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Sianne Sarif, Ismail Djakaria, and Hasan S. Panigoro

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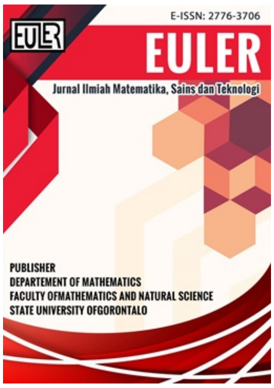

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Review Article

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Systematic Literature Review on the Integration of Technology in Enhancing Problem-Solving Skills in Mathematics Education

Sianne Sarif[1], **Ismail Djakaria**[2], **Hasan S. Panigoro**[3,*]

[1]*Magister Program in Mathematics Education, Universitas Negeri Gorontalo, Gorontalo, 96128, Indonesia*
[2]*Department of Statistics, Universitas Negeri Gorontalo, Bone Bolango, 96554, Indonesia*
[3]*Department of Mathematics, Universitas Negeri Gorontalo, Bone Bolango, 96554, Indonesia*

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ABSTRACT. *This systematic literature review explores how technology is being used in math instruction students and the effect on this issue of problem-solving. Based on nine chosen studies, the review synthesises evidence about which kind of technological tools help improve problem-solving skills and the advantages and disadvantages of their use. The results show that the integration of technology positively helps students improve their problem-solving performance within pedagogically aligned learning activities, one that fosters strategic thinking, metacognitive skills and collaborative involvement. Some suitable tools are dynamic mathematics software, computer algebra system, Interactive learning tool and TPACK (technological pedagogical content knowledge) based technology. It also notes that benefits come with the caveat of schools not yet being prepared to teach, curriculum alignment and sufficient access to materials for learning, while challenges include equity of technology infrastructure, inadequate training and the speed at which digital tools change. The synthesis provides overall evidence of a conditional but significant effect of technology on developing problem-solving skills in mathematics education.*

1. Introduction

Technology use in mathematics education has undergone incredible changes the last few decades. As 21st-century technology-infused learning environments become more prevalent and access to digital tools for students grows, teachers are starting to investigate how technology can better support math instruction. Firstly, the use of various technological tools (computer algebra systems (CAS), dynamic geometry software, learning platforms in a moodle environment) produces possibilities for visualizing complex mathematical ideas and calling students to solve problematic tasks actively. Instead of passive recipients of knowledge, students became active learners in adapting the mathematical concepts to their context, which has changed the modality of teaching [1]. Learners are able to play with mathematical problems, change variables and receive instant feedback through technology which helps deepen their understanding of abstract concepts [2].

With this development, the push for technology integration in math education has experienced some growing pains. However, there is a significant gap between the technology and its implementation in classrooms. However, due to factors such as lack of resources, teacher training and infrastructure challenges that need to be overcome many schools are still struggling in fully integrating digital tools into the curriculum [3]. Decision-making plans that rely on technology can greatly teacher effectiveness, but the more technological tools

*Corresponding Author.

Email : *hspanigoro@ung.ac.id* (H. S. Panigoro)
Homepage : http://ejurnal.ung.ac.id/index.php/euler/index / E-ISSN : 2776-3706

used, the more pedagogically sound planning must take precedent in how these forms of enhancement play a role in effective learning [4]. Inadequately-trained teachers who implement technology may find it difficult to integrate instruction and integration seamlessly, which can result in fragmented learning opportunities for students. Moreover, the fast-moving nature of technological change provides a perennial challenge to educators striving to stay at the forefront of new tools, platforms and best practices [5]. These obstacles can stifle the capacity of technology to really improve in deep, meaningful ways how students solve problems in mathematics.

However, when appropriately applied, technology can vastly improve students' problem-solving skills. Interactive simulations, platforms for online collaboration, and so forth mathematical software tools are some students can do collaborative activities such as problem solving. These instruments promote students to engage in critical thinking, cultivate new approaches, as well as improve their problem-solving processes [6]. The engagement that technology encourages gives students the opportunity to explore solutions to mathematical problems in different ways, thus enhancing their understanding of what it means. In addition to this, technology fosters the development of metacognitive skills, with students monitoring their progress and adjusting on-the-spot based on real-time feedback from the tools they employ [7]. Self-regulation and reflection that takes place as part of this process makes further contributions to developing cognitive and analytic abilities, both important in mastering mathematical problem-solving.

