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Edupreneurial Innovations in Mathematical Literacy and Global Instructional Practices

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ABSTRACT

This study provides a global synthesis of pedagogical innovations and research developments in mathematical literacy from 2022 to 2026, uniquely emphasizing an edupreneurial perspective that integrates entrepreneurial creativity into mathematics education through innovative teaching and learning practices. **The analysis utilizes** the Scopus, ERIC, and Google Scholar databases to identify global trends and research gaps. Employing the Systematic Literature Review (SLR) method based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework, a total of 564 articles were initially identified, with selected studies analyzed to address predefined research questions. **The review highlights** that research on mathematical literacy is predominantly characterized by qualitative and quantitative approaches, with junior high school students as the most frequent subjects and research settings. A growing trend in edupreneurial pedagogical practices is evident through the integration of contextual problem-solving strategies, ethnomathematical perspectives, and technology-enhanced learning models. Recommendations for future research and policy include strengthening teacher conceptual understanding of mathematical literacy, developing contextually rich assessment models, advancing technology-integrated instruction, and expanding research toward psychological factors influencing mathematical literacy. Moreover, **the study underscores** the need for increased research at the vocational education level and calls for education policymakers to design and implement professional development programs aimed at enhancing teachers' and students' competencies in mathematical literacy through innovative, entrepreneurial-based learning approaches.

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1. INTRODUCTION

The rapid development of technology in the era of globalization has significantly influenced various aspects of life, particularly education quality. Through its diverse applications, technology supports society and educational institutions by enhancing daily learning and administrative activities [1]. The demands of educational institutions to be able to develop learning that is in accordance with the development of the times

must be prepared. Therefore, the rapid development of technology requires teachers to be responsive and quick in adapting, thinking creatively and innovatively to create interesting learning in accordance with the development of the times through digital technology-based learning that also embraces edupreneurial skills. By fostering an edupreneurship mindset, educators are encouraged not only to utilize technology but also to design and offer innovative, adaptive, and sustainable learning experiences. This mindset transforms teachers into edupreneurial actors who integrate business thinking, value creation, and opportunity recognition within educational contexts [2].

In line with the demands of educators to be able to teach students from the millennial generation according to their needs, technology has become the most important tool in accessing information. Students spend most of their time with gadgets, making technology an integral part of their learning experience [3]. Along with the rapid development of knowledge and technology, educational institutions must also evolve through innovative approaches that can provide solutions to various educational challenges.

Mathematical understanding examines the capacity to use mathematical concepts effectively in real-life contexts, helping to improve literacy skills across different levels and playing a crucial role in everyday decision-making [4, 5]. Mathematical concepts assist individuals in understanding and applying mathematical skills in daily life. In the context of 21st-century education, these skills are essential for adapting to modern society, with mathematical literacy being one of the most important competencies to possess. The Ministry of Education and Culture emphasizes that 21st-century skills consist of three main components: basic literacy, competence, and character [6].

Mathematical literacy refers to the ability to formulate, use, and interpret mathematics in various contexts. It includes the capability to reason mathematically using concepts, procedures, and facts to describe and analyze real-world phenomena [7, 8]. Previous studies have shown that learning models such as the flipped classroom can enhance teachers' abilities to improve mathematical literacy, and the use of digital tools such as WhatsApp modules has been found effective for this purpose. Other studies indicate that flipped learning approaches can also reduce students' mathematics anxiety [9].

Integrating edupreneurial approaches into these learning innovations empowers educators to think creatively and entrepreneurially in designing and delivering engaging, student-centered mathematics instruction. Such edupreneurship enables teachers to act as innovators who utilize digital platforms and contextual materials to meet diverse learners' needs while promoting 21st-century competencies [10, 11].

Several studies have explained that students who engage in Problem-Based Learning (PBL) models demonstrate better mathematical literacy compared to those in non-PBL settings [12]. Factors that influence mathematical literacy include learning independence, motivation, and self-efficacy. Various models such as problem-posing learning and Realistic Mathematics Education (RME) supported by multimedia tools like Adobe Flash have been shown to enhance literacy outcomes. Additionally, research on mathematical anxiety reinforces the importance of addressing psychological factors in learning. These factors include self-efficacy, motivation, involvement, anxiety, attitudes, cognitive-linguistic skills, and peer tutoring, as well as teachers' pedagogical strategies. Cooperative learning approaches are particularly effective in reducing mathematics anxiety [13, 14].

