INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN PROGRESSIVE EDUCATION & DEVELOPMENT
OPEN ACCESS JOURNAL
Vol 15, Issue 1, (2026) E-ISSN: 2226-6348

Exploring Blended Learning Approaches in School Mathematics: A Systematic Review of Implementation Patterns, Learning Outcomes, and Pedagogical Models

Khairuddin Abd Rahman, Noor Dayana Abd Halim*
Department of Advanced Learning Technology, Faculty of Educational Sciences and Technology, Universiti Teknologi Malaysia
Email: khairuddin87@graduate.utm.my
Corresponding Author Email: *noordayana@utm.my

DOI Link: http://dx.doi.org/10.6007/IJARPED/v15-i1/27556

Published Online: 15 February 2026

Abstract
Blended learning has emerged as an innovative approach in school mathematics, integrating traditional face-to-face instruction with digital and online resources to enhance students' learning outcomes. However, despite its widespread adoption, there remains a lack of synthesized evidence on how blended learning approaches are designed and implemented in mathematics contexts, particularly within school settings. This systematic review aims to examine existing empirical studies on blended learning in school mathematics to identify implementation patterns, mathematics learning outcomes, and the role of the pedagogical models associated with blended learning implementation. Following PRISMA guidelines, a structured search was conducted in the Scopus and Web of Science databases, covering publications from 2023 to 2025, resulting in 27 studies included in the review. The findings indicate that the flipped classroom model is the most frequently adopted blended learning design, with research predominantly focused on secondary school students. In terms of learning outcomes, blended learning demonstrates consistent positive effects on students' achievement, knowledge retention, higher order thinking skills, and motivation. Effective implementation of blended learning in mathematics is also associated with the integration of pedagogical approaches such as project-based, inquiry-based, gamification and collaborative learning. Future research should focus on underexplored populations, integration of other blended learning models with established pedagogical models and explore the potential of emerging technologies in blended mathematics learning. In conclusion, this review provides evidence-based insights into the strategic integration of blended learning in school mathematics, offering practical implications for educators, curriculum developers, and policymakers to enhance pedagogical practice and optimise student learning experiences.
Keywords: Blended Learning, Flipped Classroom, Mathematics, School

Introduction

Education systems have increasingly explored alternative pedagogical approaches that integrate technology to support students' learning. The rapid advancement of digital technologies has accelerated the adoption of blended learning in education (Suripah et al., 2025). Graham (2006) describes blended learning as the integration of different delivery modalities, the combination of varied teaching methods, and the blending of online with face-to-face instruction. Similarly, Staker & Horn (2012) define it as formal education in which students learn partly through online content, enabling them to control the time, place, path, and pace of learning. The growing adoption of blended learning across educational levels highlights its potential to remain a key component of sustainable and effective teaching practices (Topping et al., 2022; Van der Westhuizen & Hlatshwayo, 2023). In school contexts, blended learning is increasingly implemented to support differentiated instruction, enhance pedagogical variety, and foster student-centered learning environments. This makes it particularly relevant for subjects where conceptual understanding and skill application are critical.

The advantages of blended learning are especially pronounced in mathematics education, where traditional instruction has often emphasized teacher-centered lectures and repetitive procedural exercises, limiting opportunities for active learning, conceptual reasoning, and student engagement (Bas & Kivilcim, 2021). Blended learning enables teachers to leverage the strengths of both face-to-face and online modalities by combining structured classroom instruction with digital resources such as interactive simulations, multimedia content, and online exercises (Kadirbayeva et al., 2022). This integration allows students to use online technologies to visualize abstract concepts, explore mathematical relationships, manipulate virtual environments, and engage with learning material at their own pace (Cirneanu & Moldoveanu, 2024; Wolff & Girnat, 2024). Furthermore, face-to-face sessions complement these online experiences by facilitating collaborative problem-solving, peer discussion, and immediate feedback, which are essential for consolidating conceptual understanding. Empirical evidence demonstrates that blended learning in mathematics enhances academic achievement, promotes higher-order thinking, and strengthens problem-solving skills (Abdelmalak, 2024; Esperanza et al., 2021; Jamaluddin et al., 2022). By strategically integrating digital and traditional modalities within a coherent instructional framework, blended learning provides a dynamic and adaptive environment that supports students in developing the skills required for success in mathematics.

