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Review Article

Mobile instant messaging applications in STEAM education: Scoping review

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ABSTRACT

Mobile messaging surged as a teaching aid during and after the COVID-19 lockdowns, yet its evidence base in integrated science, technology, engineering, arts and mathematics (STEAM) education remains fragmented. Guided by Arksey-O'Malley and Joanna Briggs Institute scoping protocols, this review systematically searched Web of Science, Scopus, and ERIC for peer-reviewed articles published between 2020 and 2024 that embedded WhatsApp in STEAM learning. Twenty-one studies satisfied the requirements. Seventy-two percent of the applications were for math or science, and there weren't many for engineering, technology, or, especially, the arts. This shows a clear imbalance between the fields. Most of the studies were short, cross-sectional, or qualitative; only four used experimental or longitudinal designs. Most of the reported benefits were in problem-solving, working together, and grasping concepts. The impact sizes were moderate, and there wasn't much testing of higher-order skills like creativity, design thinking, and creative expression. Low data costs and user familiarity made it easy for people to start using it quickly, but too many messages, privacy problems, and exhaustion from interacting with too many people–especially in groups with more than fifty members–threatened long-term use. There was still not much evidence on fairness, ethics, and long-term learning. The review suggests (1) broadening the focus of the disciplines to include engineering, technology, and the arts, (2) using stronger, more complex research designs, (3) incorporating validated tools that measure advanced STEAM skills, and (4) including clear privacy and ethics guidelines to support long-lasting, scalable practice. The results together lay out a study plan for moving mobile instant

messaging applications, such as WhatsApp, from being used as a one-off pilot to making strong, balanced contributions to STEAM teaching.

Keywords: WhatsApp, STEAM education, scoping review, mobile learning

INTRODUCTION

In the last five years, distance and blended learning models, accelerated by COVID-19, have made WhatsApp/Telegram a "micro-LMS" thanks to its low data usage and widespread user base (Abdul Halim, & Abd Halim, 2024; Basilaia & Kvavadze, 2020; Biton & Segel, 2024; Mohammed et al., 2024; Romero-Saritama et al., 2025; Shittu & Taiwo, 2023; Zhang, 2024). When we look at science, technology, engineering, arts and mathematics (STEAM) fields, we see that 72% of the literature is focused on math and science, while engineering-technology-arts studies are very limited in number (Scherz et al., 2023). While most studies use cross-sectional or qualitative designs with small samples, higher-order STEAM competencies (creativity, design cycle, and artistic expression) are rarely measured quantitatively and effects are often short-term (Amanova et al., 2025). Furthermore, message overload and privacy concerns-notification fatigue and data security risks, especially in large groups-make sustainable integration difficult (Ariel & Levy, 2024).

This review makes the above imbalances and methodological gaps visible by mapping current usage patterns of WhatsApp in STEAM education. In line with the findings, the research questions of the study are structured as follows:

1. In which disciplines, at which teaching levels and with what sample characteristics is WhatsApp integration reported in STEAM fields?
2. How are the main pedagogical roles of the platform (content transfer, discussion, collaboration, feedback, etc.) reported in terms of their impact on learning outcomes, especially higher-order STEAM skills?
3. How do design variables such as group size, message density, privacy/ethical protocols shape the long-term and balanced use of WhatsApp?

LITERATURE REVIEW

What is WhatsApp?

WhatsApp is a cross-platform instant messaging program that Jan Koum and Brian Acton invented in 2009. It lets people talk to each other one-on-one or in groups by sending text, pictures, audio, video, and documents over mobile data or Wi-Fi (Santos & Faure, 2018). Recent studies have shown that WhatsApp has more than two billion monthly active users and is the most studied platform in mobile learning research. The app's end-to-end encryption architecture is what sets it apart from other apps. Cryptographic studies show that this infrastructure keeps more than 100 billion messages each day private. According to educational literature, this "ubiquitous" and secure communication paradigm makes it easier to share content and get quick response by merging teacher-student and peer-peer interaction in one channel. This makes WhatsApp a cheap "micro-LMS" (Romero-Saritama et al., 2025; Syairofi et al., 2023).

Educational usage of WhatsApp

Among the abundance of digital tools, instant messaging applications have gained remarkable popularity with the emergence of WhatsApp as a widely used application by billions of people worldwide (Martins et al., 2022; Suárez-Lantarón et al., 2022). The popularity and ease of use of WhatsApp have naturally spread to the field of education. Though its relevance has much increased in recent years, especially with the move toward remote and blended learning models pushed by the COVID-19 pandemic (Seufert et al., 2022), the usage of WhatsApp in education is not a novel phenomenon (Lee et al., 2023; Romero-Saritama et al., 2025). Numerous studies (Enakrire & Kehinde, 2022; Lee et al., 2023; Yeboah & Nyagorme, 2022) have examined how WhatsApp might improve teaching and learning across various educational institutions, from elementary schools to universities and vocational training programs. WhatsApp facilitates the integration of formal and informal learning environments by offering mobile, instantaneous communication that enables rapid information

exchange, group discussions, and collaboration through text, audio, and video (Cronjé & Van Zyl, 2022; Seufert et al., 2022). Globally, educators and learners are increasingly using WhatsApp to enhance communication and engagement beyond traditional classrooms.

WhatsApp for communication and collaboration in education

WhatsApp is widely used in the field of education as a tool for communication and cooperation (Bueno-Roldan & Röder, 2022). Research based on facts indicates that in the settings of middle schools and higher education, it has developed into a main channel for communication relevant to classroom dynamics. A study conducted in Israeli middle schools, for instance, demonstrated that WhatsApp groups were primarily leveraged for the purposes of administrative coordination and the regulation of classroom activities (Rosenberg & Asterhan, 2018). Students value these groups for their ability to share information quickly and easily. Teachers typically use them to share announcements, answer questions, and maintain discipline; students use them to ask for help and coordinate with their peers. This communication extends learning beyond the school walls and fosters a sense of belonging among class members (Rosenberg & Asterhan, 2018; Tragant et al., 2022).

Similarly, universities use WhatsApp for comparable reasons. University academics claim they would rather use WhatsApp to share materials, talk about course work, and work on group projects (Lee et al., 2023). WhatsApp's multimedia features greatly improve academic performance and support efficient group work among student cohorts (Afful & Akrong, 2020; Enakrire & Kehinde, 2022). Nevertheless, the importance of face-to-face communication in fostering team cohesion is also acknowledged (Lee et al., 2023). The potential that WhatsApp offers for interdisciplinary collaboration is underscored. Educators observe that WhatsApp groups foster peer learning through mechanisms of chat, inquiry, and resource sharing. Studies conducted in different countries show that teachers integrate WhatsApp into collaborative learning tasks and that teacher candidates also recognize these advantages (Alubthane & Alyoussef, 2021; Gcabashe & Oyinlola, 2023). However, WhatsApp's potential for collaboration depends on how it is used. Establishing groups autonomously is inadequate; proactive guidance is imperative to facilitate engagement. Although discussions directed by students and collaborative projects enhance interaction, unilateral communication from instructors may reduce students passive participants (Rahmadi, 2020; Udenze & Oshionebo, 2020). The integration of WhatsApp within educational settings fosters enhanced communication and collaborative problem-solving among students (Dahdal, 2020). WhatsApp can thus create a social learning space that extends beyond the classroom and supports informal communication.

The use of WhatsApp varies across educational levels and disciplines. Its flexibility, ranging from primary to higher education, makes it effective in different educational settings (Suárez-Lantarón et al., 2022). Its value is increasing in distance education, particularly due to its accessibility and ease of use, and it supports communication between students and educators (Romero-Saritama et al., 2025; Yeboah & Nyagorme, 2022).

The impact on student participation and motivation

The functionalities of sharing text, audio, images, videos, and documents enable WhatsApp to facilitate instantaneous communication (Romero-Saritama et al., 2025; Suárez-Lantarón et al., 2022). Educators and learners engage in the rapid exchange of inquiries; group discussions provide a platform for both synchronous and asynchronous discourse regarding assignments. The sharing of resources and collaborative problem-solving enhances decision-making capabilities and fosters motivation (Mulyono et al., 2021). A graded WhatsApp activity increased out-of-class discussion time and participation (Dahdal, 2020). The platform's multimedia feature supports vocabulary and writing development, particularly in language courses.

It improves satisfaction with information and service quality; satisfaction, in turn, explains the intention to continue the course (Ali et al., 2023). Additionally, WhatsApp lessons did not change nursing students' exam scores but improved their course experience (Al Mutair et al., 2025). Shy students express their ideas more comfortably via messages, and overall participation increases. First-year students felt less lonely with support groups, and recent graduates gained professional confidence (Madge et al., 2019; Pimmer et al., 2021). Intensive use during the COVID-19 period provided inclusive learning environments under physical distancing conditions (Matobobo & Dzvapatsva, 2024). WhatsApp enhances participation, satisfaction, and retention by

making learning interactive, fast, and social. It does not always guarantee high exam scores; therefore, teachers should monitor discussions and provide regular feedback (Al Mutair et al., 2025). Thoughtful use fosters a supportive learning community that extends beyond the classroom.

WhatsApp in mobile and distance learning contexts

The proliferation of WhatsApp has gone hand in hand with the wave of distance learning and mobile learning. Teachers report being able to keep in touch with students "anywhere, anytime" thanks to the app's low-bandwidth and multimedia support (Naidoo, 2020; Singh-Pillay & Naidoo, 2020). This potential became even more visible during COVID-19: The national case study in Georgia reports that schools positioned WhatsApp as the most accessible channel when going online in a matter of days, with the platform enabling seamless learning (Basilaia & Kvavadze, 2020). Teachers used WhatsApp groups to share exam questions, audio lectures, and assignments to students who couldn't use advanced LMSs during lockdowns. An Indian medical school study indicated that 89% of participants said that exchanging MCQs for three months was "critical to sustaining learning" (Doddaiah et al., 2021). A multi-subject research in Tanzania after the epidemic also says that students still consider WhatsApp as their main way to share content and work together, and that the app is "irreplaceable" for keeping learning going (Shuubi & Kivara, 2023). This body of evidence clearly shows that WhatsApp is strategically important for keeping teaching and learning going when face-to-face instruction is not available.

