

# Digital Messaging for Mathematical Understanding: A Systematic Review of Whatsapp Use in Indonesian Junior High Schools

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## Abstract

This study aims to investigate how WhatsApp has been used to deliver mathematics lessons in Indonesia across multiple educational levels, with a particular focus on junior high schools, within the last four years. The objective is to identify the extent, practices, and effectiveness of WhatsApp as either a primary or supplementary instructional tool in mathematics teaching at the elementary, junior high, senior high, and tertiary levels. The research method employed was a systematic literature review of Scopus-indexed journal articles published in English between 2019 and 2024. Relevant studies were selected, analyzed, and synthesized according to their research design, educational level, and findings. Both qualitative and quantitative research were included to provide a comprehensive understanding of how WhatsApp has been integrated into mathematics education. In many cases, WhatsApp is integrated into instructional designs such as blended learning, flipped classroom activities, and collaborative problem solving, allowing students to interact with teachers and peers. The results show that WhatsApp is widely adopted by Indonesian teachers, particularly during and after the pandemic, to facilitate communication, share learning materials, and support problem-solving activities. At the elementary and junior high levels, studies report that WhatsApp helps improve students' motivation and engagement, though the impact on learning outcomes is mixed. At the senior high and vocational levels, WhatsApp is often combined with other digital platforms such as YouTube to support blended learning. Evidence from higher education remains limited, with indications that WhatsApp serves mainly as a communication channel rather than a structured learning platform. In conclusion, WhatsApp is a practical, low-cost, and accessible tool that supports mathematics instruction in Indonesia. However, its effectiveness depends on instructional design, teacher facilitation, and integration with other pedagogical strategies.

**Keywords:** whatsapp; students' motivation, mathematics education

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## INTRODUCTION

Mathematics is a foundational discipline that enables students to develop critical thinking and problem-solving skills, competencies considered essential for success in the twenty-first century (OECD, 2019; National Research Council, 2012). Contemporary mathematics education aims not only to teach formulas and procedures but also to cultivate mathematical literacy, defined as the capacity to recognize, interpret, and apply mathematics in real-world contexts to make informed decisions (D'Ambrosio, 2006; National Council of Teachers of Mathematics, 2005). Ideally, mathematics instruction should be active and student-centered, aligning with constructivist perspectives that view knowledge as being constructed by learners rather than passively received from teachers (Vygotskij & Cole, 1981; Piaget et al., 1973). This principle also underpins Realistic Mathematics Education (RME), an approach that emphasizes the use of authentic, real-life problems as a means of developing mathematical understanding (Gravemeijer & Doorman, 1999; Zulkardi, 2002). In Indonesia, national curriculum policies similarly emphasize the importance of mathematical literacy and higher-order thinking skills as preparation for students' future participation in society and the workforce (Badan Standar, Kurikulum, dan Asesmen Pendidikan, 2024).

Despite these policy orientations, a substantial gap exists between the ideal goals of mathematics education and the actual learning outcomes observed. Results from international large-scale assessments, such as PISA and TIMSS, consistently demonstrate that Indonesian students perform below the global average, particularly in mathematical reasoning and problem-solving (OECD, 2019; TIMSS, 2019). Classroom practices often reinforce this gap, with instruction remaining teacher-centered and focused primarily on rote memorization. The COVID-19 pandemic further exacerbated these challenges, as schools were compelled to transition abruptly to remote learning. Following the pandemic, mathematics learning in Indonesia began integrating various digital platforms such as Google Classroom, Learning Management Systems (LMS), Zoom, Microsoft Teams, and YouTube. These platforms are often combined with WhatsApp to support communication, assignment distribution, and asynchronous discussions. The increased use of various platforms indicates a shift towards technology-based learning environments in mathematics education (Borba et al., 2016). In some schools, WhatsApp remains one of the most accessible tools because it requires relatively low internet bandwidth and is already widely used by students and teachers for daily communication (Ikhlās, 2021). In this context, many teachers and students relied on readily available, low-cost platforms such as WhatsApp to sustain instructional activities (Nida et al., 2020). WhatsApp quickly became one of the most widely used tools because of its ubiquity and minimal data requirements.