Further, technology fits with current pedagogical paradigms that highlight active, student-centered learning. Constructivist and inquiry-based approaches to the teaching of mathematics strongly recognise that learners must be active constructors of their own understanding. While dynamic geometry software and interactive platforms allow student to visualize and interact with mathematical concepts, thus making abstract notions more tangible and comprehensible [2]. Since these tools enable students to investigate through hands-on how mathematical relationships work and notice patterns, they align with the principles of constructivism. Technology is not just an enabler of individual exploration, it also allows collaborative learning one of the most significant components in modern pedagogical strategies. Discussion boards, online classrooms, or collaborative workspaces where students communicate with their peers to share ideas and deepen the reasoning process strengthen problem solving ability and communication of mathematical ideas [6].

Incorporating more technology into mathematics education becomes an increasing phenomenon, so a better understanding of the pros and cons regarding technology usage is essential. Though there is great opportunity in improving problem-solving and math understanding, these things also require teachers to address the complexities surrounding technology in their classrooms. So, making sure that teachers are receiving professional development and have adequate access to resources is necessary for technology in the classroom to be effective. Also, resolving challenges of inequitable access to technology within schools and regions remains essential in order for all students to realise the benefits of these advancements in technology [8]. Nevertheless, the increasing number of studies points to a nuanced and often more positive picture where technology, when carefully planned and deployed in mathematics education, seems capable of making large contributions to developing student problem solving.

The following research questions guide this systematic literature review:

RQ1 : How does the integration of technology in mathematics education impact students' problem-solving skills?
RQ2 : What types of technological tools are most effective in enhancing problem-solving abilities in mathematics education?
RQ3 : What are the challenges and benefits of integrating technology in teaching problem-solving skills in mathematics?

2. Methods

2.1. The Prisma Methods

This systematic literature review (SLR) used the new PRISMA 2020 standard to provide a transparent, rigorous, and reproducible review process framework for studying technology integration in mathematics education by improving problem-solving skills. PRISMA is widely recognized as a benchmark for systematic evidence synthesis because it offers a structured procedure for identifying, screening, assessing eligibility, and selecting studies for inclusion, supported by a 27-item checklist and a flow diagram that documents each review stage in a transparent manner [9]. In this review, PRISMA was selected because its emphasis on methodological clarity aligns well with the objective of synthesizing evidence across diverse educational contexts and technological interventions. The review process was guided by three research questions concerning the impact of technology integration on students' problem-solving skills, the types of technological tools that are most effective, and the benefits and challenges associated with their implementation in mathematics instruction. In line with recent applications of PRISMA across varied fields, this review adopted the framework not only as a reporting guide but also as a methodological foundation for structuring the entire evidence selection and synthesis process [10–12].

A detailed review process started with the development of concise objective eligibility criteria based on research questions, concentrating on studies reporting about technology use in mathematics lessons and its impact on students solving problems. The search process was in accordance with the PRISMA framework, systematic and documented, including identification of potential records to screening by title, abstract, and full texts [9]. Specific attention was paid to documenting the search strategy, keywords used, and justification for study inclusion/exclusion so that the review could be critically appraised and replicated by other researchers [9], in keeping with PRISMA-S reporting recommendations. Studies were assessed at each step of the process for relevance to mathematics learning contexts, identified technological interventions and outcomes associated with problem-solving abilities and ease of measurement or description. For the selection process, using a PRISMA flow diagram to record the number of studies identified, excluded and kept in an included form is important when describing the selection process to enhance transparency and create a clear audit trail [13].

After the last set of inclusion studies was defined, data were extracted and synthesized in an organized fashion to answer with detail each of the research questions. We extracted information on the study characteristics, including educational level, research design, type of technological tool(s), instructional context, and reported effects in mathematical problem solving as well as implementation benefits and challenges. This approach is part of the wider strength of PRISMA as a tool in developing systematic and comprehensive evidence synthesis across many areas, with methodological consistency [14]. The drawn findings were thematically analyzed to look for patterns of change in students problem-solving performance from the way technology implemented, what tools seem most effective, and contextual constraints that shape classroom implementation success. In this study, the framework was employed not only to structure a body of evidence but also to add rigour and comprehensiveness to the review process that it is adapted for new review contexts consistent with the ongoing development of PRISMA and its extensions [13, 15]. In this way, the review sought to produce a fair and trusted synthesis of the current evidence in technology-enhanced mathematics education.