These studies reinforce the importance of continuing to explore mathematical literacy research. Building upon the authors' prior work in edupreneurial learning design and mathematical literacy development, this review identifies effective global practices and innovations that bridge pedagogy with entrepreneurial perspectives in education [15]. It also serves as a guide for educators and policymakers to better understand factors influencing mathematical literacy and to design more adaptive, entrepreneurship-oriented learning models [16].

2. LITERATURE REVIEW

Mathematical literacy also aligns closely with the Sustainable Development Goals (SDGs) established by the United Nations, particularly SDG 4 (Quality Education) and SDG 9 (Industry, Innovation, and Infrastructure). SDG 4 emphasizes inclusive and equitable quality education as well as lifelong learning opportunities for all, which directly connects to the goal of enhancing mathematical literacy as a foundational 21st-century competency [17]. Meanwhile, SDG 9 encourages innovation and sustainable industrialization, where mathematical and digital literacy play critical roles in building creative, problem-solving, and technology-oriented mindsets. By integrating mathematical literacy with edupreneurial approaches, educational institutions not only foster cognitive and analytical abilities but also contribute to achieving global sustainability through innovative

pedagogical practices and the development of future-ready learners [18].

Efforts to improve mathematical literacy can be achieved by providing students with opportunities to solve problems in real contexts, such as personal, social, work, and cultural contexts. The mathematics curriculum in Indonesia has been optimized to integrate mathematical literacy, with learning outcomes tailored to the characteristics of mathematics as a subject [19, 20]. Similarly, Singapore has developed a curriculum framework that includes concepts, skills, processes, metacognition, and attitudes to build mathematical literacy competencies. In contrast, China emphasizes problem-solving abilities, using them to develop ideas that align with mathematical literacy competencies [21].

3. RESEARCH METHODS

This study employs the Systematic Literature Review (SLR) method, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, to systematically summarize and present comprehensive findings from primary studies. The steps in collecting journals were designed to ensure the management and quality of objectives, thus improving and maintaining good practices in developing SLR methodologies [22, 23]. Literature studies were conducted through Harzing's Publish or Perish (PoP) application, as well as Scopus, Google Scholar, and ERIC databases.

The formulation of the research questions (RQ) is as follows:

- RQ1: What are the research trends related to mathematical literacy over the last 5 years (2022–2026)?
- RQ2: What learning strategies have been used to improve mathematical literacy?
- RQ3: What recommendations have been made to improve mathematical literacy?

3.1. Research Procedure

The search process is conducted across several academic databases, including Scopus, Google Scholar, and ERIC, using Boolean operators to refine and narrow the search results. These operators connect keywords and phrases, allowing for more targeted and efficient retrieval of relevant academic articles. By combining terms with operators such as "AND", "OR", and "NOT", Boolean logic helps eliminate irrelevant studies while expanding coverage to include closely related topics. This process ensures that the literature gathered aligns precisely with the research objectives and scope. In addition, the structured use of Boolean logic enhances transparency and reproducibility, which are essential components of a rigorous SLR [24, 25]. Overall, this approach increases the precision of the literature search and supports the identification of key studies most relevant to the field. Table 1 below outlines the Boolean indicators and strategies applied in this study to optimize the search process.

Table 1. Search via Boolean Indicators

Database	Search with Boolean Indicators
Scopus	(”mathematical literacy” OR ”mathematics literacy” OR ”numeracy skills”) AND (”learning” OR ”education” OR ”teaching”) AND (”SLR” OR ”SLR” OR ”review study”)
ERIC	(”mathematical literacy” OR ”numeracy skills”) AND (”learning” OR ”teaching”) AND (”SLR” OR ”review study”)
Google Scholar	”mathematical literacy” OR ”numeracy skills” AND (”learning” OR ”education”) AND ”SLR” OR ”SLR”

- Inclusion and exclusion criteria
  The inclusion and exclusion criteria were established to ensure methodological transparency and consistency throughout the PRISMA selection process [26], where articles were included if they were published between 2022 and 2026, constituted peer-reviewed empirical studies or case studies, and were directly related to mathematical literacy or edupreneurial pedagogical innovations, while non-empirical works such as theses, reports, and book chapters were excluded, resulting in 79 studies meeting the inclusion

criteria out of an initial 564 records and 37 being retained for full analysis, as reflected consistently in Table 2 and Figure 1 without repetition [27, 28].