The integration of WhatsApp into mathematics instruction raises critical questions about its pedagogical role, effectiveness, and limitations in the Indonesian context. To date, there is no comprehensive synthesis of how WhatsApp has been utilized for mathematics teaching across educational levels in Indonesia, the outcomes associated with its use, or the challenges encountered by teachers and learners. Research on WhatsApp's role in mathematics learning shows a mix of promising benefits and clear limits. For instance, Nida et al. (2020) reported that using WhatsApp within a blended-learning approach helped students develop more creative thinking in math, although its effect on easing mathematics anxiety was inconsistent. Ikhlās (2021) similarly found that WhatsApp became a central tool for communication and instruction during remote teaching; however, gains in students' learning outcomes depended heavily on how the activities were designed and run. Studies from other countries echo these findings. The research in South Africa by Ofori-Kusi and Tachie (2022) showed that WhatsApp groups fostered engagement and supported achievement by keeping interaction, peer discussion, and collaborative problem-solving going outside scheduled class time. Jacobs (2022) also pointed out that WhatsApp lets students quickly share questions, compare solution approaches, and get feedback from teachers and classmates, which can strengthen collaborative mathematical thinking and communication. However because WhatsApp is primarily text-based, it can be difficult for subjects that rely on symbolic notation, detailed diagrams, or lengthy, complex explanations, where richer media or specialized tools are often needed (Bouhnik & Deshen, 2014).

This study addresses this research gap through a systematic literature review. The primary focus is on junior high school education, given that this stage marks the transition from basic arithmetic to more complex and abstract mathematical concepts (OECD, 2019). This developmental phase is particularly

important for cultivating higher-order thinking skills targeted by PISA and TIMSS. Moreover, an initial survey of the literature suggests that the majority of existing studies on WhatsApp in Indonesian mathematics education concentrate on this level, providing a sufficiently robust evidence base for review. Junior high school students also face common challenges in online learning, such as low self-discipline and limited access to resources, making this age group a meaningful case study for exploring the effectiveness of WhatsApp-based instruction.

The study is guided by several theoretical perspectives. The Technology Acceptance Model (TAM) explains the widespread adoption of WhatsApp, positing that technology use is strongly influenced by perceived usefulness and ease of use (Davis, 1989). WhatsApp satisfies both conditions, which may account for its rapid integration into educational practice. The Technological Pedagogical Content Knowledge (TPACK) framework further highlights instructional challenges, emphasizing the need to integrate disciplinary knowledge (mathematics), pedagogical strategies, and technological proficiency to achieve effective teaching (Koehler et al., 2013). In addition, the concept of self-regulated learning provides insight into how students manage their learning processes in online environments, particularly where direct teacher supervision is limited.

Previous research offers mixed evidence regarding the effectiveness of WhatsApp in mathematics education. Several empirical studies report positive outcomes, showing that WhatsApp enhances teacher–student communication, facilitates peer collaboration, and increases student engagement (Nida et al., 2020; Ikhlas, 2021). In addition, a review study by Sarwoedi et al. (2025) highlights similar patterns of increased interaction and collaboration in mathematics learning. Conversely, some studies highlight limitations in improving achievement or higher-order skills, citing barriers such as unstable internet connections, off-task distractions, and the difficulty of conveying complex mathematical concepts through chat-based media (Prabowo et al., 2019; Muhtarom et al., 2022). Moreover, WhatsApp’s role varied across contexts, functioning as a supplementary tool for assignments and feedback in some studies and as a primary instructional medium in others (Muhtarom et al., 2022).

Given these inconsistencies, a systematic literature review is warranted to synthesize evidence on how WhatsApp has been used in junior high mathematics education in Indonesia, its impact on student engagement, motivation, and achievement, and the primary challenges experienced by teachers and learners. The results aim to inform both educational practice and policy, providing guidance for the strategic integration of mobile messaging applications in resource-constrained learning contexts.