Despite growing evidence regarding the effectiveness of blended learning in mathematics education, notable gaps remain. Existing reviews either focus primarily on higher education contexts (Haziki et al., 2025) or generalize findings across all educational levels without distinguishing between them (Ishartono et al., 2023; Jailani et al., 2025), resulting in limited coverage of the school context. This gap is significant because school mathematics is shaped by specific curricular structures, pedagogical practices, and institutional constraints. Furthermore, the school context serves students at critical stages of development, where mathematical foundations are established and the need for engaging and effective instruction is particularly important. As Angawi & Tasir (2024) argue, examining how different blended learning approaches and pedagogical models function within specific subject areas and educational levels can provide valuable insights for instructional design.

To address these gaps, this systematic literature review synthesizes empirical research specifically focused on blended learning in school mathematics education, guided by three objectives: (i) to identify implementation patterns of blended learning in school mathematics, (ii) to examine the effects of blended learning on students' mathematics learning outcomes, and (iii) to explore the role of pedagogical models in shaping the effectiveness of blended learning approaches in school mathematics. This review contributes to the field by providing guidance for educators on implementing effective blended learning practices in school mathematics and supporting the development of teaching strategies that integrate traditional classroom instruction with digital learning technologies.

Methodology

This study employed a systematic literature review methodology to identify, appraise, and synthesize empirical research related to blended learning in mathematics within school education context. The review was guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, which offers a standardized approach to conducting and reporting systematic reviews (Page et al., 2021). The PRISMA was adopted to ensure methodological rigor, clarity in study selection, and reproducibility of the review process (Sarkis-Onofre et al., 2021). In accordance with the PRISMA protocol developed for this study, the review process consisted of three main stages, namely identification, screening, and inclusion, as illustrated in Figure 1.