Table 2. Inclusion and Exclusion Criteria

Inclusion Criteria	**Exclusion Criteria**
Articles published between 2022 and 2026	Articles published before 2022
The type of article is a research article or case study.	Types of articles other than research articles or case studies
Empirical research published through international journals	Book Chapters, theses, dissertations, short reports, and non-empirical studies or articles that provide little empirical evidence
Related to the study of mathematical literacy	Not related to mathematical literacy studies

- Data extraction and critical evaluation
  Data extraction and critical evaluation is a step in a systematic review that requires in-depth planning and testing. This process is illustrated in a high-definition PRISMA flow diagram in Figure 1, ensuring improved visibility and accuracy in depicting each selection stage [29, 30]. A total of 564 articles were initially identified, 79 were screened, and 37 were included in the final analysis. To further clarify the study's theoretical foundation, a new conceptual figure 1 has been added to illustrate the relationship between edupreneurial innovation, pedagogical strategies, and mathematical literacy outcomes. This diagram emphasizes how innovative teaching practices contribute to entrepreneurial thinking and sustainable educational development [31].

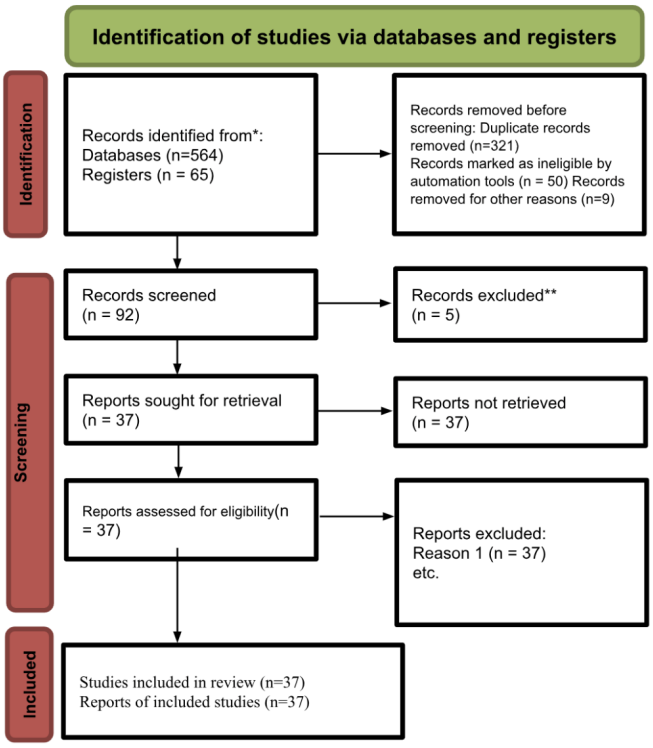

Figure 1. PRISMA flowchart

4. RESULTS AND DISCUSSION

Based on a review of studies discussing research trends in mathematical literacy and mathematical anxiety in learning, formulated within the research questions and systematically selected through several stages of the PRISMA procedure [32, 33], the analysis identified common patterns related to research design, participant characteristics, and educational settings. These findings highlight the growing focus on integrating technology and innovative learning approaches to enhance mathematical literacy. The summarized results, as shown in Table 3, were produced to answer RQ1:

Table 3. Research Trends Related to Mathematical Literacy

No	Year	Literature Mathematical Literacy
1	2022	[18, 32, 34–39]
2	2023	[3, 4, 7, 16, 40]
3	2024	[19, 41–51]
4	2025	[21]
5	2026	[17, 27, 29, 31]
Total		30

RQ1: Research Trends Related to Mathematical Literacy 2022-2026

Figure 2 illustrates the overall classification and interrelation of key variables examined in global studies on mathematical literacy between 2022 and 2026. The visualization highlights four primary dimensions Design Study, Data Collection, Participants, and Country that collectively shape research trends in mathematical literacy.