## METHOD

This study employs a systematic literature review (SLR) as its methodological approach. The SLR was selected because it enables a comprehensive and objective synthesis of existing scholarship while ensuring analytical rigor and transparency. This approach is particularly appropriate for the field of educational technology, where findings are often fragmented or contradictory, complicating efforts to generate coherent insights (Petticrew & Roberts, 2006). By following a structured protocol, the review minimizes researcher bias and enhances the reliability of the conclusions drawn.

The central focus of this review is the use of WhatsApp in mathematics education within the Indonesian context. The scope of analysis is narrowed to the junior high school level, where prior evidence indicates a concentration of empirical studies, thereby providing a sufficiently robust corpus for synthesis. The review seeks to examine (1) the pedagogical models and applications of WhatsApp implemented in mathematics education, (2) the reported learning outcomes and effectiveness of these implementations, and (3) the primary challenges encountered by educators and students. These three dimensions were drawn from the discussions on technology integration in mathematics education, which emphasize examining instructional practices, learning outcomes, and implementation challenges when analyzing digital tools in teaching and learning (Borba et al., 2016). The relatively small number of included studies reflects the strict inclusion criteria, particularly the focus on English-language, Scopus-indexed journal articles within the Indonesian context.

### Data Sources and Selection Criteria

Data were drawn exclusively from peer-reviewed journal articles to ensure academic credibility. The inclusion criteria required studies to: (1) be published between 2019 and 2024; (2) be written in English; (3) focus explicitly on the integration of WhatsApp in mathematics teaching or learning; and (4) be situated in Indonesia. Articles were excluded if they (1) were not peer-reviewed (e.g., proceedings without DOI); (2) did not focus on mathematics or WhatsApp; or (3) were conducted outside of Indonesia. This process ensured the selection of literature that was both relevant and methodologically sound.

### Data Collection Procedures

The review process followed a systematic protocol adapted from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009). The procedure consisted of five stages:

1. Database Search: Comprehensive searches were conducted in Scopus and Google Scholar.
2. Keyword Strategy: Search strings included: “WhatsApp” AND “mathematics education” AND “Indonesia”, “mobile learning” AND “mathematics” AND “WhatsApp”, and “online learning” AND “mathematics” AND “Indonesia”.
3. Screening: Titles and abstracts were reviewed against the inclusion and exclusion criteria, and duplicates were removed.
4. Full-Text Review: Eligible articles were examined in full to confirm relevance and quality.
5. Data Extraction: Key information was systematically recorded, including research design, educational level, sample size, pedagogical strategies, findings, reported effectiveness, and identified challenges.

The inclusion of English-language articles was intended to ensure consistency in analysis and to focus on studies indexed in international databases such as Scopus. However, this criterion may have excluded relevant studies published in Bahasa Indonesia, particularly those in local or national journals.

### Data Analysis

A thematic analysis was conducted to identify recurring patterns within the extracted data (Braun & Clarke, 2006). The analysis followed several stages: (1) familiarization with the data through repeated reading of the selected studies; (2) initial coding of key information related to pedagogical practices, learning outcomes, and implementation challenges; (3) grouping of codes into broader categories; and (4) development of themes that captured common patterns across studies.

Data were extracted using a structured framework that included research design, sample characteristics, type of WhatsApp use, reported outcomes, and identified limitations. These elements were then coded and organized into thematic categories presented in the results section.

The analysis was further guided by the Technology Acceptance Model (TAM) (Davis, 1989) and the Technological Pedagogical Content Knowledge (TPACK) framework (Koehler et al., 2013). TAM was used to interpret findings related to the adoption and use of WhatsApp, particularly in terms of perceived usefulness and ease of use. Meanwhile, the TPACK framework was applied to examine how technological tools were integrated with pedagogical strategies and mathematical content in the reviewed studies.

