The Implementation of ICT in Improving Mathematical Literacy Skills: A Systematic Literature Review Study

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Abstract. This study aims to examine the use of Information and Communication Technology (ICT) in improving students' mathematical literacy skills. With a literature review approach, this study analyzes various academic sources, including journal articles, books, and PISA reports. The main focus of the research is on the use of educational applications and software that support students' understanding of mathematical concepts and analytical skills. Data were collected through literature screening related to the use of ICT in mathematics learning and the mathematics literacy ranking of Indonesian students. The screening occured in google scholar, semantic scholar and scopus, where there are 35 articles related to study. Data analysis was carried out using thematic methods, identifying themes such as ICT effectiveness, challenges in implementation, and their impact on mathematical literacy skills. The results show that the application of ICT in mathematics learning has the potential to increase students' interest and problem-solving skills, although teacher training and curriculum adaptation are needed to optimize the use of this technology in the context of Indonesian education.

Keywords: : Mathematical Literacy; Mathematics Learning; ICT

1 Introduction

One of the essential rights protected by the law is education. Education is a deliberate and planned attempt to create a learning environment and learning process so that students actively develop their potential to have religious and spiritual strength, self-control, personality, intelligence, noble character, and skills needed by themselves, society, nation, and state, as stated in Law No. 20 of 2003 regarding the national education system. According to the concept of education given above, national education aims to optimize students' affective and psychomotor abilities while also enhancing their cognitive abilities. One of the subjects that is essential to schooling is mathematics[1]. Through mathematics, students are trained to think logically, critically, and systematically [2]. However, the reality in the field is that mathematics is the subject that is least in demand by students. Most students think mathematics is complex [3] and has nothing to do with their life. This makes sense because, in addition to being abstract, the educational process is still traditional and repetitive, which makes it less effective at

ICEHHA 2024, December 13-14, Ruteng, Indonesia

DOI 10.4108/eai.13-12-2024.2355558

maximizing students' potential. As expressed by [4], many educators need to understand how to learn mathematics well and have a direct impact on students in their daily lives. As a result, students need help understanding the abstraction of mathematical objects, which affects students' low interest and achievement in learning mathematics, both on a national and international scale.

The Organization for Economic Cooperation and Development (OECD) administers the Program for International Student Assessment (PISA), which measures students' proficiency in mathematics. The ability of students to recognize, comprehend, and apply mathematical ideas necessary for daily living is the main focus of the PISA study. According to the survey, Indonesia was ranked 39th out of 41 countries in 2000, 38th out of 40 in 2003, 50th out of 57 in 2006, 61st out of 65 in 2009, and 64th out of 65 overall in 2012 [5].

The government, in this case the Ministry of Education and Culture, has undertaken a number of initiatives to raise educational standards. Creating the curriculum is one of them. Three curriculum modifications have been documented in Indonesian education since 2000: the 2004 curriculum, the 2006 curriculum, and the most recent 2013 curriculum. These initiatives haven't, however, improved students' performance in global arenas. The 2020 PISA study's results, which ranked Indonesia 69th out of 80 countries, demonstrate this [6]. [7] explained, the results of the 2022 Program for International Student Assessment (PISA) research were recently announced on December 05, 2023, and Indonesia is ranked 68th with scores in mathematics (379), science (398), and reading (371).

Although the curriculum has evolved, the roles and responsibilities of teachers in mathematics education—which are largely related to how they present the material—have not changed [8]. The study's results [9] on Pangkal Pinang high school students showed that instructors' capacity to implement instruction has a favorable impact on students' learning results in mathematics. Therefore, it's important to consider the students' conditions when selecting the best learning model [10], the nature of the teaching materials [4], the available media facilities, and the condition of the teacher himself [11].