2.2. Literature Search Strategy

The literature search strategy was conducted using Boolean keywords in the SCOPUS database for the years 2009-2026, carried out on January 30, 2026. Boolean keywords are search terms combined with the logical operators AND, OR, and NOT to regulate the relationships among terms in a literature search strategy. In practice, AND is used to narrow the results because it retrieves only documents containing all combined terms, OR is used to broaden the results because it retrieves documents containing at least one of the searched terms or synonyms, whereas NOT functions to exclude certain terms so that the search results become more specific. In systematic searching, these operators are usually combined with parentheses to group related synonyms or concepts, making the search structure more accurate, sensitive, and easier to replicate. Therefore, the use of Boolean keywords is very important in literature reviews as well as systematic literature reviews, because it helps researchers balance the breadth of the search with the precision of the results obtained [16–18] . In this study, the keywords used in the SCOPUS database were: Math* AND Problem Solving Ability AND Learning QUALITY AND School.

2.3. Screening Criteria

Based on the 83 documents retrieved using the Boolean keywords mentioned above, a screening was then conducted according to the type of article. Articles classified as conference papers (27 document), review (4 document), conference review (4 document), book chapter (2 document), book (2 document), retracted (1 document) were removed from the list of articles to be reviewed. Subsequently, a screening was performed based on country of origin. One article from Chinese (3 document), German (1 document), Russian (1 document) & Spanish (1 document) was excluded from the list of articles to be reviewed. This process resulted in a total of 26 documents to be processed further. These 26 documents were then subjected to an additional screening based on the established screening criteria.

Inclusion Criteria:

- Research related to technology integration in mathematics education.
- Studies that investigate the effect of student use of technology on ways to solve problems in mathematics.
- Research identifying or describing types of technological tools specifically employed to support problem-solving activities in mathematics learning
- Results, findings or discussions directly related to the improvement of mathematical problem-solving skills.
- The studies that deal with positive and negative aspects, challenges/obstacles to using/perceived benefits of technology in teaching mathematical problem-solving.
- Studies undertaken in math teaching and learning related educational contexts.
- Studies that allow detailed examination and extraction of data in the full text

Exclusion Criteria:

- Research that does not see mathematics education as a primary learning context.
- Studies that do not refer to mathematical problem solving do not appear well connected to a focus on technology in education.
- Research that does not examine students' problem-solving skills, strategies, processes or outcomes in mathematics.
- Syntheses in which the technological intervention, tool or digital resource is poorly defined.
- Papers without results or discussions pertinent to the research question
- Studies for which the full text is not available or accessible for review
- Duplicate or substantially overlapping studies with other included studies.

As a result, we have 9 documents to include in the review process. All process provided in Figure 1.