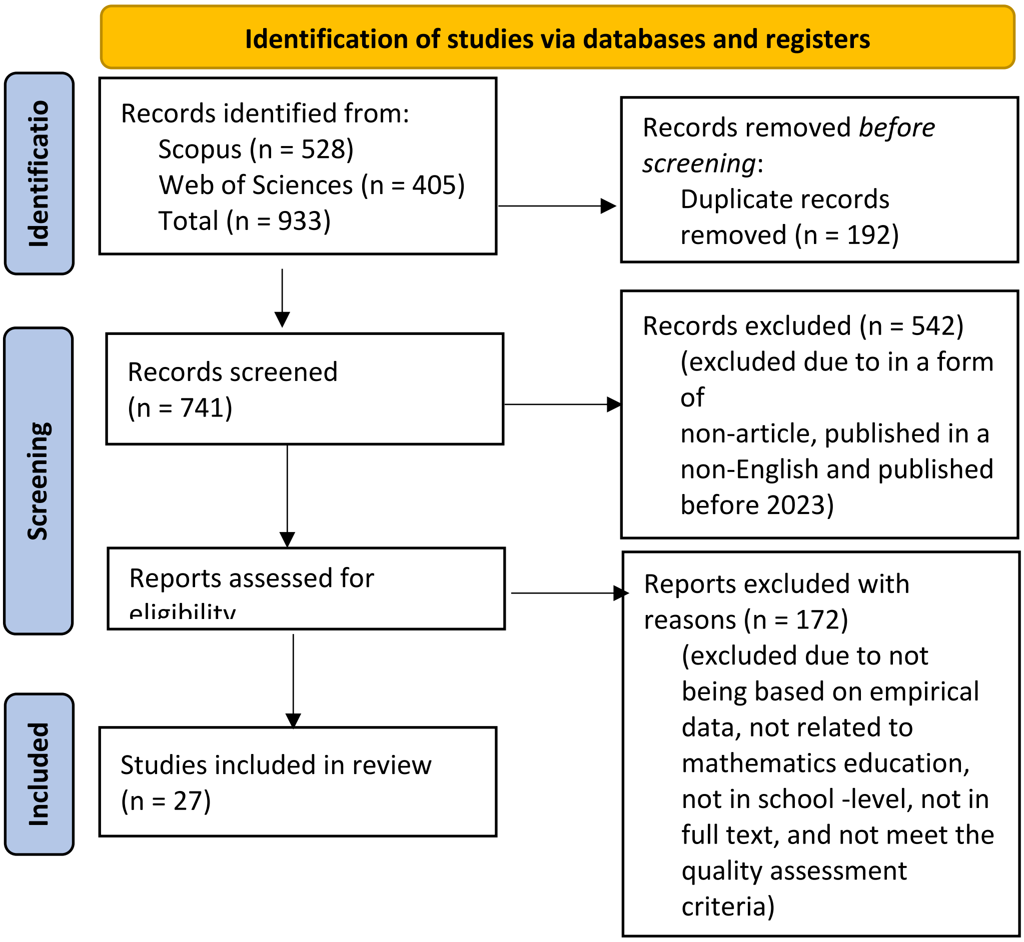

Figure 1. The process of article review

In the identification stage, a comprehensive literature search was conducted using two databases: Scopus and Web of Science. These databases were selected because they are widely regarded as reliable sources of credible and high-quality scholarly publications. The search strategy employed a combination of keywords related to blended learning and mathematics education, including "blended", "flipped", "mathematics", "school", "primary" and "secondary" which were systematically combined using Boolean operators such as "AND" and "OR" to refine the search results (see Table 1). The terms "blended" and "flipped" were used to capture the most reported instructional models associated with blended learning. The keyword "mathematics" was included to ensure disciplinary specificity and to exclude studies related to other subject areas, while the term "school", "primary" and "secondary" was used to restrict the search to school-level educational settings. Together, these keywords ensured that the search strategy was sufficiently broad to capture relevant variations of blended learning, while focused on mathematics education within school environments. This initial search identified a total of 933 records, comprising 528 records from Scopus and 405 records from Web of Science. During this stage, duplicate records identified across the two databases were removed, resulting in the exclusion of 192 duplicate articles.

Table 1
The search strings used in the identification stage

Database	Searching string
Scopus	TITLE-ABS-KEY ((“blended" OR "flipped”) AND "mathematics" AND (“school" OR "primary" OR "secondary”))
Web of Sciences	ALL = (“blended" OR "flipped”) AND "mathematics" AND (“school" OR "primary" OR "secondary")

Following the identification stage, the screening stage involved a multi-step evaluation process. First, the remaining 741 records were assessed against predefined inclusion and exclusion criteria (see Table 2). These criteria focused on the literature type, language, and publication period. Only journal articles were considered, as they provide peer-reviewed empirical evidence, while reviews, meta-syntheses, meta-analyses, books, book chapters, and conference proceedings were excluded. Additionally, the review was limited to English-language publications. To ensure relevance to current educational practices, only studies published between 2023 and 2025 were considered. This time frame was selected to capture recent empirical evidence on blended learning implementation and pedagogical design in school mathematics. By applying these criteria, the screening process ensured that only suitable and relevant studies were retained for further evaluation.