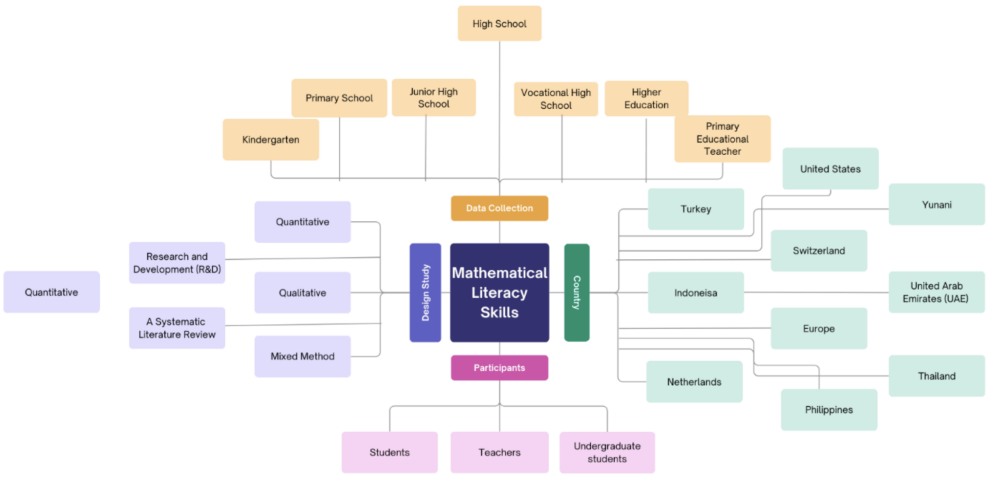

Figure 2. Classification of Mathematical Literacy Research Trends

In terms of Design Study, most research applied quantitative and qualitative methods, followed by Research and Development (R&D), SLR, and a few mixed-method approaches. Under Data Collection, the diagram shows that the largest number of studies were conducted at the junior high school level, followed by primary school, high school, and higher education, with limited research found in kindergarten and vocational high schools.

Regarding Participants, most studies focused on students, while a smaller number involved teachers and undergraduate students, reflecting an emphasis on classroom-level investigations. Finally, the Country dimension shows that mathematical literacy research is globally distributed, with major contributions from Indonesia, Turkey, Switzerland, the United States, the Netherlands, the Philippines, Thailand, the United Arab Emirates (UAE), Europe, and Greece (Yunani).

Overall, the figure demonstrates the diversity of research methodologies, educational levels, and geographical contexts, emphasizing a balanced global interest in developing and understanding mathematical literacy skills through varied pedagogical approaches.

4.1. Research Trends in Mathematical Literacy

The analysis of research trends revealed details on four key aspects: research methods, data collection procedures, research locations, and participant types [34]. As shown in Tables 4, 5, and 6 below, most studies applied quantitative and qualitative approaches, engaging students and teachers from various countries to explore mathematical literacy development:

Table 4. Mathematical Literacy Research Methods

Design Study	2022	2023	2024	2025	2026	Amount
Quantitative	4	5	1		4	10
Qualitative	3		5			11
Mixed Method			1			1
R&D	1	1				3
A SLR			3	1		4
Amount	**8**	**6**	**10**	**1**	**4**	**29**

From Table 4, it can be seen that most studies on mathematical literacy use quantitative and qualitative methods, showing a balance between numerical analysis and contextual exploration. The emergence of R&D and SLR approaches in recent years indicates a growing trend toward developing new learning models and synthesizing global research findings. This reflects an increasing effort to connect innovative teaching practices with deeper theoretical understanding in mathematical literacy.

As for data collection from the Mathematical Literacy Literature Review:

Table 5. Collection of Mathematical Literacy Data

Data Collection	2022	2023	2024	2025	2026	Amount
Kindergarten			1			1
Primary School	1		4			5
Junior High School	6	5			2	12
High School			4			5
Vocational High School	1					1
Higher Education		1	1	1	1	3
Primary Education Teacher			1		1	2
Amount	**8**	**6**	**11**	**1**	**4**	**29**

From the data in Table 5 Above, the highest distribution of data collection was obtained with the distribution of research from 2022-2026 as many as 18 studies at the Junior High School level. Research at the Kindergarten (TK) and Vocational High School (SMK) levels is still minimal, so it becomes a recommendation for future research [35, 44].

4.2. Subjects of Research That Have Been Conducted

Table 6. Subjects

Participants	2022	2023	2024	2025	2026	Total
Students	7	5	6		3	20
Teachers	1		4			6
Undergraduate Students		1	1	1		3
Amount	**8**	**6**	**10**	**1**	**4**	**29**

The analysis of study participants or participants who were used as research subjects with the highest category was carried out by students (from various levels of education) which was then followed by teacher participants and university undergraduate students [36, 52].