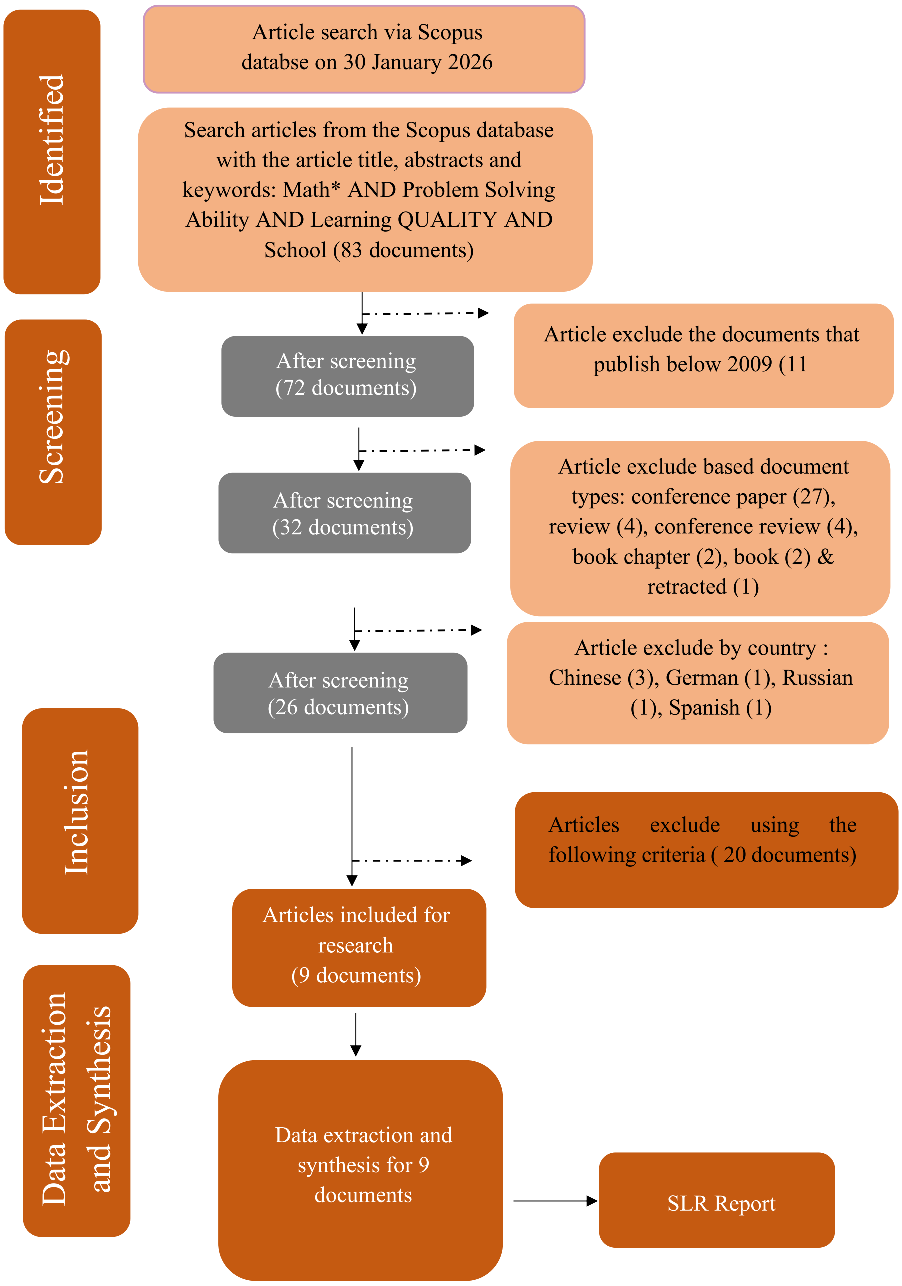

Figure 1. Prisma flow diagram of the article selection process.

3. Result and Discussion

3.1. RQ1 : How does the integration of technology in mathematics education impact students' problem-solving skills?

The references in the attached file as a set indicate a positive but quite conditional relation between technology integration and student development in mathematical problem solving. The clearest evidence in this corpus comes from [6], who were explicit about the link between technology and the development of problem-solving strategies in mathematics education. The modern focus is validated by overarching syntheses on the role of technology in mathematics classrooms suggesting that digital integration is not utilized merely as a supplement to instruction, but integral aspect of arranging design for mathematical learning [1, 2]. Reading these sources together and reviewing the research on ICT integration, it appears to be an established view that technology may provide affordance for more substantive learning processes, more so than just content delivery [5]. This means that the effect of technology on solving problems is pedagogically mediated: while the technology itself matters, its value comes from how that technology is integrated into the learning processes.

The second theme present in the bibliography is that the use of technology seems to benefit mathematical proficiency and analytic processes alone, but not isolated procedural knowledge. According to Mason & Johnston-Wilder [7] mathematics learning is framed as developing expertise and this aligns well with the argument that if it proposes an enhancement of problem solving through structured reasoning, reflection on solutions and adaptation of strategies when using technology it can strengthen students reasoning in mathematics. Grover & Pea [3], while focused on K–12 computational thinking instead of mathematics alone, contribute an adjacent insight: that technology-rich environments can foster forms of logical, stepwise and transferrable reasoning that overlap significantly with problem-solving in mathematics. At the same time, the attached corpus fails to reasonably argue that an overwhelming or automatic effect was established in a consistent or universal manner. Rather, the thematic result is less vague: integration of technology appears to enhance problem solving only when done intentionally in connection with reasoning about mathematics, strategy use and expertise development but not simply as new innovation [5–7].

3.2. RQ2: What types of technological tools are most effective in enhancing problem-solving abilities in mathematics education?