### Ethical Considerations

As this study is a literature review, it did not involve human participants and thus did not require considerations related to informed consent, confidentiality, or data protection. All analyzed materials were publicly available academic publications, and appropriate citation practices were followed in accordance with APA guidelines.

### Limitations

Several limitations should be noted. The findings are restricted to published research and therefore may not capture informal practices or unpublished studies. Furthermore, the reliance on English-language sources indexed in specific databases may have excluded relevant studies published in Bahasa Indonesia or in local, non-indexed journals. Finally, as a review, this study cannot fully account for the

nuanced realities of classroom practice. Future research should complement these findings with empirical investigations, such as classroom observations, teacher interviews, or large-scale surveys, to provide more contextually grounded insights into the role of WhatsApp in mathematics education. This language restriction may have led to the exclusion of relevant local studies, potentially limiting the comprehensiveness of the evidence base and underrepresenting research conducted in Indonesian contexts. The small number of included studies ( $n = 4$ ) also limits the generalizability of the findings. This may be due to the narrow inclusion criteria, including language restrictions and database selection. Relevant studies indexed in other databases, such as ERIC, or published in non-indexed local journals may not have been captured.

## RESULTS AND DISCUSSION

### Results

The review identified four studies at the junior high school level that met the inclusion criteria. These studies were published between 2019 and 2022, with one in 2019, one in 2020, one in 2021, and one in 2022. This limited number indicates that empirical research on this topic remains relatively scarce under the defined criteria.

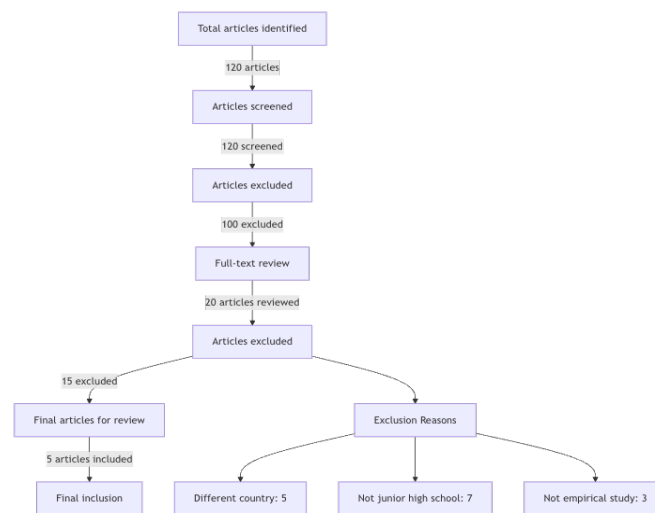


Figure 1. PRISMA Flow Diagram of the Study Selection Process

This distribution indicates an initial concentration of research in the early years of the COVID-19 pandemic, a period when educational institutions were forced to adapt rapidly to remote and technology-supported learning, followed by continued interest in WhatsApp's educational role in the post-pandemic era (2022–2022). Methodologically, the reviewed works consisted of three quasi-experimental studies, one developmental study, and one literature review, highlighting the predominance of applied, intervention-focused approaches rather than purely exploratory or descriptive ones.

**TABLE 1.** Summary of Reviewed Studies on WhatsApp for Junior High Mathematics Education

<b>Author(s), Year</b>	<b>Sample</b>	<b>Design</b>	<b>Findings</b>	<b>Limitations</b>
<b>Nida et al. (2020)</b>	3 junior high schools (Central Java), size not specified	Quasi-experimental (blended learning vs direct)	The study combines WhatsApp as the communication tool, blended learning as the teaching approach, and mathematics problem-solving activities as the learning content. This combination appears to support students' creative thinking, although the results on mathematics anxiety were mixed. The study is limited by the unspecified sample size, its focus on a specific region, and the short duration of the intervention.	No exact N; limited region; short-term; math anxiety results mixed
<b>Ikhlas (2021)</b>	34 junior high students (Kerinci)	Quasi-experimental (pretest–posttest, control)	The study used WhatsApp as the learning platform, with teaching activities conducted through group discussions and assignment sharing. The mathematics content was delivered through online interactions between the teacher and students. The results showed an improvement in students' post-test scores. However, the findings are limited by the	Small sample, no control, one school, short-term