RQ 2: Learning Innovations Used to Improve Mathematical Literacy

This article presents an analysis of effective learning innovations aimed at improving mathematical literacy through various pedagogical approaches and technology-based strategies [37]. One of the highlighted

models is the Realistic Treffinger Learning model assisted by Schoology, which has shown strong effectiveness in enhancing students' mathematical literacy skills compared to the PBL model. Similarly, the Techno-Mathematical Literacy Strategy (TML) integrates didactic, process-oriented, and inquiry-based learning approaches to strengthen students' mathematical understanding [38, 53].

Activity-based learning strategies have also been implemented to improve mathematical literacy by providing students with practical experiences that connect classroom learning to real-world applications [45]. However, mathematical literacy problems are still insufficiently addressed in standard textbooks and are mostly available in online resources related to PISA and TIMSS examinations [39].

The RME approach, supported by digital tools such as Adobe Flash Professional CS6, has contributed to improving students' literacy through the promotion of self-regulated learning [46]. The Contextual Teaching and Learning (CTL) strategy also plays an essential role, as it connects mathematical concepts to real-life situations, allowing students to better understand and solve problems [40].

Technology integration further enhances mathematical literacy through ICT-based STEM learning models, which have demonstrated significant positive outcomes following experimental analysis [41]. Moreover, the development of e-learning–based teaching materials, particularly in statistics, has shown a positive impact on mathematical literacy. The application of Guided Inquiry Learning with Augmented Reality (GILAR) further supports interactive and visual engagement in mathematics learning [42].

Beyond individual strategies, learning models such as STEMEN and flipped classroom approaches using WhatsApp modules have also proven effective in improving students' mathematical literacy and problem-solving abilities [43].

This article presents an analysis of effective pedagogical innovations to enhance mathematical literacy, including models such as Realistic Treffinger Learning, TML, and STEM-ICT–integrated approaches. To provide a clearer overview of these innovations, research gaps, and recommendations, an explanatory summary has been added Table 7.

Table 7. Summary of Pedagogical Innovations, Research Gaps, and Recommendations

Pedagogical Innovation	**Key Findings**	**Identified Research Gaps**	**Recommendations**
Realistic Treffinger Learning (Schoology-assisted)	Improves student literacy and engagement compared to traditional PBL	Limited to junior high level studies	Extend to vocational and higher education contexts
Techno-Mathematical Literacy Strategy (TML)	Integrates technology to strengthen conceptual reasoning	Lack of longitudinal studies on digital integration	Encourage blended-learning models with entrepreneurial context
Ethnomathematics-based Learning	Enhances contextual understanding through cultural relevance	Few studies link cultural context to edupreneurial innovation	Develop culture-based entrepreneurial learning projects
STEM-ICT Integrated Model	Promotes innovation and collaboration in problem-solving	Limited data on implementation challenges	Conduct cross-country comparative analysis
Flipped Classroom (WhatsApp Module)	Boosts self-regulated learning and reduces math anxiety	Minimal exploration of business /entrepreneurship integration	Combine flipped pedagogy with project-based edupreneurial models

RQ 3: Recommendations for Mathematical Literacy Perspectives for the Future

Perspective is a way for someone to see or understand something from various perspectives that underlie it. This analysis underlies the understanding of perspective on mathematical literacy, with the literature that has been analyzed starting [47]. The perspectives analyzed in the study are:

- Teacher Conception The understanding of secondary school teachers toward mathematical literacy in this study reveals that teachers perceive it in various ways some view it as practical mathematics or

problem-solving skills, while others associate it with mathematization, reasoning and argumentation, innate mathematical ability, conceptual understanding, and motivation to learn mathematics [54]. This variation in perspective indicates a lack of unified understanding of what mathematical literacy truly represents. Teachers' conceptions of mathematical literacy significantly influence how they design learning and assessment strategies to measure literacy achievement. Therefore, this study recommends the development of professional programs through seminars and training on mathematical literacy to strengthen teachers' conceptual understanding [49]. Curriculum design should also emphasize literacy competencies, and contextual learning modules should include question development guidelines and literacy-based assessments [50].

Further studies have shown that a large proportion of teachers still have insufficient knowledge about mathematical literacy. Many demonstrate stronger understanding of classroom learning processes than of literacy assessment frameworks such as those applied in international evaluations [51]. These findings suggest the need to promote mathematical literacy awareness across teacher communities through structured programs and professional development initiatives [55].