Table 2
The inclusion and exclusion criteria used in this review

Criteria	Inclusion	Exclusion
Literature type	Journal (article)	Reviews, meta-syntheses, meta-analyses, books, book chapters, and conference proceedings
Language	English	Non-English
Timeline	2023 - 2025	< 2023

As a result, 199 records remained and proceeded to the next step of the screening process. The subsequent screening step involved a detailed examination of the titles and abstracts of the 199 remaining records to determine their relevance to the objectives of the review. Studies were excluded if their titles and abstracts indicated that they were not empirical, not focused on blended learning in mathematics education, or not conducted in school-level contexts. Subsequently, the Mixed Method Appraisal Tools (MMAT) by Hong et al. (2018) was employed by the authors based on the tools' assessment criteria, which were specifically designed to evaluate the quality of empirical studies. This screening and eligibility assessment resulted in the exclusion of 172 records.

The final inclusion stage comprised 27 empirical studies that met all predefined criteria and aligned with the research focus of the review. Eligible studies were required to present empirical findings, explicitly involve blended learning in the context of mathematics education, and be conducted at the school level. These studies were systematically analyzed and synthesized to examine patterns in the implementation of blended learning for school students in mathematics. The structured and transparent application of PRISMA-guided procedures ensured that the review was conducted rigorously and methodologically sound. The details of the 27 studies are summarized in Table 3 and further analyzed and discussed in the subsequent sections.

Table 3
Summaries of the studies

No	Authors	Year	Sample Size and School Level	Blended Learning Model(s)	Implementations of Blended Learning	Findings
1	Oladejo & Olateju	2025	208 - Secondary School	Flipped Classroom with 5I Model	Pre-class YouTube videos; in-class discussion and problem solving.	The 5I flipped classroom model performed significantly better than the conventional flipped classroom.
2	En-Nhiri et al.	2025	80 - Secondary School	Station Rotation	Teacher-led instruction, small-group discussion, and online learning through digital platform.	Blended learning significantly positively affected students' mathematics achievement compared to traditional teaching methods.
3	Abdissa et al.	2025	83 - Secondary School	Lab Rotation	Face-to-face teaching with online assignments and assessments via Google Classroom.	Blended learning is more effective than conventional methods in improving mathematics achievement.
4	Widyasari et al.	2025	60 - Secondary School	Flipped Classroom	Pre-class videos; in-class discussion,	Flipped classroom more effective than conventional learning

					problem-solving and concept application.	in improving mathematics learning outcomes.
5	Mansour & Wardat	2025	61 - Secondary School	Flipped Classroom	Videos via Google Classroom; in-class peer collaboration and quizzes.	Flipped classroom substantially enhances students' engagement and motivation in mathematics that conventional model.
6	Fitrah et al.	2025	91 - High School	Flipped Classroom with project-based learning	Pre-class videos; in-class collaborative project work.	Project-based learning integrated with flipped classrooms significantly improved computational thinking skills.
7	Egara & Mosimege	2024	94 - Secondary School	Combination of Station Rotation and Flipped Classroom	In-class learning rotate from face-to-face group and online stations; post-class videos, quizzes, and tasks.	Blended learning improved mathematics achievement and retention more than the conventional approach.
8	Egara & Mosimege	2024	84 - Secondary School	Flipped Classroom	In-class group activities; post-class videos and online quizzes.	Students had higher mathematics achievement and interest in flipped classroom than the conventional approach.
9	Gasparič et al.	2024	55 - Primary School	Flipped Classroom	Pre-class videos; in-class guided practice and repetition.	Flipped learning and traditional approach were equally successful in transferring knowledge but flipped classroom students had higher knowledge retention.
10	Chen et al.	2024	120 - Primary School	Self-Regulated Gamified Flipped Classroom	Pre-class self-regulated gamified e-books and videos; in-class discussion and practice.	Self-regulated in gamified e-books with flipped classroom enhance students' achievement, self-regulation abilities, motivation, and meta-cognition tendency than gamified flipped and