Author(s), Year	Sample	Design	Findings	Limitations
<b>Prabowo et al. (2019)</b>	Teachers + Depok 3 JHS students (exact N not given)	Developmental (app design + trial)	small sample size, the absence of a control group, and the short duration of the study.	N not stated; single context; only short trial; tech limitations
<b>Muhtarom et al. (2022)</b>	72 JHS students	Quasi- experimental (LMS vs WhatsApp)	The study compares WhatsApp and an LMS as the technological tools used to support mathematics learning. Both platforms were used to deliver mathematical tasks and facilitate	Small N; limited scope; short-term; only critical thinking measured

Author(s), Year	Sample	Design	Findings	Limitations
			interaction between teachers and students. The results show that students improved in critical thinking in both groups, although the LMS group performed better overall. The study involved 72 junior high students, but the scope was limited, the intervention was relatively short, and the analysis focused only on critical thinking.	

Across the studies reviewed, WhatsApp was used in several ways to support mathematics learning. Teachers often used the platform to share announcements, respond to students’ questions, and distribute assignments. Students typically submitted their work by sending text responses, photos of handwritten solutions, or documents. For example, in the study by Nida et al. (2020), WhatsApp-supported blended learning was used for mathematics tasks aimed at developing students’ creative thinking. Similarly, Abdul Ikhlas (2021) reported that WhatsApp groups were used to deliver materials and collect students’ work, which contributed to improved post-test scores. WhatsApp groups also enabled students to discuss mathematical problems with their peers. In some cases, students compared answers and explained their solution steps through group chats. Muhtarom et al. (2022), for instance, used WhatsApp as a platform for sharing and discussing mathematics tasks when comparing it with an LMS-based environment. Overall, the findings suggest that WhatsApp supports communication, coordination, and interaction in mathematics learning, particularly in facilitating discussions and problem-solving activities among students.

TABLE 2. Pedagogical Applications of WhatsApp in Junior High Mathematics Education

Pedagogical Application	Examples from Studies	Notes
<b>Communication &amp; Interaction</b>	Used for announcements, clarifying questions, maintaining teacher–student contact (Prabowo et al., 2019; Ikhlas, 2021)	Supports teachers in explaining solution steps, clarifying mathematical concepts, and guiding students’ reasoning during problem-solving discussions beyond classroom hours.

<b>Pedagogical Application</b>	<b>Examples from Studies</b>	<b>Notes</b>
<b>Assignment Distribution &amp; Submission</b>	Sharing tasks, submitting answers via text, images, or files (Nida et al., 2020; Ikhlas, 2021)	Allows teachers to assign mathematics problems and review students' solutions, including photos of handwritten work, making it easier to follow students' problem-solving steps outside class.
<b>Collaborative Learning</b>	Group discussions, peer interaction, and collaborative problem-solving through WhatsApp groups (Nida et al., 2020; Muhtarom et al., 2022)	Supports students in discussing mathematical problems, comparing solution strategies, and explaining their reasoning during collaborative problem-solving activities.
<b>Flipped/Blended Learning Support</b>	Pre-class content delivery, post-class reinforcement (Nida et al., 2020)	Allows teachers to share explanations, example problems, or short videos before class and continue discussing mathematical concepts and solutions with students after class.
<b>Project &amp; Problem-Solving Activities</b>	Coordination of group work and real-time feedback (Prabowo et al., 2019)	Helps students coordinate group work, discuss solution approaches, and receive feedback from teachers while working on mathematics problem-solving tasks.
<b>Comparative Platform Use</b>	Compared with LMS—effective but less impactful for critical thinking (Muhtarom et al., 2022)	Shows that while WhatsApp can support discussion and sharing of solutions to mathematics problems, more structured platforms such as LMS may better support deeper analysis and development of students' critical thinking.