One of the educational abilities that math teachers need to possess is the ability to use information and communication technology (ICT) to enhance learning, as stated in Permendiknas RI No. 16 of 2007. Regretfully, schools continue to underutilize digital media, particularly when it comes to teaching mathematics. Due to time constraints and incapacity to use these resources, many math teachers do not incorporate ICT-based learning materials into their lessons. [12] stated that The majority of teachers in schools just used PowerPoint software and did not use the computers that were already there to aid in learning.

Numerous portable software programs and applications are available for use in mathematics education in the current technology era. Software such as Microsoft Mathematics, Speq Mathematic, Matlab, GeoGebra, and GeoEnzo are a few examples. In addition to serving as a visualization tool, integrating technology into math lessons helps pique students' enthusiasm in learning and acquaint them with new technologies. [13] states that Technology serves as a medium or instrument to speed up and facilitate students' work in addition to assisting to build favorable learning environments for their mindset. It also, of course, imparts sophisticated technology abilities. In light of this context, this essay will discuss how ICT might be used to help students become more proficient readers. The overall goal of this article's writing is to determine how much using ICT media to teach mathematics affects students' ability to become more literate.

2 Method and Materials

This study uses a literature review approach to understand the influence of ICT on mathematical literacy. This study involves analyzing and synthesizing various studies and journal articles relevant to the use of technology in mathematics education. The primary sources of information come from research publications, journal articles and related academic reports. With this approach, the study thoroughly understood the topic and identified trends, outcomes, and potential improvements in ICT-based mathematics learning.

The identification of data and articles for this systematic literature review followed a structured process using Google Scholar, Semantic Scholar, and Scopus as primary databases. The search was conducted using relevant keywords such as "ICT in mathematical literacy," "technology in math education," and "digital learning for mathematical skills." A total of 35 references were selected through a multi-stage process, including initial screening based on titles and abstracts, followed by a full-text review to ensure relevance. The inclusion criteria for article selection encompassed studies published in peer-reviewed journals or conference proceedings, research focusing on the impact of ICT on mathematical literacy skills, and publications within the last ten years to ensure up-to-date findings. Articles that lacked empirical evidence, were not written in English, or focused solely on theoretical discussions without clear methodological frameworks were excluded. This rigorous selection process ensured that only high-quality, relevant studies were included in the review.

Data for this study were collected through screening of academic literature by the topic of study. The data are classified based on subthemes, such as the type of ICT used, the results of its application in the context of mathematical literacy, and the challenges in applying this technology in schools. Data collection also involved the study of PISA reports as a critical reference to identify student's current level of mathematical literacy. This method of filtering literature helps identify the most relevant sources and provides a solid theoretical foundation.

The data analysis involves thematic analysis methods to review and group data from the collected literature. In this process, key themes such as ICT effectiveness, implementation constraints, and their impact on mathematical literacy are further analyzed. The data were analyzed to assess patterns in the results of existing studies and compare findings across different studies. Through this analysis, the research seeks to provide recommendations and identify the need for further research on using ICT in mathematical literacy.

3 Results and Discussion

3.1 Result

3.1.1 Mathematical Literacy

According to the United Nations Educational, Scientific, and Cultural Organization (UNESCO), "Literacy for All" is a buzzword. This tagline highlights that everyone has the fundamental right to literacy as a means of embracing life. The quality of life for people, families, and communities can all be enhanced by literacy. Eliminating poverty, lowering child mortality, slowing population growth, attaining gender equality, and promoting sustainable development, peace, and democracy are just a few of the many benefits of literacy [14].

The ability to create, use, and interpret mathematics in a variety of contexts, including mathematical reasoning and mathematical concepts, methods, facts, and instruments to describe, explain, and forecast phenomena, is referred to as mathematical literacy in PISA 2020. People who are literate are better able to understand the importance of mathematics in daily life and make the wise decisions and judgments required of them as thoughtful and active citizens. [10]

defines The ability of students to comprehend facts, concepts, principles, operations, and mathematical problem-solving is known as mathematical literacy. Another interpretation is conveyed by [15], who explains that understanding and applying the fundamentals of mathematics in daily life is known as mathematical literacy. Meanwhile, [16] states that The ability to formulate, use, and comprehend mathematics in a variety of circumstances is known as mathematical literacy.