In addition, an in-depth analysis highlights the importance of understanding mathematical language and symbols between teachers and students as part of efforts to enhance literacy [56]. The introduction of frameworks such as LEPsco, designed to improve teachers' comprehension and application of mathematical literacy in educational settings, contributes to this goal [57]. Strengthening teachers' conceptual understanding through professional approaches remains essential, particularly by aligning training with the OECD definition and contemporary theories of mathematical literacy, while integrating literacy-based learning into the curriculum and contextual classroom practices [58].

- Contextual Based Problems
  Analysis of the perspective of the problems studied from mathematical literacy also obtained that the analysis of student success in completing contextual and non-contextual tasks, the strategies used, showed that the relationship between mathematical knowledge and mathematical literacy is very complex [59]. Students in many cases are more successful in completing non-contextual tasks where, the recommendation from this study is that the context chosen is mathematical content in contextual cases or problems using authentic material related to everyday life and culture, because it has a significant impact on the teaching and learning process [60]. Mathematics is not culturally neutral but its growth is the result of interactions between humans and the environment that reflect the cultural values of society. Conducting further contextual research by exploring more deeply how mathematical values are formed from the context of multicultural schools, post-pandemic situations and online or hybrid learning is a recommendation. Mathematics learning that integrates culture is ethnomathematics [61]. This learning significantly increases mathematical literacy compared to conventional learning. This proves that learning with contextual content with an ethnomathematics approach provides a different learning experience, thereby increasing mathematical literacy [62]. Integrating learning with an ethnomathematics approach in the curriculum, especially in the material of transformation geometry and uncertainty and data, using innovative media such as Pop-Up Books based on ethnomathematics and a visual thinking approach that has an effect on mathematical literacy, the use of technology and the expansion of other meta-analysis topics are recommended in research [63].

- Assessment Techniques
  Another perception about mathematical literacy is obtained from analysis related to assessments that must be understood, this is confirmed by research results that the assessment model for assessing mathematical literacy in each domain needs to be studied so that the ability of each stage can be measured and students' difficulties in solving problems can be described and how to overcome them can be planned [64]. Training is provided to high school mathematics teachers who must be given how to create good mathematical literacy problems and can provide information on the differences in problems used to measure mathematical literacy [65]. Likewise, enrichment for students with the aim of strengthening understanding of PISA questions is carried out because enrichment will form good habits and consolidation. In line with research by producing performance based on personal and social contexts as the most capable contexts while scientific and occupational are the weakest. The recommendations put forward are that teachers need to be trained to formulate questions that accustom students to changing real situa-

tions into mathematical models (formulate), improve mathematical reasoning skills (reasoning) through exploratory and reflective training based on problems and realistic and create enrichment programs based on PISA to prepare students to understand high-level questions based on real contexts [66, 67]. The development of contextual-based remedial learning packages is also carried out in improving mathematical literacy and information on reviewing research subjects in terms of gender, which results in an analysis of the abilities of male students with the abilities of representation, modeling, mathematical communication and problem posing that they have, while the ability to use mathematical symbols, think and reason mathematically for female students, as well as an assessment of the components of mathematical argumentation and the use of technological tools is recommended in research.

- Technology Assisted Learning
  Distance learning also provides good recommendations for future research on the relationship between mathematical literacy levels in effective distance learning conditions post-Covid-19 to improve mathematical literacy, so that it continues to be implemented as a learning medium by considering the conditions that do not yet allow learning to be carried out at school. Another recommendation regarding the focus of research on the use of models to improve mathematical literacy. The use of Google Classroom technology or other LMS platforms as a means of connecting learning inside and outside the classroom is a recommendation for learning with the Flipped Classroom model. The positive impact of increasing mathematical literacy by using technology is very significant for the quality of learning. Integration of technological literacy in the curriculum is a recommendation in numeracy and problem-solving learning. Flipped classroom, blended learning, and application-based e-learning are developed more widely at the elementary and secondary education levels. STEAMIL Module digital learning is significantly more effective than conventional learning in improving mathematical literacy with a contribution effect of 16.1%. The design of the module based on the local cultural context must be developed by integrating STEAM-Inquiry learning into the Merdeka curriculum.

- Psychological factors that influence
  Information on psychological factors that influence the improvement of mathematical literacy by exploring the role of self-efficacy and learning environment with recommendations for future educators or researchers to improve self-efficacy, math anxiety, and self-regulated learning.