The reported outcomes of these implementations were varied but generally positive. WhatsApp enhanced student engagement and participation, largely due to its accessibility and students’ familiarity with its interface. Teacher–student communication and feedback became more immediate, enabling continuous support beyond classroom hours. WhatsApp also fostered peer collaboration and community building, where students shared solutions and supported one another in mathematical problem-solving. In terms of learning outcomes, some studies reported gains in creative thinking, reduced anxiety, and improved performance. However, evidence was mixed: while WhatsApp was effective for motivation and participation, comparative studies suggested that other platforms (e.g., LMS) may better support higher-order skills such as critical thinking.

**TABLE 3.** Synthesis of Reported Outcomes from WhatsApp Use in Mathematics Education

Reported Outcome	Evidence from Studies	Notes
<b>Increased Engagement &amp; Participation</b>	Students more active due to familiarity with WhatsApp (Ikhlas, 2021; Nida et al., 2020)	Accessibility key factor
<b>Improved Teacher–Student Communication</b>	Faster feedback and continuous support (Prabowo et al., 2019)	Extends learning time
<b>Enhanced Peer Collaboration</b>	Group discussions, peer interaction, and collaborative problem-solving facilitated through WhatsApp groups (Nida et al., 2020; Muhtarom et al., 2022)	Encourages collaborative mathematical problem-solving.
<b>Learning Gains</b>	<b>Achievement</b> Improved posttest scores, creative thinking ↑ (Nida et al., 2020; Ikhlas, 2021)	Some gains context-specific
<b>Reduced Math Anxiety</b>	Blended learning reduced anxiety in some cases (Nida et al., 2020)	Not consistent across studies
<b>Limitations in Higher-Order Thinking</b>	LMS > WhatsApp for critical thinking (Muhtarom et al., 2022)	WhatsApp best for basic–intermediate support

Despite these advantages, several barriers were consistently identified. Unequal access to devices and stable internet remained the most pressing issue, creating a digital divide that limited equitable participation. Teacher readiness and pedagogical skills were also limited, as many educators used WhatsApp primarily for communication rather than as a structured learning tool. The informal nature of the platform led to distractions and off-task behavior, which reduced learning focus. Furthermore, the text-dominant format of WhatsApp posed challenges in explaining abstract or visual mathematical concepts. Comparative studies further showed that WhatsApp may be less effective than learning management systems (LMS) in fostering higher-order thinking skills, highlighting the platform’s limitations for deeper cognitive engagement.

**TABLE 4.** Challenges of Using WhatsApp in Junior High School Mathematics Education

Challenge	Evidence from Studies	Notes
<b>Digital Divide</b>	Unequal device and internet access excluded some learners (Ikhlas, 2021; Nida et al., 2020)	Limits some students’ ability to access problem-solving discussions, receive explanations of mathematical

Challenge	Evidence from Studies	Notes
		concepts, or submit their solutions online.
<b>Teacher Readiness</b>	Limited training in pedagogical integration (Prabowo et al., 2019)	Teachers often use WhatsApp mainly for sending tasks rather than guiding students through solution steps or explaining mathematical concepts.
<b>Distractions &amp; Informality</b>	Off-task chats and informal interactions reduced focus (Ikhlas, 2021; Nida et al., 2020))	The informal nature of WhatsApp communication may lead to less focused learning interactions, particularly when discussions are not well structured or guided by the teacher.
<b>Text-Based Limitations</b>	Difficult to explain abstract/visual math concepts (Nida et al., 2020)	Text messages make it harder to show diagrams, formulas, or step-by-step explanations needed for complex mathematical concepts.
<b>Limited Higher-Order Thinking Support</b>	LMS > WhatsApp for critical thinking (Muhtarom et al., 2022)	WhatsApp discussions often focus on sharing answers rather than supporting deeper reasoning or analysis of mathematical problems.