It is evident from some of these insights that while mathematical knowledge and comprehension are necessary, problem-solving skills involving the application of mathematics are far more important. The table below lists the six mathematical literacy proficiency levels for students as determined by PISA [17]**.**

Table 1. Mathematical Literacy Ability Level According to PISA

No	Level	Learners' Abilities
1	6	Students are able to solve mathematical problems using reasoning, draw generalizations, and create and present their conclusions.
2	5	Students are able to address complicated problems and work with models for complex scenarios.
3	4	Students are able to choose and combine various representations, work with models efficiently, and then apply these to real-world situations.
4	3	Students are able to select effective problem-solving techniques and follow procedures while solving difficulties.
5	2	Students are able to decipher difficulties and use formulas to solve them.
6	1	Pupils can solve both routine and general problems using what they've learned.

3.1.2 The Implementation of ICT in Mathematics Learning

ICT (information and communication technologies) in mathematics learning is based on a philosophical foundation. [18] emphasizes Children and adults should be digitally literate not just for life skills but also to support secondary, post-secondary, and tertiary education. "Every student should have a calculator, possibly one with graphing capabilities, a computer should be available at all times in every classroom for demonstration purposes, and all students should have access to computers for individual and group work," according to the Curriculum and Evaluation Standard For School Mathematics (2000), which also recommends the use of ICT in education" [19].

In mathematics, research on ICT and mathematics learning has increased since the eighties, generally focusing more on handheld calculators, internet technology, and computer software [20]. [21] stated that ICT use can be used to gauge how well students are learning maths. ICT use in the classroom can be used with a variety of teaching strategies. As said [22], There are four approaches that can be used to integrate ICT with math education: Individual learning, cooperative learning, inquiry-based learning, and expository learning are the four types of learning. Application-based and technology-based learning media are indispensable in teaching development. According to [23], they are learning by utilizing technology as a medium, which is essential because, in terms of teaching and materials, both affect the results and interest of students in learning.

[24] states that For kids to become proficient problem solvers, team players, communicators, and creators, they must use technology. Students can use digital technology to organize,

integrate, and expand their knowledge. Students must be proficient in using technology for research, planning, assessing, and sharing information [5]. Thus, "Information and communication technologies (ICTs) must be harnessed to strengthen education systems, knowledge dissemination, information access, quality and effective learning, and more effective service provision," as stated in the Incheon statement [25].

Graphs, calculators, spreadsheets, computer graphics, algebra software, mathematics software, global positioning system (GPS) equipment, and online resources that align with learning methodologies are some instruments students can use to learn mathematics [26]. With these technologies, students can communicate mathematical thinking by constructing it through the appropriate function graph or statistical data graph.

3.1.3 The Implementation of ICT in Improving Literacy Skills

The term mathematical literacy was first used by NCTM (National Council of Teachers Mathematics) prior to its introduction through PISA. Mathematical problem solving, mathematical communication, mathematical reasoning, mathematical connection, and mathematical representation are the five skills in mathematics learning. Mathematical literacy is the skill that encompasses the five abilities [5]. Many studies have been conducted using ICT to improve the five competencies. Research [10], which highlights students' higher-level thinking skills, states that the use of GeoGebra in mathematics learning improves high-level mathematical skills, including mathematical communication skills, mathematical reasoning, and mathematical critical skills. [15] In his literature study, He concluded that kids who learned mathematics using GeoGebra had a significantly different capacity for mathematical reasoning than those who got direct instruction [27]. This also increases reasoning skills, so students' learning outcomes can improve compared to students who get direct learning without *GeoGebra*.