- Discussion
  Increasing mathematical literacy is one of the focuses of abilities in the 21st century. Mathematical anxiety is one of the factors that causes a decline in mathematical literacy. This study analyzes the research trends that have been carried out, and based on the discussion, it can be concluded that in improving mathematical literacy, particularly when viewed through the lens of mathematical anxiety, the resulting research trend from 2022 to 2026 indicates a steady increase in the focus on this area. Mathematical literacy continues to gain significant attention globally, as evidenced by approximately 10 countries actively researching the quality and enhancement of mathematical literacy through various strategic efforts. The recommendations emerging from these studies offer valuable insights into improving mathematical literacy and provide actionable guidelines for educators and policymakers.

  This study primarily explores current trends and key recommendations in enhancing mathematical literacy. Future work should integrate supporting cognitive, affective, and psychomotor factors that influence learning outcomes. In addition, educators should adopt edupreneurial strategies that foster innovation and adaptability in mathematics instruction. Emphasizing contextual and non-routine problem-solving can stimulate real-life thinking and improve students' conceptual understanding. This integration is expected to significantly improve students' literacy skills and better prepare them for the challenges of the 21st century.

5. MANAGERIAL IMPLICATIONS

The findings of this study offer actionable insights for policymakers, educational leaders, and practitioners seeking to enhance mathematical literacy through edupreneurial approaches. Policymakers should integrate entrepreneurial thinking into national curricula to promote creative and sustainable education systems

aligned with SDG 4 (Quality Education). Education managers are encouraged to foster institutional ecosystems that support teacher innovation, business-model thinking in pedagogy, and technology-based learning initiatives.

For practitioners, adopting edupreneurial strategies means designing learning experiences that merge mathematics with real-world business applications such as digital startups, design-based projects, and innovation-driven problem-solving. These efforts can improve students' engagement, motivation, and readiness for industry challenges. By institutionalizing these strategies, educational institutions can transform mathematical literacy from a purely academic skill into a foundation for creative economic growth and social innovation. Further studies should also explore other factors influencing low mathematical literacy, such as socio-economic factors and the role of digital tools in enhancing mathematical understanding.

6. CONCLUSION

Enhancing mathematical literacy is recognized as a key component of 21st-century skills and aligns directly with the SDGs, particularly SDG 4 (Quality Education) and SDG 9 (Industry, Innovation, and Infrastructure). The integration of edupreneurial approaches in mathematics education supports SDG 4 by promoting inclusive, equitable, and innovative learning environments, while also advancing SDG 9 through the development of creative educational technologies and entrepreneurial ecosystems. From 2022 to 2026, global research on mathematical literacy has shown steady growth across at least ten countries, reflecting a collective movement toward educational innovation and sustainable development.

One critical factor affecting students' mathematical literacy is mathematical anxiety, which continues to be a significant barrier to achieving optimal learning outcomes. Research trends highlight the increasing use of contextual problem-solving strategies, integration of mathematical concepts, and student-centered approaches as effective methods to address this issue. These approaches not only improve mathematical understanding but also foster confidence, critical thinking, and adaptability among learners in diverse educational contexts.

However, this review remains limited to identifying research trends and general recommendations. Therefore, future research should explore supporting factors such as cognitive, affective, and psychomotor domains that influence mathematical literacy. Teachers are encouraged to provide students with regular exposure to contextual and non-routine problems reflecting real-life situations and to implement integrated learning models that promote deeper understanding. Vocational high schools should be prioritized due to limited existing research, and parental involvement is recommended to strengthen students' mathematical development. Lastly, interdisciplinary studies incorporating technological innovation and edupreneurial approaches are essential to design more engaging, future-oriented, and sustainable mathematical learning experiences.

7. DECLARATIONS

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7.2. Author Contributions

Conceptualization: SS; Methodology: NA; Software: SM; Validation: SB and EP; Formal Analysis: NA and WW; Investigation: SB; Resources: SS; Data Curation: EP; Writing Original Draft Preparation: NA and WW; Writing Review and Editing: SB and EP; Visualization: SM; All authors, SS, WW, SM, SB, EP, and NA, have read and agreed to the published version of the manuscript.

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The data presented in this study are available on request from the corresponding author.

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7.5. Declaration of Conflicting Interest

The authors declare that they have no conflicts of interest, known competing financial interests, or personal relationships that could have influenced the work reported in this paper.

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