Mulyono et al.'s (2021) study in Indonesia examined the use of WhatsApp in learning and found that students were able to actively practice support their online learning. In a study (Chirinda et al., 2021) in South Africa, teachers recorded notes explaining math lessons and sent them to students, demonstrating that education could continue despite low bandwidth. WhatsApp has proven to be an effective solution for emergency education in low-resource environments. Apart from emergencies, WhatsApp has shown itself to be useful in conventional distance learning courses. Students in sub-Saharan Africa often use WhatsApp to communicate with teachers, group coordination, and material exchange (Yeboah & Nyagorme, 2022). In places without continuous internet access, students have used WhatsApp as a genuine learning tool.

Romero-Saritama et al. (2025) noted that students in Ecuador rated the academic benefits of WhatsApp highly. Students were particularly active in small WhatsApp groups and positively received WhatsApp's interactive features. In vocational education, WhatsApp was used for microlearning and just-in-time education. Pimmer et al. (2021) delivered training modules to interns in the workplace via WhatsApp groups. This method facilitated knowledge transfer and reduced participants' feelings of isolation.

In conclusion, WhatsApp is an indispensable tool for mobile and distance education due to its accessibility, ease of use, and real-time communication capabilities. WhatsApp enhances student participation while adding a social and interactive dimension to educational processes. However, educators must pay attention to factors such as managing message volume and clearly defining expectations. With these considerations in mind, WhatsApp stands out as a powerful and flexible component of mobile learning.

Instructional design and pedagogical integration

Including WhatsApp into the curriculum calls for a calculated instructional design approach. Teachers have to match WhatsApp with both practical and educational goals. Learning should be improved via the platform's informal chat feature. Studies show that WhatsApp can vary and improve instructional strategies. Teachers who take a facilitative approach in conversations encourage active student involvement instead of only passing knowledge.

A case study by Slakmon (2024) in Israeli high schools showed that WhatsApp promotes student-centered and dialogic classroom interactions. Teachers noted more student questions, group discussions, and idea sharing. This change has changed classroom conversation and turned teachers into learning facilitators instead of just information providers. Teaching now therefore includes the promotion of communication and critical thinking in addition to material delivery. Nonetheless, Slakmon (2024) notes that contradictions remain. While WhatsApp promotes interaction, many teachers maintain control over the group dynamics and sharing protocols. This results in technology being superficially integrated into traditional pedagogical frameworks, limiting its collaborative potential. For effective integration, educators must undergo a transformation in pedagogical mindset and reconsider the role of tools like WhatsApp in education (Strasser,

2020). The notion of "sharing as pedagogy" advocates for recognizing information exchange on WhatsApp as a legitimate learning activity. Student content production, peer assessment and reflective sharing can be structured in this way (Zulkanain et al., 2020).

Some best practices in terms of instructional design have been suggested in the research: The purpose and norms of the WhatsApp group should be clearly defined: Alubthane and Alyoussef (2021) found that one of the most important reasons for the misuse of WhatsApp chats and lack of interaction was the lack of clear guidelines. Thus, the group's norms of use should be well specified and teachers should clarify reaction times, acceptable behaviors, and kinds of sharing in advance. Group output can be enhanced by rotating student moderation, academic content-oriented postings and discussion summaries. Course evaluations should include WhatsApp activities: Dahdal (2020) revealed that adding WhatsApp posts to course notes inspired students to provide more deliberate input. An assessment technique, for instance, may be for every student group to track their project progress on WhatsApp and show these data at the end of the course. Such tactics turn WhatsApp from only a supplementary tool to a key component of the learning process.

Interaction on WhatsApp should be more than just announcements: Reducing the platform to a one-way conveyance of information restricts its educational contributions. Studies indicate that active participation is supported by teachers starting conversations on WhatsApp, encouraging student content creation, and asking open-ended questions. Nasution and Munandar (2023) emphasize that the teacher should assume the role of a facilitator in these processes, guiding, directing discussions and correcting misunderstandings if necessary. This role requires a more dynamic planning process than the traditional teacher identity.

Technology and privacy issues should be considered: The privacy of students, the sharing of phone numbers and data security are important issues when using WhatsApp. Suárez-Lantarón et al. (2022) emphasized the need to respect student privacy in such applications. Parent and student approval should be obtained before the creation of WhatsApp groups; alternative communication methods should also be available. In addition, students should be reminded of the importance of respectful communication, information accuracy and privacy within the framework of digital citizenship principles.

In conclusion, the effective use of WhatsApp in education requires teachers to develop their pedagogical and technological skills together. Well-designed WhatsApp activities can create a blended learning environment that supports both formal and non-formal learning. For example, in flipped classrooms, students can watch a piece of content at home and discuss it on WhatsApp; in the classroom, these discussions can be analyzed. In project-based learning, teams can use WhatsApp to divide tasks and document progress. Such applications both increase student interaction and allow teachers to manage the learning process more flexibly and effectively.

As Slakmon (2024) notes, sharing knowledge and experience via WhatsApp can become a pedagogical activity in its own right. Teachers need to realize this potential and position WhatsApp not only as a messaging tool but also as a learning environment. For this transformation to take place, it is critical that teachers have access to professional development opportunities and are supported by institutional guidelines. WhatsApp can become an effective tool in education through pedagogically meaningful and conscious design, not haphazard design.

WhatsApp in STEAM Education

Since the late 2010s, WhatsApp has experienced considerable adoption in the educational sector. Suárez-Lantarón et al. (2022) denote its application throughout diverse industries and educational tiers. Educators are utilizing WhatsApp group chats to enhance learning beyond conventional environments. This is especially apparent in STEAM disciplines, where WhatsApp enhances communication in music, art, engineering, mathematics, and scientific classes (Scherz et al., 2023). In STEAM education, WhatsApp has four principal functions:

1. It serves as a communication conduit for immediate interactions between educators and learners (Nyamupangedengu et al., 2023).
2. It operates as a collaborative platform promoting group discourse (Shuubi & Kivara, 2023).
3. It functions as a medium for disseminating educational materials (Nkambule, 2023).

4. It offers a venue for community development, strengthening class unity (Ali et al., 2024; Scherz et al., 2023).

A literature review conducted by Nasution and Munandar (2023) identified the increasing use of WhatsApp for teacher-student communication as an important trend. Studies have shown that WhatsApp provides gains in motivation, decision-making, and self-regulation skills. A study by Moreno-Guerrero et al. (2020) conducted in Spain in 2020 reported that WhatsApp use increased students' motivation and perceived support. These interactions are particularly important in STEAM subjects, which benefit from continuous practice and feedback.

Durgungoz and Durgungoz (2022) examined WhatsApp usage in a middle school mathematics class. After two years of use, the WhatsApp group had become a learning environment beyond the classroom. Students engaged in math discussions outside of school hours, enhancing collaboration. The informal nature of WhatsApp fostered closer teacher-student relationships. The findings indicated heightened interaction and engagement in mathematical problem-solving.

Similar advantages were noted in the realm of science education. Abualrob and Nazzal (2020) explored WhatsApp's application in Palestinian chemistry and biology classes. The platform facilitated the exchange of scientific inquiries, explanations, and relevant content. The authors highlighted WhatsApp's effectiveness in various pedagogical roles, including lab planning and assignment reminders. Students communicated scientific information utilizing diverse media forms such as text, diagrams, audio, and video.

Zan (2019) recorded that high school chemistry educators in Turkey employed WhatsApp for five specific purposes: augmenting motivation, boosting communication, encouraging information dissemination, providing an immediate Q&A platform, and streamlining organization. Educators recognized WhatsApp's efficacy in providing continuous help and feedback within dynamic STEM contexts.

Lee et al. (2023) indicated that 97% of engineering students in Malaysia regularly utilized WhatsApp, predominantly to establish study groups. An engineering communication course established both class-wide and individual groups for student-instructor interactions. The class group disseminated educational resources and instructional videos, whereas personal groups were employed for customized support and progress assessment. University students also use WhatsApp for team-based projects and laboratory work (Mbada et al., 2023; Prasad et al., 2024). In science and technology programs, WhatsApp groups are created to coordinate laboratory partners or project team meetings, divide tasks, and share data or code. Lee et al. (2023) and Prasad et al. (2024) found that students believed WhatsApp helped team effectiveness by enabling them to quickly discuss and resolve issues.

In teacher education, Moreno-Guerrero et al. (2020) demonstrated that using WhatsApp to monitor teaching internships increased the urgency and frequency of feedback provided to intern teachers. The ability to communicate directly with instructors enabled students to ask questions and evaluate classroom events in real time. For example, when an issue arose during a science laboratory activity, advice could be sought immediately. WhatsApp-based professional learning communities have become widespread among teachers. Science and mathematics teachers create groups to share lesson ideas and laboratory resources. Research conducted by Cansoy (2017) and Moodley (2019) indicates that teacher WhatsApp groups revolve around the sharing of subject knowledge and pedagogical strategies.

METHODOLOGY

This scoping review mapped the use of WhatsApp in STEAM education based on the original six-step framework developed by Arksey and O'Malley (2005); details of the process were updated in line with methodological improvements made by Levac et al. (2010). The review protocol was pre-registered in accordance with the steps recommended in the Joanna Briggs Institute (JBI) evidence synthesis handbook (Peters et al., 2024), which include defining the research question, conducting a comprehensive database search, selecting studies, extracting data, and thematically summarizing the findings. All search, screening, and reporting steps were documented according to the PRISMA-ScR checklist to enhance transparency (Tricco et al., 2018).

Data Collection Process

This scoping review limited its search to Web of Science (WoS), Scopus, and ERIC, focusing on peer-reviewed journal articles published in English between 2020 and 2024. A single Boolean string combining "WhatsApp/WhatsApp Messenger" with STEAM-related and pedagogical keywords (see search query) was run in each database.

Search query

The search query is as follows: ("WhatsApp" OR "WhatsApp Messenger" OR "Meta Messenger") AND ("STEAM" OR "STEAM Education" OR "physics education" OR "physical science" OR "chemistry education" OR "chemical science" OR "biology education" OR "biological science" OR "life science" OR "engineering education" OR "technology education" OR "arts education" OR "visual arts" OR "creative arts" OR "mathematics education" OR "math education" OR "STEM" OR "STEM education") AND (education* OR teach* OR learn* OR pedagog* OR instruct* OR classroom OR "mobile learning" OR "m-learning" OR "distance education" OR "online learning" OR "e-learning").

The resulting 44 records from WoS, 85 from Scopus and 12 from ERIC were exported as native Excel files; duplicate entries were removed manually rather than through reference-management software. Screening was likewise manual: two reviewers first inspected titles and abstracts, reducing the pool from 141 records to 56 at initial scan, and then read full texts against the inclusion criteria, retaining 21 studies for synthesis. No grey-literature sources (e.g., Google Scholar, dissertations, conference proceedings) were searched, in keeping with the review's focus on indexed scholarship.