						traditional flipped classroom.
11	Baidoo & Luneta	2024	381 - Secondary School	Flipped Classroom	Out-of-class online learning using YouTube and WhatsApp.	Blended learning outperforming traditional teaching approach in term of students' performance.
12	Johnson et al.	2024	3 - Secondary School	Station Rotation	Rotate through computer-based instruction, teacher-led groups, and seatwork stations.	There is a functional relation between blended learning and on-task behaviour.
13	Latif et al.	2024	91 - Secondary School	Station Rotation	Randomly assigned groups to video learning, independent practice, collaborative and teacher-led stations.	Station rotation model positively impacts students' performance in adding and subtracting fractions.
14	Ansari et al.	2024	44 - High School	ANSARI Blended Learning	Structured six-stage learning across online and face-to-face sessions.	ANSARI blended learning has effects in improving all categories of students' HOTS and its aspects but in moderate level.
15	Mohammed & Bello	2024	70 - Secondary School	Flipped Collaborative Classroom	After-school video learning; in-class discussion and guidance.	Students in flipped collaborative classroom performed better in both achievement and retention compared to conventional flipped classroom.
16	Ergene & Karaboğaz	2024	56 - Secondary School	Flipped Classroom	Pre-class videos and tests; in-class question-answer and discussion using online platform and WhatsApp.	Flipped classroom model was more effective in terms of mathematics achievement than the control group.
17	Kavaz & Kocak	2024	48 - Secondary School	Flipped Classroom	Pre-lesson videos and materials; live problem-solving sessions.	The flipped classroom group performed better in the first stage, but no difference in the second stage. They

						also experienced lower cognitive load except in the first week. Students in flipped learning had more positive attitudes toward mathematics.
18	Özcan & Zengin	2024	18 - Secondary School	Inquiry-based Flipped Classroom with 5E Model	GeoGebra-based pre-class learning; in-class interaction.	Through the 5E-based flipped classrooms using GeoGebra, the students created productive arguments using different representations.
19	Nguyen et al.	2023	74 - Secondary School	Flipped Classroom	Video-based preparation; in-class practice using GeoGebra.	Flipped classroom and GeoGebra has positive impact on learning outcomes and students' problem-solving ability.
20	Cortez et al.	2023	40 - High School	Cooperative Flipped Classroom with 5E Model	Pre-class videos; cooperative teacher-guided in-class activities.	Cooperative learning techniques proved to be an excellent complement to flipped learning.
21	Zaitoun et al.	2023	50 - High School	Flipped Classroom	Pre-class videos and note-taking; in-class group problem solving.	Flipped classroom was more effective than the traditional method in improving students' performance in mathematics.
22	Ruiz-Palmero et al.	2023	113 - Secondary School	Flipped Classroom	Asynchronous videos; synchronous group work and guidance.	Flipped classroom in teaching mathematics particularly for geometry helps develop students' skills and competencies.
23	Kundu et al.	2023	200 - Primary School	Flipped Classroom	Pre-class videos and quizzes; collaborative in-class problem solving.	Students in the face-to-face group performed the best, but the flipped group reported the highest satisfaction compared to face-to-

						face and fully online groups.
24	Diana et al.	2023	128 – High school	Flipped Classroom	Online video learning and online discussion; in-class problem-solving, group discussion and presentation.	Flipped classroom more effectively junior high school students' understanding of mathematical concepts and higher order thinking skills compared to conventional learning.
25	Nadarajan et al.	2023	131 - Secondary School	Flipped Classroom	Pre-class videos, online discussion and quizzes; student-centred in-class activities; and after class reflections.	Flipped classroom successfully created an effective learning situation in improving students' higher order thinking skills.
26	Jamaluddin et al.	2023	128 - Secondary School	Flipped Classroom & Flex Models	Flipped: pre-class videos; and in-class discussion Flex: in-class online learning with teacher support.	Flipped classroom students performed better in their problem-solving abilities than those in the flex class.
27	Zahedi et al.	2023	221 - Primary School	Station Rotation	Collaborative problem-solving activities then split groups to teacher-led instruction and online learning using math platform.	Significantly higher increase in the performance of the station rotation group compared to the traditional teaching group.