As per the attached bibliography, evidence available does not identifies any one technology tool as definitively best for improving mathematical problem-solving. Rather, the references refer to more general classes of tools and, even more critically, to the circumstances which allow such tools to work. Many sources employ umbrella terms like technology, ICT or technology in mathematics classroom meaning that the literature reflected within siane. While bib is less focused on specific scoring of tools or platforms in [1, 2, 5], it is more concerned with patterns of educational use. So the most defensible themed conclusion is tools that help students engage strategically with Mathematical gthis. Geiger et al. [6] gives the strongest affirmation of this by locating technology at developing problem-solving strategies, while Grover & Pea [3] note that computationally oriented tools can serve a meaningful role when they support structured reasoning. This means that the idea of effectiveness is much less closely associated with the label itself, and rather its purpose in supporting thinking, strategy, and interaction with ideas mathematically across the entirety of the corpus.

The references attached also imply that tool success cannot be delineated from construct

Table 1. The impact of technology integration on students' problem-solving skills in mathematics education.

Theme	Observed pattern	Educational implication	Nature of support in the attached corpus	Context emphasis	Ref.
Technology and problem-solving strategies	Technology is linked with the development of mathematical problem-solving strategies	Technology should be embedded in strategy-oriented learning tasks	Direct thematic relevance	Mathematics education	[6]
Technology in mathematics education	Technology is positioned as a meaningful component of mathematics learning	Integration should focus on instructional value rather than mere access	Broad review-level support	Mathematics education research	[1]
Technology in the mathematics classroom	Research synthesis indicates a sustained relationship between technology use and classroom learning processes	Classroom use should be connected to mathematical activity design	Synthesis-level support	Mathematics classroom	[2]
ICT and learning outcomes	Positive outcomes depend on how ICT is integrated pedagogically	Technology should be treated as a pedagogical tool rather than an isolated intervention	Cross-educational review support	Education more broadly	[5]
Development of mathematical expertise	Problem-solving improvement is tied to expertise formation	Technology use should support reasoning, reflection, and adaptive thinking	Conceptual support	Mathematics teaching and learning	[7]
Computational thinking overlap	Technology-rich learning can foster logical and transferable thinking habits	Problem-solving gains may extend through computationally structured reasoning	Adjacent conceptual support	K–12 learning	[3]

and discipline alignment. The idea of Voogt et al. [4] that technology is educationally powerful if teachers can link the tool to relevant pedagogy and subject matter. So, this is of utmost relevance to mathematics education as a tool that may be technically accessible but incompatible with mathematical intentions is unlikely to extend problematic solving in any substantive manner. In a similar vein, Mason & Johnston-Wilder [7] emphasize the development of expertise which suggests that well-matched technological tools are those that enable learners to move from habitual execution toward qualitative mathematical skills. Put together, the citations in the references address a nuanced response to RQ2: the best tools are not necessarily latest or most available; they're pedagogically integrated, mathematically significant, and intentionally reasoned. This conclusion should be interpreted as a thematically-synthesised rather than ranked comparison of tools [4, 6, 7] given the bibliographic rather than full empirical detail afforded by the attached file.

Table 2. Technological tools that are most effective in enhancing problem-solving abilities in mathematics education.

Tool category or framing	Inferred function for mathematics learning	Contribution to problem-solving	Condition for effectiveness	Evidence basis in the attached corpus	Ref.
General technology in mathematics education	Supports instructional design and learning engagement	Contributes when linked to mathematical activity	Requires meaningful classroom integration	Broad review framing	[1]
Technology for problem-solving strategies	Directly supports strategy development in mathematical tasks	Strongest direct relevance to problem-solving enhancement	Must be used in strategy-oriented teaching	Focused mathematics education study	[6]
Technology in the mathematics classroom	Provides classroom-based support for mathematical learning processes	Useful when integrated into authentic classroom tasks	Depends on task design and use context	Research synthesis	[2]
ICT in education	Supports learning outcomes at a broader instructional level	Indirectly strengthens problem-solving through improved learning conditions	Depends on pedagogical integration	Critical review	[5]
Computational tools and environments	Foster logical, stepwise, and transferable reasoning	May strengthen problem-solving through computational thinking habits	Best used where reasoning processes are emphasized	Adjacent conceptual review	[3]
Technology aligned with TPACK	Connects tools, pedagogy, and mathematics content	Increases the likelihood that tool use supports genuine mathematical reasoning	Requires teacher knowledge and alignment	Review of pedagogical-content integration	[4]

3.3. RQ3: What are the challenges and benefits of integrating technology in teaching problem-solving skills in mathematics?