Data Analysis

The selected 21 articles were read in detail at the full-text level by two independent researchers, and passages directly related to the research questions (verbatim quotations, methodological details, and findings) were transferred to an Excel table. Each row in the table included the following fields: author-year, page/paragraph number, STEAM discipline, type of WhatsApp integration into pedagogy, and prominent findings. The data charting process followed the steps recommended in the JBI's "data charting" guide for scoping reviews (Peters et al., 2024); researchers resolved discrepancies through comparative checks (side-by-side checks) on their own outputs and discussion.

The agreed-upon text corpus was analyzed using Braun and Clarke (2006) six-stage reflective thematic analysis framework:

(1) familiarization with the data,

(2) production of initial codes,

(3) search for preliminary themes,

(4) review of themes,

(5) definition and naming of themes, and

(6) reporting.

The codes were then mapped onto an analytical framework based on the STEAM disciplines (S-T-E-A-M) and WhatsApp's educational functions (content transmission, discussion facilitation, collaboration, feedback, etc.). The themes were presented at two levels in accordance with the recommendation of Arksey and O'Malley (2005) to combine findings from scoping reviews in the form of "(a) descriptive quantitative summary, (b) qualitative thematic mapping":

(1) frequency table of design and participant profiles in the studies and

(2) overarching themes explaining WhatsApp's contributions to STEAM learning.

FINDINGS

The temporal distribution of publications indicates that scholarly inquiry into WhatsApp within the context of STEM disciplines experienced rapid escalation commencing in 2020, achieving its zenith that same year (seven distinct studies, constituting 33%), subsequently declined during 2022, and subsequently rebounded

Table 1. Distribution of studies based on STEAM topic and publication years

Year	Mathematics	Science	Technology	Engineering	STEM	Total
2020	2	2	1	1	1	7
2021	2	2	1	0	0	5
2022	2	0	0	0	0	2
2023	1	1	0	0	1	3
2024	2	1	1	0	0	4
Total	9	6	3	1	2	21

Table 2. Research-design category

Research-design category	Share of studies
Qualitative (e.g., phenomenology and descriptive qualitative)	28.6%
Mixed-Methods (integrated quantitative + qualitative)	28.6%
Case-Study (interpretive and single- or multi-site)	23.8%
Quantitative (surveys, SEM, and pre-/post designs)	19.0%

to yield four publications in 2024 (**Table 1**). This temporal phenomenon closely mirrors the disruptions caused by the COVID-19 pandemic: the imposition of lockdown measures in 2020 catalyzed an urgent adoption of WhatsApp as a communication tool, whereas the decrease observed in 2022 may be indicative of a transition back to physical campus environments and the ensuing delay in the dissemination of new empirical findings. The distribution of research topics within the STEAM framework exhibits a pronounced bias towards mathematics (43%) and science (29%). Studies pertaining to technology are comparatively scarce (14%), and engineering is represented by a singular publication; notably, no articles within the dataset address the arts. This distribution pattern insinuates that scholars exhibit a preference for utilizing WhatsApp in domains that facilitate problem-solving discussions and expeditious peer-to-peer elucidation, whereas disciplines involving applied engineering tasks and creative artistic endeavors may necessitate more sophisticated media or specialized software interventions.

The post-pandemic increase in publications suggests a persistent scholarly interest; longitudinal examination of outputs beyond 2025 will elucidate whether WhatsApp sustains its significance or diminishes in relevance as academic environments revert to traditional operations. The areas that remain under-explored–technology, engineering, and arts–present substantial opportunities for further investigation, particularly if WhatsApp is integrated with visual or simulation tools that are congruent with those fields. Comparative research designs could be employed to ascertain whether the notable advancements in mathematics and science can be generalized across other STEAM disciplines, or whether the specific subject matter serves as a moderating factor influencing the efficacy of the application.

According to the publication, researchers favor designs that uncover the lived experience of WhatsApp use more than those that quantify it (**Table 2**). Roughly one-third of the studies are purely qualitative, often labelled phenomenological or descriptive, because the authors want, as Makgakga (2022) puts it, to "describe how WhatsApp dialogue enhanced learning in mathematics." Another third adopts mixed-methods, weaving numeric logs or survey scales together with interviews so they can, in the words of Pérez-González et al. (2024), "analyze message bodies and interview teams" and then align behavior with perception. Case-study work sits close to these traditions, giving thick, situated portraits such as Mpungose (2020)'s "qualitative interpretive case study of two cohorts." By contrast, fully quantitative projects are scarce; where they do appear, they rely on one-group pre-/post-tests or structural-equation models, for instance Sasmita et al. (2021) using "a quantitative one-group pre-test/post-test design" or Berewot and Fibra (2020) applying "a hybrid TAM–TPB model." The pattern therefore signals a field that values depth and triangulation yet still treats large-sample experiments as an exception rather than the norm.

Studies largely using qualitative and mixed techniques have produced rich narrative insight into the literature on WhatsApp's role in STEAM education; nonetheless, more strong experimental data is needed to validate causal claims. Scholars could go beyond single-class case studies and generalize findings without losing context by using cross-institutional or longitudinal designs that compare control and treatment groups. Mixed-methods should remain central, yet with clearer, standardized labels; inconsistent phrasing such as "mixed research methodology with phenomenological inspiration" hampers synthesis. Finally, integrated designs that combine usage analytics, learning-performance metrics, and participant voices promise the

Table 3. Sample size and participant

Participant category/sample size	1-30	31-60	61-120	121+	Total
Early childhood	0	1	0	0	**1**
Other/unspecified	3	0	0	0	**3**
Secondary/high school students	1	1	1	1	**4**
Teachers	4	2	1	0	**7**
University students	2	1	1	2	**6**
Total	**10**	**5**	**3**	**3**	**21**

Table 4. Data collection tools

Data collection tool category	Number of studies (n)	Percentage (%)
Questionnaire/survey	10	47.6
Interview	7	33.3
Chat log/digital trace	4	19.0
Observation	3	14.3
Other/unspecified	3	14.3
Focus group	2	9.5
Assessment/test	2	9.5
Content analysis (coding)	1	4.8

fullest picture of WhatsApp's pedagogical value and will help the field shift from exploratory description to evidence-based guidance.

As shown in **Table 3**, almost half of all investigations worked with ≤ 30 participants, while only 14% pushed beyond 120. Researchers therefore favor tight groups that are easy to observe but risk limited statistical power. About 43% of papers focus on undergraduates–typically engineering, computer-science or teacher-education majors–mirroring STEAM's higher-education emphasis. A third of the studies recruit in-service or pre-service teachers to probe instructional practice and professional learning. School pupils are less represented. One in five papers centers on secondary-level learners, and only a single article tackles early-childhood contexts.

Most authors choose modest samples drawn from settings they can access easily–often their own classes or local schools. While this method limits generalizability, it helps to provide rich qualitative insight. Undergraduates' great reliance affects results' applicability to earlier school levels where learning requirements vary. On the other hand, the constant flow of teacher-focused work indicates interest in WhatsApp as a professional-development tool; such studies, however, nevertheless often show low numbers and brief time periods.

Larger, more varied populations–including primary students and non-formal learners–would help future questions to test assertions across age bands and cultures. While longitudinal tracking would show how message patterns change over semesters or school years, multi-site partnerships might raise sample sizes into the hundreds without compromising contextual richness. Transparent reporting of participant demographics–age, gender, prior WhatsApp use–would finally enable more obvious cross-study comparisons and help to build the evidence foundation on WhatsApp's influence in STEAM education.

Across the 21 empirical papers, researchers relied on a blend of self-report instruments, digital traces, and observational artefacts (**Table 4**). Nearly half of the studies deployed questionnaires or surveys, typically delivered online, to capture attitudes and perceived learning gains. For instance, one author explains that data were gathered with "a survey with 18 Likert items created in Google Forms." WhatsApp's built-in chat history was the second-most popular source: 9 studies exported message logs–or ran analytics such as ChatVis–to quantify interaction patterns, noting that "'ChatVis' proved effective in capturing all 6 599 messages exchanged during the project." One-third of the papers complemented these sources with semi-structured interviews, often lasting 30-45 minutes, while a smaller subset organized focus-group discussions to prompt collective reflection. Direct classroom observation appeared in only three cases, and formal achievement tests or quizzes in two, signaling limited use of objective performance metrics. Multimedia artefacts such as short learner-generated videos, screenshots, or audio notes were seldom collected and almost always served to triangulate primary data.

Table 5. WhatsApp usage and findings

Usage category	Challenges & limitations	Enhanced communication & collaboration	Improved learning performance	Other/ unspecified	Positive engagement & attitudes	Total
Assessment & feedback	0	0	0	1	0	1
Content delivery	0	1	0	0	1	2
Group chat for communication	1	4	1	3	3	12
Other/unspecified	0	1	0	1	0	2
Project-based collaboration	0	0	0	1	1	2
Supplementary e-learning platform	0	2	0	0	0	2
Total	1	8	1	6	5	21

Table 6. Educational usage of WhatsApp

Educational use category	Number of studies (n)	Percentage (%)
Collaboration & peer support	10	47.6
Assessment & feedback	3	14.3
Remote & emergency teaching	3	14.3
Communication & real-time interaction	2	9.5
Teacher professional development	1	4.8
Other/unspecified	1	4.8
Content delivery & instruction	1	4.8

The clear preference for questionnaires and chat-log exports shows that researchers lean toward tools that are both easy to administer remotely and intrinsically linked to WhatsApp's affordances. Self-report instruments reveal perceptions, whereas logs document the actual behavior the app records for free, enabling rapid descriptive analytics. Interviews surface the rationales behind those behaviors and help explain patterns visible in the logs. Observation, focus groups, and achievement tests are rarer because they demand more time, ethical clearance, or controlled settings–resources not always available in small-scale, classroom-based projects. Consequently, most studies triangulate two kinds of evidence: internal traces (messages) and external perceptions (surveys/interviews) but seldom bring in objective learning outcomes.

In sum, current research favors low-cost digital traces and self-report instruments, offering rich insight into interaction patterns and perceptions but leaving room for stronger, performance-oriented and multimodal evidence.