[28], the use of computer learning materials in conjunction with Cabri Geometry II software to teach geometry has an impact on the development of mathematical connection skills, according to his experimental study on the improvement of mathematical connections among grade VIII students at SMP Negeri 26 Bandung through the study of Van Hiele Geometry. Meanwhile, [29] conducted a research on how well the TPS model can be learned with the help of Geometer's Sketchpad to assess students' proficiency in solving problems using grade VII triangular material. According to the study's findings, students who used the TPS model in conjunction with Geometer's Sketchpad software performed better on average on the problem-solving ability test than both students who used the expository method and students who used the TPS learning model alone.

The study's results [30] showed that the student's understanding of the concept in the trigonometry function graph that obtained the guided discovery approach assisted by Autograph software was higher than that of the students who received the usual approach. Another study was conducted using OneNote Class Notebook software by [31] to determine the ability of mathematical literacy to be reviewed from metacognition. The survey results stated that CPM learning assisted by OneNote Class NoteBook can improve students' metacognition, impacting mathematical literacy skills. Previously, [32] had also researched literacy abilities reviewed from the Mailing Merge worksheet-assisted metacognition. The results of the research stated that inquiry learning assisted by Mailing Merge worksheets was able to facilitate students in solving mathematical problems independently through discussions, class presentations, and individual assessments, which improved students' mathematical literacy skills.

3.2 Discussion

Research on using ICT to improve mathematical literacy skills shows that integrating technology in mathematics learning contributes significantly to student understanding. The results show that digital tools, such as educational software, interactive simulations, and math applications, provide a more immersive learning experience and help students understand abstract concepts more practically and visually. In this context, ICT provides access to a broader range of materials and fosters interest in learning mathematics, especially in developing analytical and problem-solving skills.

The implications of this study include a paradigm shift in mathematics teaching methods, where teachers are encouraged to adopt technology as an essential tool in learning. The application of ICT allows for a more student-centered approach to learning, which helps to develop critical thinking and problem-solving skills. Given the low level of mathematical literacy among students reflected in the 2020 PISA score, this implication is essential in the Indonesian context, suggesting that improvements in learning methods may contribute to this increase in scores.

According to the study's findings, students can develop the foundational skill of mathematical literacy by using ICT to help them make links between abstract mathematical ideas and real-world scenarios. With ICT, students can explore and interact with the material directly, which allows them to gain a deeper and more relevant understanding. This learning experience encourages active student engagement, increases interest in learning, and provides opportunities to learn independently [33], [34].

This study is in line with several other studies that show the effectiveness of ICT in improving mathematical literacy skills. Several developed countries have shown that using digital tools in mathematics learning positively impacts students' understanding of this field [20]. In Finland, in comparison, ICT is used extensively in education and contributes to the acquisition of higher PISA scores [35]. The difference between outcomes in Indonesia and these countries highlights the importance of applying ICT in learning to close the education gap [7], [21]. Based on the results and interpretations above, this study recommends further research on Indonesia's most effective ICT approach in mathematics learning. An in-depth analysis of contextual and adaptive ICT implementation methods can help find the right strategies to improve mathematical literacy skills at large. In addition, further research could explore the development of educational software tailored to the national curriculum and involve teacher training to maximize the effectiveness of technology in teaching.

4 Conclusion

The use of ICT in mathematics education has a positive effect on reasoning abilities, mathematical communication, problem-solving, and mathematical connections—all of which are part of the five competencies in mathematical literacy—according to the explanation given above and research on the subject. Students' reading abilities can be indirectly enhanced by the usage of ICT in the classroom. The effectiveness of media use, in this case ICT, depends on the model, learning strategy, teaching materials, and teachers' mastery of the applications or software used. Therefore, the author hopes teachers will also consider these factors before using ICT.

Acknowledgments. The authors would like to express their sincere gratitude to the Ganesha University of Education, Bali, Indonesia, especially for Doctoral Education Study Program - the continuous support and academic guidance throughout this research. Special appreciation is

extended to the faculty members and colleagues who provided valuable insights and constructive feedback during the study. Lastly, the authors acknowledge the contributions of researchers whose works have been referenced in this systematic literature review.

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