As evidenced in the attached bibliography, using technology to enhance mathematics problem-solving can only be seen when we utilise technology as an enabler of more meaningful learning processes. The most common beneficiaries of the corpus were identified as course development, positive impact on learning outcomes and alignment with current educational needs [5, 6]. Personalised learning environments and realisation of productive disposition in mathematics learning This sentiment is echoed by Alvarez et al. [1] and Moyer-Packenham & Westenskow [2] broad reviews in which the role that technology has come to play as a strand of dimensional research into mathematics classrooms its value for education primarily being felt in terms of affording broader opportunities for teaching and learning. Meanwhile, Becta [19] goes on to frame technology as the future of education which positions technology integration not simply an instructional choice but a response to shifts in educational expectations. These benefits, viewed in relation to Mason & Johnston-Wilder [7], seem to coalesce upon one matter technology is most effective when it contributes towards developing expertise and strategic habits alongside persistent engagement with mathematical problem-solving, rather than digitising the actions of traditional teaching practices.

Moreover, the references also make it just as clear that technology integration poses significant challenges. Hennessy et al. [8], prioritise teacher factors affecting classroom use of

Table 3. Benefits and challenges of integrating technology in teaching problem-solving skills in mathematics.

Benefit or challenge	Thematic interpretation	Underlying condition	Implication for mathematics teaching	Source emphasis	Ref.
Development of problem-solving strategies	Technology can strengthen how students approach mathematical tasks	Strategy-oriented use of technology	Design learning around reasoning and solution processes	Direct mathematics problem-solving focus	[6]
Improved learning outcomes	Positive effects are possible when ICT is integrated well	Strong pedagogical integration	Technology use should be instructionally purposeful	Critical review of ICT and outcomes	[5]
Technology as part of future-ready education	Technology supports responsiveness to contemporary educational demands	Institutional and curricular commitment	Integration should be treated as a strategic educational direction	General education perspective	[19]
Teacher factors	Classroom technology use is shaped by teacher readiness and context	Professional competence and contextual support	Teacher development is essential for implementation	ICT classroom use	[8]
Need for pedagogical-content-technology alignment	Effective integration requires more than technical access	TPACK capacity	Teacher knowledge must connect tools to mathematics teaching goals	Review of TPACK literature	[4]
Expertise development	Benefits are strongest when technology contributes to deeper mathematical learning	Focus on expertise rather than routine use	Use technology to support sustained mathematical thinking	Mathematics learning perspective	[7]

ICT stating that it is 'largely dependent on teachers' beliefs and contextual conditions which must be in place before implementation can begin'. And this concern is exacerbated [4] since TPACK shows that technology access alone is not enough; the knowledge needed to integrate technological, pedagogical, and content decisions in a comprehensive way must also be available. Similarly, Tondeur et al. [5] portraying technology integration in a negative light also propose that, without careful implementation, positive experiences can not be expected. The major takeaway, then, is that benefits and challenges really are two sides of the same coin: technology can be a boon to the mathematics process but its efficacy cannot outstrip professional capacity, pedagogical coherence, or contextual support. This makes good sense: in practical terms, you can buy and install the most sophisticated tools manufactured, but it is how these tools are integrated which builds the instructional climate that actually enable those tools to improve opportunities for problem solving in students [4, 5, 8].

4. Conclusion

Synthesizing the evidence indicates that improving students' problem-solving skills in mathematics education through technology integration can be basically achieved with careful thought and strategic implementation. Technology benefits learning, as illustrated by studies reviewed here, when it strategically stimulates engagement in mathematical tasks and task-focused expertise development throughout the reflection-adaptation process. Studies show that cooperative math problem-solving, critical thinking skills and metacognitive skills are all strengthened through interactive simulations, dynamic geometry environments, and computational tools. However, technology is only as successful as those three things are: integration of pedagogy, teacher competence and access to resources. Identified challenges such as inequity in technological infrastructure, lack of professional development, and the constantly changing nature of digital tools can hinder its effective implementation. Thus, results indicate that the positive effects of technology are contingent upon teacher training and preparation, instructional design and delivery, and access to digital resources. To summarize, technology can be an effective and powerful catalyst for improved problem-solving in mathematics education, but effectively leveraging that potential requires thoughtful embedding within well-structured learning environments substantively informed by pedagogical principles and adequately supported not only in policy but at all levels of implementation.

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