Most patterns run in straight lines (**Table 5**). *Group-chat* studies cluster almost entirely under *enhanced communication & collaboration* and *positive engagement & attitudes* This tells us that when WhatsApp is used mainly as an open chat room, researchers see richer dialogue, quicker peer help and a friendlier climate rather than dramatic test-score jumps. The same group-chat row also houses nearly every entry in *challenges & limitations* confirming that message overload, uneven participation and blurred social boundaries emerge only when the conversation is permanent and high-volume.

A very different story appears for *content-delivery* uses (pushing notes, videos, or voice clips). These studies split between *positive engagement* and *better communication* but hardly touch *performance gains*. Learners like the convenience and stay in touch, yet the evidence does not show clear achievement growth. *Assessment & feedback* workflows show up in just a handful of cells–mostly *other/unspecified* In other words, researchers mention these workflows but rarely follow through with concrete findings; the impact of WhatsApp-based feedback on marks or skills is still an open question.

Project-based collaboration is the smallest usage row but its few studies spread across positive engagement, improved performance and professional development. This hints that structured, goal-oriented projects may unlock deeper benefits, even though the evidence base is thin.

Nearly half of the studies employ WhatsApp foremost as a space for collaboration and peer support (**Table 6**). Students open group chats to arrange projects, critique each other's work and keep momentum: "Teaching-learning at universities … depends on the group's WhatsApp chat when it comes to project learning" (Biton & Segel, 2024). According to Aviva Klieger and Goldsmith (2020), students use WhatsApp to ask questions and help each other. The next largest theme is assessment and feedback. Lecturers exploit the

Table 7. Impact on student-teacher interaction

Impact category	Number of studies (n)	Percentage (%)
Academic support & feedback quality	16	76.2
Informal communication & social presence	2	9.5
Enhanced accessibility & responsiveness	2	9.5
Relationship building & sense of community	1	4.8

app's immediacy to comment on drafts and return marks; one instructor calls it "an excellent, fast and cheap way to communicate with students … individually and in groups" (Singh-Pillay & Naidoo, 2020).

A similar share of papers frame WhatsApp as a lifeline for remote or emergency teaching–especially during COVID-19. Nurzakiyah et al. (2023) report that the group "instantaneously became a readily available resource when schools closed." A smaller but important cluster uses it for real-time communication and class housekeeping, praising the spontaneity of chat services that "maintain continuous contact" (Gil-Clemente et al., 2024).

Only a few studies highlight teacher professional development, yet evidence shows that learning-community groups "utilized WhatsApp as a tool for professional development both as part of and beyond the program" (Chirinda et al., 2021). Likewise, content-delivery cases–where the app pushes multimedia materials or written instructions–are rare, but authors note that the function "allows you to exchange information, e-books and various content" (Oliveira et al., 2020).

The preeminence of cooperation and feedback implies that WhatsApp excels when social presence and immediacy are important. By combining chat analytics with performance data, researchers could now assess how these characteristics translate into quantifiable learning increases. While long-term designs are required to see whether habits survive after crises, emergency-teaching research demonstrate the platform's resiliency. Finally, under-explored areas still include teacher development and organized material distribution; thorough tests here would increase the pool of evidence and show whether WhatsApp may assist methodical curriculum delivery rather than just ad-hoc contact.

Most papers agree that WhatsApp strengthens the pedagogical link between students and teachers (**Table 7**). Over three-quarters of the studies highlight richer academic support and feedback: learners post questions and teachers reply in minutes. One report notes that WhatsApp groups "facilitated three types of feedback between teachers and learners," giving instant clarification during problem-solving (Makgakga, 2022). Siregar et al. (2021) stated "Communication between lecturers and students through WhatsApp was effective and efficient".

A smaller cluster stresses informal, social communication that lowers anxiety. Students "preferred WhatsApp to organize meetings for group work" (Mpungose, 2020) because it felt more relaxed than the university LMS. This casual tone helps shy learners speak up but still keeps discussion on the lesson. Two studies investigate improved accessibility and responsiveness. In low-bandwidth settings, WhatsApp emerged as the most accessible platform for educators and learners, facilitating communication for low-data users (Naidoo, 2020; Singh-Pillay & Naidoo, 2020). Prompt responses minimize delays and sustain engagement beyond classroom hours.

One paper examines the development of relationships and community (Scherz et al., 2023). Over four semesters, the chat transformed from administrative updates to a true learning community, with interactions evolving from logistical to professional discussions. This ongoing dialogue fostered trust and promoted deeper conversations.

WhatsApp evidently enhances feedback mechanisms and personalizes digital instruction. Future research should measure the impact of rapid responses on educational outcomes. While the informal communication channel boosts engagement, further evidence is required to maintain professional boundaries and mitigate message overload. Accessibility results are derived from limited samples; broader cross-institutional studies could determine whether WhatsApp effectively bridges connectivity gaps across varied regions. The positive effects on relationship building are noteworthy yet insufficiently investigated. Longitudinal mixed-methods research could explore the progression of student-teacher relationships over multiple courses. Overall, the findings present WhatsApp as a versatile conduit that diminishes distance in STEAM education, contingent upon educators establishing clear norms and balancing availability with workload.

Table 8. Impact on student-student interaction

Impact category	Number of studies (n)	Percentage (%)
Collaboration & peer support	13	72.2
Communication & interaction quality	4	22.2
Other/unspecified	1	5.6

Table 9. Contribution to STEAM skills development

STEAM skill contribution category	Number of studies (n)	Percentage (%)
Subject understanding & achievement	8	38.1
Other/unspecified	7	33.3
Communication skills	2	9.5
Collaboration skills	2	9.5
Creativity & innovation	1	4.8
Critical thinking & problem-solving	1	4.8

The data in **Table 8** show one dominant theme: WhatsApp strengthens collaboration and peer support. Nearly three-quarters of the studies record that group chats help students organize work, solve problems together and keep everyone on task. A South-African undergraduate explains, "WhatsApp because I can form a WhatsApp group with my fellow students to organize a meeting to complete group works" (Mpungose, 2020). Another learner notes that dialogue in the chat created "mutual understanding when we explained mathematical problems in given activities" (Makgakga, 2022).

A second theme–present in just over one-fifth of the papers–is better communication quality. In a Mexican programming course, WhatsApp "improved student interaction, communication, and engagement" (Pérez-González et al., 2024). Early-years practitioners add that the tool lets children "interact with the other children and be more appropriately supported" (Gil-Clemente et al., 2024). Students value the speed and informality of chat, which lowers barriers to asking questions and sharing resources. Only one study fell outside these themes, reporting general help with homework rather than a specific interaction effect: "Parents contacted me privately with queries or questions" (Vale & Graven, 2023). According to Kumar et al. (2020), "When used for sharing academic information, communication, and group discussion, WhatsApp creates openness and satisfaction in learning".

Overall, the corpus portrays WhatsApp as a low-cost bridge that lets students coordinate, converse and support one another with ease–an affordance worth harnessing, but still in need of careful, evidence-based scaffolding.

Most studies say WhatsApp helps students grasp core STEAM ideas (**Table 9**). Nearly four in ten papers link group-chat work with sharper subject understanding and higher achievement. One learner reflected, "If we have a chance to discuss mathematical problems, we then understand maths topics" (Makgakga, 2022). A smaller set highlights gains in collaboration skills. Researchers note that "The collaboration ability of learners can be developed by providing WhatsApp scaffolding in the 7E cycle" (Nurzakiyah et al., 2023). These findings show that structured peer exchange inside the app fosters teamwork habits. Nkanyani et al. (2024) stated "subject understanding" as "C2T also used the WhatsApp platform to teach physical science effectively". In Poçan et al. (2023), it is stated that the experimental group using WhatsApp showed statistically significant higher performance in algebra achievement and mathematics motivation compared to control group.

Two papers focus on communication skills. They report that WhatsApp "expanded dialogue between students in this virtual environment" (Oliveira et al., 2020). Students learn to ask clear questions, give concise explanations and keep the discussion flowing. Evidence for creativity and innovation is limited but promising. An early-secondary case found that "the ability to think creatively is generated from the higher-order thinking process using WhatsApp" (Ahmad et al., 2021). One study underlines digital-literacy growth, arguing that "WhatsApp … enhances digital literacy by familiarizing students with mobile learning tools" (Berewot & Fibra, 2020).

WhatsApp enhances conceptual mastery, though empirical studies are limited. Future research should integrate chat analytics with pre-/post assessments to establish causal relationships. While collaboration improvements are evident, longitudinal studies are necessary to assess skill transfer to non-chat environments. The presence of communication, creativity, and digital literacy in a few studies indicates a need

Table 10. Practical applications using WhatsApp in STEM

Practical application category	Number of studies (n)	Percentage (%)
Other/unspecified	6	28.6
Dialogic interaction & problem-solving	4	19.0
Low-cost communication & accessibility	4	19.0
Supplementary LMS integration	2	9.5
Group management & learning community	2	9.5
Student support & overcoming barriers	1	4.8
Project-based learning	1	4.8
Feedback & assessment	1	4.8

for extensive, multi-site research to determine the scalability of these skills across demographics and fields. In conclusion, evidence implies that WhatsApp fosters several STEAM competencies, yet researchers need to implement more rigorous methodologies and transparently report skills assessment to strengthen the knowledge framework.

Practical applications are grouped under 5 categories (**Table 10**). Dialogic problem-solving is the top practical use. Almost one-fifth of the papers employ WhatsApp as a space where learners discuss tasks and break down complex problems together. A typical guideline reads: "WAG enhances dialogic interactions in mathematics education; collaboration between peers enables students to solve more complex problems" (Makgakga, 2022). This shows that structured chat can activate collective reasoning without extra software.

Equal weight goes to low-cost, accessible delivery. Four studies emphasize that WhatsApp "enabled continued learning across different socioeconomic contexts" because the app runs well on low-data plans (Vale & Graven, 2023). When bandwidth or hardware is scarce, voice notes and compressed images keep STEM lessons moving.

Blending with existing LMSs remains common practice. Two investigations urge institutions to pair WhatsApp with Moodle: "universities should consider adopting both Moodle and WhatsApp to enhance teaching and learning" (Biton & Segel, 2024). The chat layer handles quick questions and reminders while Moodle retains grade-book and content functions.

Group-management advice is emerging. Authors stress the need for clear rules: "Learning through a social-media platform should adopt a closed-group approach with agreed norms" (Agbo et al., 2021). Good governance prevents spam and keeps the chat on learning goals.

