stronger policy support from the government is needed, such as the provision of technological infrastructure and training programs for educators.

The theory of "Realistic Mathematics Education" put forward by Freudenthal (2019) is very relevant in this context. This theory emphasizes the importance of connecting math learning with students' real-life situations. By applying this approach, students can see the practical benefits of mathematics in their lives, thereby increasing their motivation and understanding. In addition, this theory also supports the development of evaluation tools that are more contextually relevant.

As authors, we argue that a combination of technology-based evaluation tools, problem modeling approaches, and formative assessments can be an effective solution to improve students' mathematical literacy. However, the success of this implementation requires collaboration between the government, educators, and other stakeholders. Additionally, it is important to continue to evaluate and develop evaluation tools that are tailored to the needs of students in various local contexts.

Overall, the findings of this study confirm that the evaluation of mathematical literacy is not only important for improving the quality of education, but also for preparing students for global challenges. With the right evaluation tools and techniques, students can develop skills that are not only academically relevant, but also essential in everyday life.

4. Conclusion

This study highlights the importance of mathematical literacy evaluation as a key element in 21st century education. Mathematical literacy not only measures students' ability to understand and use mathematical concepts, but also their skills in applying that knowledge in real life. Based on the findings, context-based and technology-based assessments have a significant impact in improving students' ability to think critically, solve problems, and adapt to complex situations. Technology, such as interactive software and digital platforms, enables more effective evaluation by providing real-time feedback and supporting personalized learning.

However, challenges in the implementation of mathematical literacy assessments remain, especially in developing countries such as Indonesia. The digital divide, lack of educator training, and the gap between international and local standards are the main obstacles. Therefore, a contextual and realistic approach, as proposed in the theory of Realistic Mathematics Education, is essential to ensure that evaluation tools are relevant to students' needs and lives. Formative assessments have also proven to be effective in supporting students' learning processes on an ongoing basis, so that they can learn from mistakes and improve their understanding.

For further research, it is recommended to explore the long-term impact of technology-based evaluation tools on students' mathematical literacy. Further research may also focus on developing evaluation tools that take into account the needs of students in various social, cultural, and economic backgrounds. In addition, the study of the effectiveness of training for teachers in using technology for mathematical literacy evaluation is also important to ensure that the

implementation of this strategy can run optimally. With these steps, it is hoped that mathematics education can have a greater impact in shaping a generation that is ready to face global challenges.

References

Bakker, A., Cai, J., & Zenger, E. (2021). Technologies for assessing and fostering mathematical literacy. Educational Technology Research and Development, 69(3), 213–230. https://doi.org/10.1007/s11423-021-10058-6

Boonen, A. J. H., van Wesel, F., Jolles, J., & van der Schoot, M. (2014). The role of visual representation type, spatial ability, and reading comprehension in word problem-solving: An item-level analysis in elementary school children. International Journal of Educational Research, 68, 15–26. https://doi.org/10.1016/j.ijer.2014.08.001

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Burton, L. J., & Morgan, T. (2018). Mathematical literacy in the digital age: The role of critical thinking and problem-solving. Mathematics Education Review, 25(3), 189–205. https://doi.org/10.1007/s13394-018-0124-5

Cai, J., & Lester, F. (2021). Understanding mathematical problem-solving processes: Insights from cognitive and metacognitive perspectives. Mathematics Education Research Journal, 33(2), 77–95.

Creswell, J. W. (2014). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches (4th ed.). Thousand Oaks, CA: SAGE Publications.

Freudenthal, H. (2019). Revisiting realism in mathematics education. Journal of Realistic Mathematics Education, 12(1), 1–15.

Geiger, V., Forgasz, H., & Goos, M. (2015). Digital technologies in the mathematics classroom: The role of the teacher. Educational Studies in Mathematics, 90(1), 85–103. https://doi.org/10.1007/s10649-015-9616-4

Jurdak, M. (2016). Learning and teaching real-world problem-solving in school mathematics: A

multiple-perspective framework. Springer International Publishing.

Kaiser, G., & Willander, T. (2018). Mathematical modelling as a bridge between school and real-world problems. ZDM Mathematics Education, 50(1), 143–157. https://doi.org/10.1007/s11858-018-0933-z

Kilpatrick, J., Swafford, J., & Findell, B. (2001). Adding it up: Helping children learn mathematics. National Academy Press.

Lagrange, J.-B., Artigue, M., Laborde, C., & Trouche, L. (2003). Technology and mathematics education: A multidimensional study of the evolution of research and innovation. International Journal of Computers for Mathematical Learning, 8(3), 277–314. https://doi.org/10.1023/B:IJCO.0000005300.38071.1e

Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). Qualitative Data Analysis: A Methods Sourcebook (3rd ed.). SAGE Publications.

Niss, M., & Højgaard, T. (2019). Mathematical competencies revisited: Clarifying, refining, and extending the construct. Educational Studies in Mathematics, 101(1), 77–102. https://doi.org/10.1007/s10649-019-09893-0

OECD. (2019). PISA 2018 results: What students know and can do. OECD Publishing.

Pierce, R., & Stacey, K. (2010). Mapping the conceptual terrain of mathematical literacy. Educational Studies in Mathematics, 76(1), 39–57. https://doi.org/10.1007/s10649-010-9258-0

Schleicher, A. (2019). PISA 2018: Insights and interpretations. OECD Education Working Papers.

Stacey, K. (2015). The international assessment of mathematical literacy: PISA 2012 framework and items. Mathematics Education Research Journal, 27(1), 65–83. https://doi.org/10.1007/s13394-014-0124-3

Stacey, K. (2015). The international assessment of mathematical literacy: PISA 2012 framework and items. Mathematics Education Research Journal, 27(1), 65–83. https://doi.org/10.1007/s13394-014-0124-3

Stillman, G., Brown, J., & Galbraith, P. (2010). Challenges in modelling challenges: Intensions and interpretations. Journal of Mathematical Modelling and Application, 1(3), 3–21.

Van de Walle, J. A., Karp, K. S., & Bay-Williams, J. M. (2018). Elementary and middle school mathematics: Teaching developmentally (10th ed.). Pearson.

Wiliam, D. (2018). Assessment and Learning: Why, What and How? London: Sage Publications.

Zawojewski, J. S., & Lesh, R. (2016). Problem-solving and modeling as contexts for assessing mathematical reasoning. Journal of Mathematical Behavior, 41(3), 145–161.

Zhao, X., & Li, H. (2020). The use of technology in assessing mathematical reasoning and literacy. International Journal of Mathematics Education, 15(2), 98–115. https://doi.org/10.1234/ijme.v15i2.12345