### Discussion

Taken together, these findings suggest that WhatsApp was a practical, accessible, and low-cost tool for supporting junior high school mathematics learning in Indonesia, particularly during periods of remote instruction. Its effectiveness was strongest when used as a complementary tool for communication, reinforcement, and collaboration, rather than as a standalone platform for delivering new content. The review also makes clear that successful implementation depended not only on the affordances of the platform but also on teachers' facilitation skills and students' willingness to engage.

When compared with prior international research, the results align with global patterns showing that WhatsApp works best as a supportive learning tool. However, the Indonesian case highlights unique challenges, including a pronounced digital divide, teachers' limited readiness for pedagogical integration, and constraints in supporting higher-order thinking skills, as shown in comparative studies with LMS. At the same time, the review confirms that junior high school students, often considered digital natives, adapted quickly to WhatsApp-based learning environments.

The theoretical implications of this review can be understood using established models of technology integration. From the perspective of the Technology Acceptance Model, students' generally positive responses suggest that WhatsApp is perceived as useful and easy to use, which helps explain its rapid adoption in learning contexts (Fred Davis, 1989). In mathematics learning, this accessibility allows teachers and students to exchange problem-solving tasks, discuss solution strategies, and share photos of handwritten calculations. At the same time, the mixed findings on learning outcomes highlight the importance of the Technological Pedagogical Content Knowledge framework. Effective use of technology depends on how well teachers integrate technology with pedagogy and mathematical content (Matthew J. Koehler & Punya Mishra, 2009). Several studies show that WhatsApp is often

used mainly for sharing assignments or coordinating discussions rather than explaining mathematical concepts in depth.

This review also highlights several gaps in existing research. Although many studies report that WhatsApp supports communication and collaborative problem-solving, few examine how it can be used to explain mathematical concepts step by step or to develop higher-order mathematical reasoning. In addition, most studies involve small samples and short interventions, so the long-term impact of WhatsApp on mathematics learning remains unclear. These findings suggest that teachers may need clearer guidance on how to use WhatsApp not only for communication but also for supporting discussion of mathematical ideas and solution processes. Schools should also ensure that students have adequate access to devices and reliable internet so that all learners can participate in digital mathematics learning.

## CONCLUSION

### Conclusion

This review shows that WhatsApp is a practical and accessible tool for supporting junior high school mathematics learning in Indonesia, particularly for communication, collaboration, and student engagement. However, its impact on academic achievement and conceptual understanding is mixed. While some studies reported improvements in students' performance and creative thinking (Nida et al., 2020; Ikhlas, 2021), others found that more structured platforms such as LMS were more effective in supporting higher-order thinking (Muhtarom et al., 2022).

The findings also indicate that challenges such as limited teacher readiness, uneven access to technology, and the informal nature of WhatsApp communication can affect learning quality. As a result, WhatsApp is best used as a complementary tool for example, to support discussion, feedback, and collaborative problem-solving rather than as a standalone platform.

This review is limited by the small number of studies and its focus on the Indonesian context, which may affect the generalizability of the findings. Future research should explore how WhatsApp can be more effectively integrated into structured learning designs and how teachers can be supported in using it to promote deeper mathematical understanding.

### Suggestion

It is important to recognize the limitations of this review. The evidence base relies mainly on small-scale, short-term studies, which restricts the generalizability of the findings. The exclusive focus on English-language, peer-reviewed sources may also have excluded valuable insights from Indonesian-language or non-indexed research. Moreover, the scope was limited to junior high schools, leaving the use of WhatsApp in primary and senior high school mathematics learning largely unexplored.

These limitations suggest several directions for future research in mathematics education. Longitudinal and large-scale studies are needed to examine the sustained impact of WhatsApp on students' mathematical understanding, problem-solving skills, and reasoning. Future studies should also investigate how WhatsApp can support specific mathematical activities, such as explaining solution steps, discussing multiple strategies, or sharing visual representations of mathematical ideas. In addition, research could explore how WhatsApp can be combined with other digital tools to better support the explanation and visualization of mathematical concepts. Finally, including the perspectives of teachers and students would help clarify how WhatsApp can be used more effectively in mathematics classrooms.

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