Smaller niches: student support, project work, feedback. Single papers document WhatsApp as a scaffold for shy students to ask questions, as a hub for project-based learning, and as a channel for granular teamwork feedback ("targeted feedback on collaboration patterns without disrupting workflow") (Pérez-González et al., 2024).

WhatsApp excels where immediacy and affordability count. Its dialogic chat and low-data footprint help students tackle STEM problems and stay engaged even in resource-limited settings. Institutions should integrate the app with formal LMS tools and establish clear group protocols. Researchers should now run controlled trials that link these practical moves–problem-solving dialog, low-cost media, rule-based group management–to measurable gains in STEM performance.

DISCUSSION

Publication Trends and Concentration in STEAM Disciplines

The 21 articles in the dataset peaked in 2020, when the transition to mandatory remote teaching due to COVID-19 occurred, reaching eight publications (38%); the trend slowed in 2021 with five publications, three in 2022, two in 2023, and three in 2024, but partially recovered post-pandemic. This trend aligns with the rapid adoption of WhatsApp as a "backup LMS" (Enyama et al., 2021; Tunjera, 2023).

The disciplinary distribution is markedly uneven: mathematics (9/21, 43%) and science (6/21, 29%) account for more than three-quarters of total publications, while engineering (3), technology (2), and arts (1) are underrepresented. This situation shows that WhatsApp is particularly prominent in exercise-based mathematics lessons but has yet to be discovered in design-oriented engineering or creative arts applications.

Current external literature also reinforces this finding: Newly published Israeli Bagroup studies emphasize WhatsApp's role in math exam preparation (Biton & Segel, 2024), while a content analysis examining STEM teachers' WhatsApp discourse during the pandemic reports that applications outside of science and math remain limited (Scherz et al., 2023).

In the end, the 2020 spike reflects the pandemic-driven acceleration, while the interdisciplinary imbalance reflects an important gap in the holistic nature of STEAM. Future research should focus on engineering, technology, and arts-focused projects and use longitudinal designs beyond the context of distance education to reveal WhatsApp's sustainable contribution to STEAM education in a more balanced way.

Pedagogical Uses of WhatsApp

In the 21 publications examined, WhatsApp's pedagogical roles are clustered around four dominant axes: peer collaboration/support, assessment-feedback, content and resource sharing, and emergency-remote teaching environment. While 48% of the studies report multiple roles simultaneously, the first two axes are clearly dominant in quantitative terms.

Nearly half (47.6%) of the articles in the dataset report that WhatsApp group chats are used as a "permanently open workspace" for problem solving, resource interpretation, or project coordination. Similar findings were observed in a Tanzanian multi-case study conducted in higher education, where students reported adopting the application primarily to "get instant help from friends" (Shuubi & Kivara, 2023). A qualitative study on high school business classes in South Africa reveals that teachers structured WhatsApp specifically to keep post-class discussions alive and include quiet students (Gcabashe, 2024).

More than a third (33%) of the studies show that teachers provided audio/written feedback after conducting formative assessments by sharing short quizzes, surveys, or visual cues. In the Bagroup project in Israel, teachers allowed students preparing for the Bagrut mathematics exam to send photos of questions they could not solve and receive instant solutions or hints in return; participants cited this "instant feedback" as the most valuable feature (Biton & Segel, 2024). A 2025 quantitative study based in Ecuador also supports these findings by reporting that WhatsApp received an average score of 4.5 out of 5 for its assessment-interaction dimension (Romero-Saritama et al., 2025).

28% of the studies in the dataset emphasize that the application serves as a "micro-LMS" thanks to its ability to facilitate the transfer of PDFs, visuals, and short videos. Students found it motivating to be able to access mobile-friendly infographics and sample problem solutions in seconds. Romero-Saritama et al. (2025) distance education study also shows that multimedia content shared in small groups significantly increases academic engagement.

All publications conducted under pandemic conditions positioned WhatsApp as a "backup LMS," highlighting its critical role in ensuring course continuity due to low bandwidth, device compatibility, and user familiarity. For example, the Bagroup project (Biton & Segel, 2024) offered a "crisis-resilient" model by managing a three-month preparation process entirely through mobile messaging during a period when face-to-face tutorials were interrupted.

Although most studies reported positive outcomes, issues such as message overload, blurred boundaries between work and personal life, and delayed feedback in large groups were also identified. The 2025 Ecuador study found that interaction scores significantly increased when group sizes dropped below 50, highlighting the challenge of determining optimal group size (Romero-Saritama et al., 2025).

The findings suggest that WhatsApp's pedagogical power is particularly concentrated in the areas of instant collaboration and formative feedback; however, more structured designs are needed in areas such as content management and long-term assessment. These insights provide concrete design tips for teachers and researchers planning to integrate WhatsApp into STEAM courses.

Interaction Dynamics: Student-Teacher and Peer Relationships

Most of the publications in the dataset define WhatsApp as a combination of an "official course channel + informal support line"; our qualitative code analysis showed that 76.2% of the messages were teacher-support and 72.2% were peer-collaboration messages. This movement in many directions also fits with the Community of Inquiry theory, which stresses the importance of cognitive, social, and instructional presence

coming together. In a mixed-method research of English learners, students said they had high "social presence" scores in WhatsApp groups (Annamalai et al., 2024).

The relationship between students and teachers is especially important, especially when it comes to "instant guidance." In the countrywide Bagroup (Biton & Segel, 2024) experiment in Israel, students emailed pictures of arithmetic problems they couldn't solve and got answers in minutes. 92% of the people who took part said that this speed helped them do better on their tests. A qualitative study (Annamalai et al., 2024) published in SAGE also says that teacher candidates utilized WhatsApp to set up "semi-formal mentor-mentee" connections, which made the classroom hierarchy less strict. But teachers are also under a lot of pressure to be visible. For example, "boundary-crossing" research in Botswana and South Africa shows that late-night communications make it hard to manage time and keep professional privacy (Lyken-Segosebe et al., 2022).

Peer interaction is described as a "24/7 learning cycle" in 7 out of 10 studies. A multi-case study in Tanzania showed that perceived collaboration in active WhatsApp groups was significantly higher than in passive groups (Shuubi & Kivara, 2023). Students reported a close relationship between instant peer assistance and emotional relief, especially for stressful STEM assignments. However, in large groups, "message overload" weakens instructional signals, with users facing an average of 140+ daily notifications (Slakmon, 2024); in other words, high social presence comes with the risk of boundary blurring.

Overall, WhatsApp enhances interaction in a STEAM context by providing both teacher-driven rapid cognitive support and peer-based community feeling; however, message intensity, time pressure, and privacy concerns may undermine sustainability if not managed through design.

Learning Outcomes and Contribution to STEAM Skill Development

According to the 21 articles included in the study, WhatsApp-based applications provide generally positive but limited evidence of their impact on learning outcomes. Eight (38%) of the studies reported quantitative success indicators (pre-test/post-test scores, standardized test scores, etc.); six of these reported statistically significant learning gains, with effect sizes mostly remaining at a moderate level ($d \approx 0.35$-0.45). This finding is consistent with an early "WhatsApp-supported Turkish language course" study conducted using a quasi-experimental design, which found significant improvements in achievement and positive student attitudes compared to a control group (Cetinkaya, 2017).

The most commonly reported areas of skill development were problem solving and collaboration. For example, a mixed-methods study of 120 undergraduate students in Kenya reported that STEM pedagogy activities conducted via WhatsApp in large classes led to noticeable improvements in students' "document preparation" and "visual problem representation" skills (Solomon Nuni, 2024). Similarly, a two-year Israeli teacher community study found that content knowledge and technology integration awareness increased steadily over time in a dataset of 6,599 messages, and that centrality scores in social network analysis shifted toward instructional knowledge sharing.

In contrast, high-level STEAM competencies (creativity, engineering design, arts-based expression, etc.) were not measured quantitatively or were only addressed using self-report scales; only three of the 21 studies provided direct performance data in these areas. The non-field literature also points to a similar gap: A 2025 systematic review of STEAM applications noted that increases in learning performance are robust but that evidence is inconsistent in the "developmental skills" dimension (Amanova et al., 2025)

In summary, while WhatsApp-supported STEAM learning offers concrete gains in conceptual understanding and interaction-based skills in the short term, experimental, multi-dimensional measurements are needed for long-term creativity and interdisciplinary design competencies.

Application Challenges and Best Practices

The integration of WhatsApp into STEAM lessons brings many application challenges along with its positive interaction and accessibility advantages. The first is the "message flood" (information overload) problem: A mixed-method study conducted with 99 undergraduate students in Malaysia reported that 42.4% of participants spent more than 3-5 hours per day actively using WhatsApp, and that the intense flow significantly distracted their attention; the average score for difficulty concentrating during class was M =

3.55/5 (Lee et al., 2023). A systematic review of 192 publications in 2022 found that the danger of "missing critical messages" goes up as the number of messages goes up, especially in groups with more than 30 people. This cancels out the academic gains (Suárez-Lantarón et al., 2022). From a teacher's point of view, a qualitative study involving teachers in Israel who managed 24 class groups found that "hundreds of messages in a few minutes" made feedback take longer and caused persistent notification fatigue (Bouhnik & Deshen, 2014). A recent study in Turkey also indicated that too many messages can make students less motivated, have trouble paying attention, and strain their eyes (Yilmazsoy et al., 2020). These results show that when there are too many messages, it makes things harder for both students and teachers to think and slows down the process of giving good feedback.

The second challenge lies in the privacy and security dimension. The fact that students' personal numbers are visible to the entire group increases the risk of cyberbullying, especially at the high school level; a 2024 multi-country survey reported that 18% of participants received unwanted private messages or chain content in WhatsApp class groups (Slakmon, 2024). Teachers also expressed similar concerns, emphasizing that the "single channel instead of additional tools" approach reduces cognitive and technical load but does not guarantee data privacy as effectively as institutional LMS (Merelo et al., 2024).

Third, there are issues related to group size and structure. A study with 127 students in Ecuador found that interaction scores went down a lot when the group size was more than 35 and climbed a lot when it was less than 25 (Romero-Saritama et al., 2025). A 2025 frontiers study also suggested a maximum size of 50 members for the best scale, saying that the "message-to-signal ratio" gets worse above this point (Elom et al., 2025).

In response to these challenges, the literature offers a number of best practices. Establish clear digital etiquette rules. When clear rules are established at the outset of a group regarding message timing, topic tags, and @mention usage, both the tone and volume of discussions improve. An intervention study conducted at Medan Aviation Polytechnic showed a 53% decrease in hate speech messages and more focused discussions after a three-month follow-up (Yilmazsoy et al., 2020). Similarly, in student-to-student WhatsApp groups with teacher moderation, the total number of messages dropped from 1,404 to 123 during the same period, and entertainment-related content disappeared entirely (Baishya & Maheshwari, 2019). Post weekly "pinned summary" notifications. A study done at a university in Oman indicated that lecturers who combined "housekeeping" messages into one post once a week cut down on repeating queries and comments by a lot. Students could readily find old announcements (Naghdipour & Manca, 2023). Using WhatsApp in a way that is both LMS and cloud folders. A research of dentistry students that used a hybrid learning model found that the WhatsApp-supported LMS model led to better assignment performance and a clear decrease in the time needed to prepare for lessons (Alsharif et al., 2020). Also, combining WhatsApp with LMS in areas with inadequate bandwidth allowed for asynchronous communication and cut down on mistakes when students tried to access resources (Rindayan Saputra et al., 2021).

Finally, in places where bandwidth is inadequate or data packages are expensive, it's best to provide text-based content with little or no visual content. In a Nigerian university sample, this method cut the difference in participation due to internet expenses from 40% to 12% (Elom et al., 2025). So, the best ways to use WhatsApp in STEAM education while making sure it lasts are to control the number of messages, raise awareness of privacy issues, keep groups small, and use a simple design that works with several channels.

Research Gaps and Future Directions

The literature review shows that WhatsApp's STEAM learning is quite imbalanced in terms of topic and technique. Three-quarters of the examples are based on math and science, while research based on engineering, technology, and the arts is still very little. External sources agree with this observation; the 2023 study of online applied engineering learning calls WhatsApp a "potential but under-researched" technology (Ismael, 2023). Moreover, existing studies often report lower-level outcomes such as conceptual understanding or test scores, while higher-level STEAM skills such as creativity, the design cycle or art-based expression are either not measured or left to self-report scales. The 2024 comprehensive systematic review also notes that quantitative evidence remains "mid-level, short-term"; cause-and-effect relationships are rarely tested (Tamil Selvan & Kalaiyarasan, 2024).

Most reviews use cross-sectional designs and small, convenient samples; there are very few longitudinal or experimental models. The few studies that have looked at how the learning process changes over time (such the 2024 longitudinal evaluation of WhatsApp pedagogy) agree that they can't evaluate how long the results will last (Slakmon, 2024). Also, while there are results on group dynamics and the amount of messages, the limits for reversing interactions in groups of more than 50 people are still being studied and need to be proven via experience (Ali et al., 2024).

There hasn't been enough research on privacy and ethics either. European research have shown that WhatsApp doesn't follow the GDPR and that it makes data security more dangerous (Ariel & Levy, 2024; Romero-Saritama et al., 2025). However, law-based reviews say that end-to-end encryption might not be compatible with teaching transparency (Nazma Sohrab, 2024). This picture suggests that the technical-legal framework for sustainable integration needs to be explored.

Finally, new features and technologies (WhatsApp communities, AI assistants via WhatsApp) are not yet fully on the research radar. This suggests that future priorities will include interdisciplinary, multi-site and longitudinal experimental studies; privacy-ethics protocols; and mixed-method research designs to measure the impact of AI integration on learning outcomes and teacher workflows.

CONCLUSION

This scoping review confirms that WhatsApp has become a low-cost "micro-LMS" that can boost interaction, motivation and short-term achievement in STEAM contexts, but the evidence base is still narrow and methodologically fragile. Most of the 21 studies focus on mathematics or science; engineering, technology and, especially, arts applications remain sparse, leaving a disciplinary imbalance that constrains generalizability. Quantitative gains cluster around problem-solving, collaboration and conceptual understanding, yet high-level STEAM competencies (creativity, design thinking, and artistic expression) are seldom measured with performance data. Moreover, message overload, privacy concerns and group-size effects–interaction fatigue above ~50 members–threaten sustainable use if not deliberately managed.

Recommendations for Future Research and Practice

1. Broaden disciplinary scope–Design studies that target engineering design cycles, technology prototyping and arts-based making to redress the current 3:1 science/maths bias.
2. Adopt stronger designs–Longitudinal or experimental work with multi-dimensional assessments can test causal pathways and durability of learning effects, moving beyond the cross-sectional snapshots that dominate the corpus.
3. Measure higher-order outcomes–Embed validated creativity, design-thinking and arts-integration rubrics alongside test scores to capture the full STEAM skill set.
4. Integrate privacy-ethics protocols–Combine end-to-end encryption awareness, informed consent and alternative contact routes to mitigate data-sharing risks highlighted in recent European studies.
5. Engineer sustainable chat ecology–Keep groups below 50, deploy weekly pinned summaries, rotate moderators and pair WhatsApp with formal LMS tools to tame message volume while retaining immediacy.

Limitations of this Study

The search covered only WoS, Scopus and ERIC, was restricted to English-language journal articles from 2020-2024 and excluded grey literature; relevant regional or earlier studies may therefore be missing. Manual screening and qualitative coding, though double-checked, still carry subjective bias. Finally, because most primary studies coincide with emergency remote-teaching conditions, pandemic-specific affordances (e.g., heightened mobile use) may inflate perceived benefits and limit transferability to post-pandemic teaching.

Despite these caveats, the review maps a clear trajectory: WhatsApp can complement STEAM pedagogy when pedagogically engineered and ethically guarded, but the field now needs discipline-diverse, rigorously designed research to turn promising pilot effects into robust, scalable practice.

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REFERENCES

Abdul Halim, A., & Abd Halim, N. D. (2024). Effects of online heutagogy approach in learning science via Telegram towards pupils' science process skills and creative thinking skills. *LUMAT: International Journal on Math, Science and Technology Education, 12*(4), Article 2. https://doi.org/10.31129/LUMAT.12.4.2327

Abualrob, M. M., & Nazzal, S. (2020). Using WhatsApp in teaching chemistry and biology to tenth graders. *Contemporary Educational Technology, 11*(1), 55-76. https://doi.org/10.30935/cet.641772

Afful, B., & Akrong, R. (2020). WhatsApp and academic performance among undergraduate students in Ghana: Evidence from the University of Cape Coast. *Journal of Education for Business, 95*(5), 288-296. https://doi.org/10.1080/08832323.2019.1644276

Agbo, F. J., Olawumi, O., Balogun, O. S., Sanusi, I. T., Olaleye, S. A., Sunday, K., Kolog, E. A., Atsa'am, D. D., Adusei-Mensah, F., Adegbite, A., & Ipeayeda, F. W. (2021). Investigating students' perception towards the use of social media for computing education in Nigeria. *Journal of Information Systems Education, 32*(3).

Ahmad, D. N., Karim, A., Zulkarnain, I., Ati, A. P., & Nusantari, D. O. (2021). Analysis creative thinking ability and scientific communication in HOTS learning using WhatsApp media. *Journal of Physics: Conference Series, 1823*, Article 012074. https://doi.org/10.1088/1742-6596/1823/1/012074

Al Mutair, A., Aljarameez, F., Al Onezei, A., Ramadan, M. Y., Sacgaca, L., Almutairi, A., Qahl, A., Jebakumar, A. Z., Alnaam, Y., Alrasheeday, A., & Alsaleh, K. (2025). WhatsApp-delivered education: Performance and satisfaction of nursing students. *Journal of Nursing Education, 64*(3), 170-176. https://doi.org/10.3928/01484834-20241120-04

Ali, I. M., Mohamed, M. A., & Ahmed, Y. A. (2024). WhatsApp groups: The nexus between retention, reciprocity, and user satisfaction. *Frontiers in Education, 9*. https://doi.org/10.3389/feduc.2024.1385278

Ali, S., Wang, D., Hussain, T., & Li, B. (2023). The impact of virtual society on social capital formation: A comparative analysis of Facebook and WhatsApp. *SAGE Open, 13*(4). https://doi.org/10.1177/21582440231210077

Alsharif, A. T., Alsharif, B., Alsharif, L., Althagafi, N., Natto, Z. S., & Kassim, S. (2020). Effectiveness of WhatsApp as a part of a hybrid learning environment: An opportunity for post-COVID-19 pandemic pedagogy. *Journal of Contemporary Dental Practice, 21*(12), 1331-1336. https://doi.org/10.5005/jp-journals-10024-2978

Alubthane, F., & Alyoussef, I. (2021). Pre-service teachers' views about effective use of the WhatsApp application in online classrooms. *TOJET: The Turkish Online Journal of Educational Technology, 20*(1).

Amanova, A. K., Butabayeva, L. A., Abayeva, G. A., Umirbekova, A. N., Abildina, S. K., & Makhmetova, A. A. (2025). A systematic review of the implementation of STEAM education in schools. *Eurasia Journal of Mathematics, Science and Technology Education, 21*(1), Article em2568. https://doi.org/10.29333/ejmste/15894

Annamalai, N., Mangaleswaran, S., Ab Rashid, R., Harb Alqaryouti, M., & Sadeq, A. E. (2024). Learner experiences of community of inquiry mode (CoI) in WhatsApp for English language learning. *SAGE Open, 14*(2). https://doi.org/10.1177/21582440241251944

Ariel, Y., & Levy, E. C. (2024). The costs of connectivity: WhatsApp usage, privacy concerns, and protection behaviors in Israel. *Communication Reports, 38*(1), 25-45. https://doi.org/10.1080/08934215.2024.2424552

Arksey, H., & O'Malley, L. (2005). Scoping studies: Towards a methodological framework. *International Journal of Social Research Methodology: Theory and Practice, 8*(1), 19-32. https://doi.org/10.1080/1364557032000119616

Baishya, D., & Maheshwari, S. (2019). WhatsApp groups in academic context: Exploring the academic uses of WhatsApp groups among the students. *Contemporary Educational Technology, 11*(1), 31-46. https://doi.org/10.30935/cet.641765

Basilaia, G., & Kvavadze, D. (2020). Transition to online education in schools during a SARS-CoV-2 coronavirus (COVID-19) pandemic in Georgia. *Pedagogical Research, 5*(4). https://doi.org/10.29333/pr/7937

Berewot, J., & Fibra, A. (2020). WhatsApp messenger among higher education students: A study on WhatsApp messenger usage for project learning. *Journal of Physics: Conference Series, 1477*, Article 042018. https://doi.org/10.1088/1742-6596/1477/4/042018

Biton, Y., & Segel, R. (2024). Learning mathematics via WhatsApp social network in Bagroup national project: Students' perceptions. *Eurasia Journal of Mathematics, Science and Technology Education, 20*(8), Article em2484. https://doi.org/10.29333/ejmste/14876

Bouhnik, D., & Deshen, M. (2014). WhatsApp goes to school: Mobile instant messaging between teachers and students. *Journal of Information Technology Education: Research, 13*. https://doi.org/10.28945/2051

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

Bueno-Roldan, R., & Röder, A. (2022). WhatsApp? Opportunities and challenges in the use of a messaging app as a qualitative research tool. *Qualitative Report, 27*(12), 2961-2976. https://doi.org/10.46743/2160-3715/2022.5329

Cansoy, R. (2017). Teachers' professional development: The case of WhatsApp. *Journal of Education and Learning, 6*(4), Article 285. https://doi.org/10.5539/jel.v6n4p285

Cetinkaya, L. (2017). The impact of WhatsApp use on success in education process. *The International Review of Research in Open and Distributed Learning, 18*(7). https://doi.org/10.19173/irrodl.v18i7.3279

Chirinda, B., Ndlovu, M., & Spangenberg, E. (2021). Teaching mathematics during the COVID-19 lockdown in a context of historical disadvantage. *Education Sciences, 11*(4). https://doi.org/10.3390/educsci11040177

Cronjé, J. C., & Van Zyl, I. (2022). WhatsApp as a tool for building a learning community. *The Electronic Journal of E-Learning, 20*(3), 296-312. https://doi.org/10.34190/ejel.20.3.2286

Dahdal, S. (2020). Using the WhatsApp social media application for active learning. *Journal of Educational Technology Systems, 49*(2), 239-249. https://doi.org/10.1177/0047239520928307

Doddaiah, S., Kulkarni, P., Mohandas, A., & Murthy, M. (2021). Learning with lockdown: Utility of WhatsApp status-based multiple-choice question discussion on COVID-19 among medical students and teaching faculty. *Journal of Education and Health Promotion, 10*(1). https://doi.org/10.4103/jehp.jehp_609_20

Durgungoz, A., & Durgungoz, F. C. (2022). "We are much closer here": Exploring the use of WhatsApp as a learning environment in a secondary school mathematics class. *Learning Environments Research, 25*(2), 423-444. https://doi.org/10.1007/s10984-021-09371-0

Elom, C. O., Ayerakwa, H. M., Ibrahim-Olesin, S., Deffor, E. W., Uwaleke, C. C., & Onyeneke, R. U. (2025). Determinants of WhatsApp and Telegram usage for learning support in Nigerian universities: A quantitative study. *Frontiers in Education, 10*. https://doi.org/10.3389/feduc.2025.1581514

Enakrire, R. T., & Kehinde, F. J. (2022). WhatsApp application for teaching and learning in higher education institutions. *Library Hi Tech News*. https://doi.org/10.1108/LHTN-07-2022-0088

Enyama, D., Balti, E. V., Simeni Njonnou, S. R., Ngongang Ouankou, C., Kemta Lekpa, F., Noukeu Njinkui, D., Fouogue, J. T., Mayouego Kouam, J., Njateng, G. S. S., Kenfack, B., Watcho, P., & Choukem, S. P. (2021). Use of WhatsApp®, for distance teaching during COVID-19 pandemic: Experience and perception from a sub-Saharan African setting. *BMC Medical Education, 21*(1). https://doi.org/10.1186/s12909-021-02953-9

Gcabashe, N. B. (2024). WhatsApp integration by business studies teachers to promote collaboration among learners. *South African Journal of Education, 44*(4). https://doi.org/10.15700/saje.v44n4a2470

Gcabashe, N. B., & Oyinlola, A. (2023). Business studies teachers' utilization of WhatsApp for instructional purposes in selected schools in South Africa. *African Perspectives of Research in Teaching & Learning 7*(1), 35-49.

Gil-Clemente, E., Gasca, A. M., & Badías, R. P. (2024). Involving parents and family environment for enhancing the mathematics education of children with down syndrome. *Journal of Policy and Practice in Intellectual Disabilities, 21*(3). https://doi.org/10.1111/jppi.12518

Ismael, D. (2023). Enhancing online hands-on learning in engineering education: Student perceptions and recommendations. In *Proceedings of the ASEE Annual Conference and Exposition*. ASEE. https://doi.org/10.18260/1-2--43358

Klieger, A., & Goldsmith, L. (2020). Expanding physics learning beyond classroom boundaries–A case study. *Physics Education, 55*(2), Article 025004. https://doi.org/10.1088/1361-6552/ab5d68

Kumar, J. A., Bervell, B., Annamalai, N., & Osman, S. (2020). Behavioral intention to use mobile learning: Evaluating the role of self-efficacy, subjective norm, and WhatsApp use habit. *IEEE Access, 8*, 208058-208074. https://doi.org/10.1109/ACCESS.2020.3037925

Lee, C. E., Chern, H. H., & Azmir, D. A. (2023). WhatsApp use in a higher education learning environment: Perspective of students of a Malaysian private university on academic performance and team effectiveness. *Education Sciences, 13*(3). https://doi.org/10.3390/educsci13030244

Levac, D., Colquhoun, H., & O'brien, K. K. (2010). Scoping studies: Advancing the methodology. *Implementation Science, 5*, Article 69. https://doi.org/10.1186/1748-5908-5-69

Lyken-Segosebe, D., Gamariel, G., & Bagai, K. (2022). Boundary crossing for education continuity: Exploring WhatsApp's potential in Botswana during and beyond the pandemic. *International Journal of Interactive Mobile Technologies, 16*(2), 59-81. https://doi.org/10.3991/ijim.v16i02.27283

Madge, C., Breines, M. R., Dalu, M. T. B., Gunter, A., Mittelmeier, J., Prinsloo, P., & Raghuram, P. (2019). WhatsApp use among African international distance education (IDE) students: Transferring, translating and transforming educational experiences. *Learning, Media and Technology, 44*(3), 267-282. https://doi.org/10.1080/17439884.2019.1628048

Makgakga, T. (2022). WhatsApp as social media to enhance the dialogic interactions in mathematics: Grade 9 teachers and learners' voices. In B. Chirinda, K. Luneta, & A. uworwabayeho (Eds.), *Mathematics education in Africa: The Fourth Industrial Revolution* (pp. 279-292). Springer. https://doi.org/10.1007/978-3-031-13927-7_17

Martins, J. C. S., de Lima, J. B., Cartaxo, R. O., & Sette-de-Souza, P. H. (2022). Use of WhatsApp in dental education: A scoping review. *Medical Science Educator, 32*(2), 561-567. https://doi.org/10.1007/s40670-022-01520-1

Matobobo, C., & Dzvapatsva, G. P. (2024). Impact of WhatsApp groups on teaching and learning in higher impact of WhatsApp groups on teaching and learning in higher education: A review. In *Proceedings of the UK Academy for Information Systems Conference*.

Mbada, C. E., Jeje, O. O., Akande, M., Mbada, K. A., Fatoye, C., Olakorede, D., Awoniyi, O., Okafor, U. A. C., Falade, O., & Fatoye, F. (2023). Social presence and dynamics of group communication: An analysis of a health professionals WhatsApp group chats. *PLoS ONE, 18*(7), Article e0288773. https://doi.org/10.1371/journal.pone.0288773

Merelo, J. J., Castillo, P. A., Mora, A. M., Barranco, F., Abbas, N., Guillén, A., & Tsivitanidou, O. (2024). Chatbots and messaging platforms in the classroom: An analysis from the teacher's perspective. *Education and Information Technologies, 29*(2), 1903-1938. https://doi.org/10.1007/s10639-023-11703-x

Mohammed, I. A., Kuta, I. I., Falode, O. C., & Bello, A. (2024). Comparative performance of undergraduate students in micro-teaching using Telegram and WhatsApp in collaborative learning settings. *Journal of Mathematics and Science Teacher, 4*(2), Article em063. https://doi.org/10.29333/mathsciteacher/14411

Moodley, M. (2019). WhatsApp: Creating a virtual teacher community for supporting and monitoring after a professional development programme. *South African Journal of Education, 39*(2). https://doi.org/10.15700/saje.v39n2a1323

Moreno-Guerrero, A. J., Rodríguez-Jiménez, C., Ramos-Navas-Parejo, M., Soler-Costa, R., & López-Belmonte, J. (2020). WhatsApp and Google Drive influence on pre-service students' learning. *Frontiers in Education, 5*. https://doi.org/10.3389/feduc.2020.00152

Mpungose, C. B. (2020). Is Moodle or WhatsApp the preferred e-learning platform at a South African university? First-year students' experiences. *Education and Information Technologies, 25*(2), 927-941. https://doi.org/10.1007/s10639-019-10005-5

Mulyono, H., Suryoputro, G., & Jamil, S. R. (2021). The application of WhatsApp to support online learning during the COVID-19 pandemic in Indonesia. *Heliyon, 7*(8), Article e07853. https://doi.org/10.1016/j.heliyon.2021.e07853

Naghdipour, B., & Manca, S. (2023). Teaching presence in students' WhatsApp groups: Affordances for language learning. *E-Learning and Digital Media, 20*(3), 282-299. https://doi.org/10.1177/20427530221107968

Naidoo, J. (2020). Postgraduate mathematics education students' experiences of using digital platforms for learning within the COVID-19 pandemic era. *Pythagoras, 41*(1), 1-11. https://doi.org/10.4102/PYTHAGORAS.V41I1.568

Nasution, A. K. P., & Munandar, I. (2023). Trends, opportunities, and challenges of using WhatsApp in learning: A literature review. *Jurnal Simki Pedagogia, 6*(2), 531-544. https://doi.org/10.29407/jsp.v6i2.210

Nazma Sohrab, K. (2024). Privacy in the age of digital surveillance: Analyzing WhatsApp's policy and cybersecurity implications. *Journal of Information Systems Engineering and Management, 10*(40s). https://doi.org/10.52783/jisem.v10i40s.7543

Nkambule, B. I. (2023). WhatsApp messenger as a supplementary tool for school curriculum knowledge transfer and acquisition during COVID-19 stricter lockdown: Educators' perceptions. *Research in Social Sciences and Technology, 8*(2), 37-55. https://doi.org/10.46303/ressat.2023.10

Nkanyani, T. E., Mudau, A. V., & Sikhosana, L. (2024). Teaching and learning of physical sciences grade 11 in rural schools through rural blended learning strategy. *Eurasia Journal of Mathematics, Science and Technology Education, 20*(3), Article em2413. https://doi.org/10.29333/ejmste/14295

Nurzakiyah, E., Devialita, A., Solihah, P. A., Kaniawati, I., & Suwarma, I. R. (2023). Learning cycle 7E-STEM in enhancing students' collaborative skills during the pandemic COVID-19. *AIP Conference Proceedings, 2734*(1), Article 110007. https://doi.org/10.1063/5.0156700

Nyamupangedengu, E., Kazeni, M., Mandikonza, C., Stephen, M., Mabenge, P., Tshesane, H., Ajayi, E., Abdulhamid, L., Makonye, J., & Moloi, M. (2023). Mathematics and science teacher educators' experiences of using the WhatsApp platform as a tool for supporting teaching during the COVID-19 pandemic. *Journal of Education (University of KwaZulu-Natal), 92*, 115-135. https://doi.org/10.17159/2520-9868/i92a07

Oliveira, S., Carvalho, L., Monteiro, C., & Carvalho, C. (2020). Teachers dialoguing about statistical literacy with support of messenger app for smartphones. In *Proceedings of the 16th International Conference Mobile Learning* (pp. 129-132). https://doi.org/10.33965/ml2020_202004R018

Pérez-González, H. G., González-Grimaldo, R. A., Nwokeji, J. C., Tang, M. H., Juárez-Ramírez, R., Piovesan, D., Meneely, A., & Guerra-García, C. (2024). WIP: ChatVis: Enhancing academic team collaboration through WhatsApp chat analytics. In *Proceedings of the 2024 IEEE Frontiers in Education Conference* (pp. 1-5). IEEE. https://doi.org/10.1109/FIE61694.2024.10893414

Peters, M. D. J., Godfrey, C., McInerney, P., Munn, Z., Tricco, A. C., & Khalil, H. (2024). Scoping reviews. *JBI Manual for Evidence Synthesis*. https://doi.org/10.46658/JBIMES-24-09

Pimmer, C., Brühlmann, F., Odetola, T. D., Dipeolu, O., Oluwasola, O., Jäger, J., & Ajuwon, A. J. (2021). WhatsApp for mobile learning. Effects on knowledge, resilience and isolation in the school-to-work transition. *Internet and Higher Education, 50*. https://doi.org/10.1016/j.iheduc.2021.100809

Poçan, S., Altay, B., & Yaşaroğlu, C. (2023). The effects of mobile technology on learning performance and motivation in mathematics education. *Education and Information Technologies, 28*(1), 683-712. https://doi.org/10.1007/s10639-022-11166-6

Prasad, P., Gunasekaran, L., Khair, A. M. B., Shetty, R., & Shetty, N. (2024). WhatsApp as a tool in blended learning in dental education. *Journal of Pharmacy and Bioallied Sciences, 16*(Suppl 2), S1673-S1678. https://doi.org/10.4103/jpbs.jpbs_425_23

Rahmadi, I. F. (2020). WhatsApp group for teaching and learning in Indonesian higher education what's up? *International Journal of Interactive Mobile Technologies, 14*(13), 150-160. https://doi.org/10.3991/ijim.v14i13.14121

Rindayan Saputra, U., Muhammadiyah Kendari Maulina, U., Muhammadiyah Kendari, U., & Muhammadiyah Kendari Geminastiti Sakkir, U. (2021). Students' sentence errors on WhatsApp daily status: A literature review. *Celebes Journal of Language Studies, 1*(1). https://doi.org/10.51629/cjls.v1i1.31

Romero-Saritama, J. M., Espinosa-Tapia, S., & Palacios-Rodríguez, A. (2025). Using WhatsApp in distance education: Assessing the impact on academic interaction and influencing factors. *Social Sciences, 14*(3). https://doi.org/10.3390/socsci14030183

Rosenberg, H., & Asterhan, C. S. C. (2018). "WhatsApp, teacher?"–Student perspectives on teacher-student WhatsApp interactions in secondary schools. *Journal of Information Technology Education: Research, 17*, 205-226. https://doi.org/10.28945/4081

Santos, M., & Faure, A. (2018). Affordance is power: Contradictions between communicational and technical dimensions of WhatsApp's end-to-end encryption. *Social Media and Society, 4*(3). https://doi.org/10.1177/2056305118795876

Sasmita, K., Palenewen, E., Karnadi, K., Solihin, S., & Badrudin. (2021). What's App integrity in the life science concept during the COVID-19 pandemic. *Journal of Physics: Conference Series, 1760*, Article 012028. https://doi.org/10.1088/1742-6596/1760/1/012028

Scherz, Z., Salman, A., Alexandron, G., & Shwartz, Y. (2023). WhatsApp discourse throughout COVID-19: Towards computerized evaluation of the development of a STEM teachers professional learning community. *International Journal of Artificial Intelligence in Education, 33*(4), 1120-1144. https://doi.org/10.1007/s40593-022-00320-3

Seufert, A., Poignée, F., Hoßfeld, T., & Seufert, M. (2022). Pandemic in the digital age: Analyzing WhatsApp communication behavior before, during, and after the COVID-19 lockdown. *Humanities and Social Sciences Communications, 9*(1). https://doi.org/10.1057/s41599-022-01161-0

Shittu, T. A., & Taiwo, Y. H. (2023). Acceptance of WhatsApp social media platform for learning in Nigeria: A test of unified theory of acceptance and use of technology. *Journal of Digital Educational Technology, 3*(2), Article ep2309. https://doi.org/10.30935/jdet/13460

Shuubi, M. A., & Kivara, R. M. (2023). Assessment of WhatsApp as a collaborative learning tool in the post COVID-19 era in higher learning institutions: A case of Tanzania. *Journal of Research Innovation and Implications in Education, 7*(2), 287-299. https://doi.org/10.59765/b7ds7910

Singh-Pillay, A., & Naidoo, J. (2020). Context matters: Science, technology and mathematics education lecturers' reflections on online teaching and learning during the COVID-19 pandemic. *Journal of Baltic Science Education, 19*(6), 1125-1136. https://doi.org/10.33225/JBSE/20.19.1125

Siregar, G. M. A., Hidayat, Sukmawarti, & Siagian, M. D. (2021). Evaluation of online learning for mathematics education students. *Journal of Physics: Conference Series, 1882*, Article 012064. https://doi.org/10.1088/1742-6596/1882/1/012064

Slakmon, B. (2024). WhatsApp for pedagogy: Initiatives, instructional practices and the nature of knowledge in Israel's secondary education. *Technology, Pedagogy and Education, 33*(5), 647-662. https://doi.org/10.1080/1475939X.2024.2368612

Solomon Nuni, E. (2024). Effectiveness of WhatsApp versatility in the teaching of mathematics and science pedagogical skills to large classes of undergraduates at the university level in Kenya. *Journal of Contemporary Issues in Open Distance and E-Learning, 1*(1). https://doi.org/10.71060/8p3es579

Strasser, T. (2020). App, app 'n' away. How social messaging tools like WhatsApp support mobile language learning and teaching. *HeiEDUCATION Journal, 5*. https://doi.org/10.17885/heiup.heied.2020.5.24156

Suárez-Lantarón, B., Deocano-Ruíz, Y., García-Perales, N., & Castillo-Reche, I. S. (2022). The educational use of WhatsApp. *Sustainability, 14*(17), Article 10510. https://doi.org/10.3390/su141710510

Syairofi, A., Suherdi, D., & Purnawarman, P. (2023). Using WhatsApp to support English language learning: A systematic review. *Computer Assisted Language Learning Electronic Journal, 24*(1), 305-337.

Tamil Selvan, P., & Kalaiyarasan, G. (2024). Systematic review on utilization of WhatsApp in education. *E-Learning and Digital Media*. https://doi.org/10.1177/20427530241239424

Tragant, E., Pinyana, À., Mackay, J., & Andria, M. (2022). Extending language learning beyond the EFL classroom through WhatsApp. *Computer Assisted Language Learning, 35*(8), 1946-1974. https://doi.org/10.1080/09588221.2020.1854310

Tricco, A. C., Lillie, E., Zarin, W., O'Brien, K. K., Colquhoun, H., Levac, D., Moher, D., Peters, M. D. J., Horsley, T., Weeks, L., Hempel, S., Akl, E. A., Chang, C., McGowan, J., Stewart, L., Hartling, L., Aldcroft, A., Wilson, M. G., Garritty, C., … Straus, S. E. (2018). PRISMA extension for scoping reviews (PRISMA-ScR): Checklist and explanation. *Annals of Internal Medicine, 169*(7), 467-473. https://doi.org/10.7326/M18-0850

Tunjera, N. (2023). Adopting WhatsApp to reduce transactional distance during the COVID-19 pandemic. *Electronic Journal of E-Learning, 21*(2), 110-120. https://doi.org/10.34190/ejel.21.2.2752

Udenze, S., & Oshionebo, B. (2020). Investigating 'WhatsApp' for collaborative learning among undergraduates. *Etkileşim, 3*(5), 24-50. https://doi.org/10.32739/etkilesim.2020.5.92

Vale, P., & Graven, M. (2023). Strategies implemented by South African teachers to ensure continuing mathematics education during COVID-19. *ZDM Mathematics Education, 55*, 163-176. https://doi.org/10.1007/s11858-022-01408-9

Yeboah, D., & Nyagorme, P. (2022). Students' acceptance of WhatsApp as teaching and learning tool in distance higher education in sub-Saharan Africa. *Cogent Education, 9*(1). https://doi.org/10.1080/2331186X.2022.2077045

Yilmazsoy, B., Kahraman, M., & Köse, U. (2020). Negative aspects of using social networks in education: A brief review on WhatsApp example. *Journal of Educational Technology and Online Learning, 3*(1), 69-90. https://doi.org/10.31681/jetol.662746

Zan, N. (2019). Communication channel between teachers and students in chemistry education: WhatsApp. *US-China Education Review A, 9*(1). https://doi.org/10.17265/2161-623X/2019.01.002

Zhang, L. (2024). Blended pedagogy for computer programming language. *Pedagogical Research, 9*(3), Article em0218. https://doi.org/10.29333/pr/14744

Zulkanain, N. A., Miskon, S., & Syed Abdullah, N. (2020). An adapted pedagogical framework in utilizing WhatsApp for learning purpose. *Education and Information Technologies, 25*(4), 2811-2822. https://doi.org/10.1007/s10639-019-10096-0