Results

Implementation Patterns of Blended Learning in School Mathematics

Based on the analysis of 27 articles, the findings indicate that the flipped classroom was the most frequently implemented blended learning approach, accounting for 20 of the 28 reported implementations. This model was predominantly applied at the secondary school level, which constituted the largest proportion of the study populations. Across these studies, the flipped classroom was characterised by the delivery of initial instructional content outside the physical classroom, while face-to-face sessions were primarily devoted to active learning activities.

In flipped classroom, pre-class activities typically involved students engaging asynchronously with instructional videos or digital learning materials, allowing them to access mathematical content at their own learning pace prior to formal classroom interaction (Mohammed & Bello, 2024; Widyasari et al., 2025). Teachers generally prepared or selected digital materials distributed through online platforms such as YouTube, Google Classroom, GeoGebra Classroom, or messaging applications (Baidoo & Luneta, 2024; Nguyen et al., 2023; Özcan & Zengin, 2024). These online materials were often accompanied by quizzes, note-taking tasks, or guided questions to structure students' self-directed learning. Thus, the use of technological tools in the flipped classroom was served to extend learning time and support preparation before face-to-face interactions. Meanwhile, in-class activities for the flipped classroom model were structured around discussion, problem-solving, clarification of misconceptions, and formative assessment (Diana et al., 2023; Nadarajan et al., 2023). Teachers acted as facilitators by guiding students through collaborative problem-solving and providing ongoing feedback.

In contrast to the flipped classroom, the station rotation model was implemented through multiple learning modes within the physical classroom environment. Studies adopting the station rotation model designed sequences of stations that included teacher-led instruction, online or computer-based learning, as well as collaborative or independent activities (En-Nhiri et al., 2025; Johnson et al., 2024; Latif et al., 2024; Zahedi et al., 2023). Students rotated from one station to another according to a fixed schedule to ensure that each student experienced a variety of instructional modes within a single learning session (En-Nhiri et al., 2025). This enabled teachers to provide targeted instruction to small groups, while other students engaged in online practice or collaborative tasks.

The implementation of the station rotation model in mathematics classrooms commonly involved the use of digital platforms to provide practice, feedback, and interactive learning opportunities. Platforms such as Digital Classes-Morocco and Zearn Math were used to deliver online tasks that complemented teacher-led instruction (En-Nhiri et al., 2025; Zahedi et al., 2023). At the same time, non-digital stations incorporated the use of physical manipulatives, written exercises, or peer discussions to maintain instructional balance (Latif et al., 2024). The adoption of the station rotation model in mathematics education was driven by its capacity to support diverse learning approaches and immediate instructional support. By enabling students to engage with content through multiple modes within the same learning session, this model addressed differences in prior knowledge, learning pace, and levels of student engagement.

Other patterns of blended learning implementation in mathematics classrooms reflected the strategic integration of multiple models to create more varied instructional arrangements. For instance, Egara & Mosimege (2024a) integrated the mixed of flipped classroom and station rotation models, where students rotated between face-to-face instruction, small-group discussions, and online learning during class, and subsequently engaged in asynchronous learning activities through videos, quizzes, and mathematics tasks outside the classroom. In addition, models such as lab rotation (Abdissa et al., 2025) and flex (Jamaluddin et al., 2023) further demonstrated the diversity of blended learning implementations in mathematics education. Overall, blended learning in mathematics education was implemented with the aim of restructuring learning time, promoting active engagement, and supporting diverse learning approaches.

Effects of Blended Learning on School Students' Mathematics Learning Outcomes

The reviewed studies indicate that blended learning positively impacts students' mathematics learning outcomes, including academic achievement, knowledge retention, higher-order thinking, motivation, and attitudes. In terms of academic achievement, students in blended learning environments demonstrate better performance compared to those in traditional classrooms (Abdissa et al., 2025; Baidoo & Luneta, 2024; Diana et al., 2023; En-Nhiri et al., 2025; Oladejo & Olateju, 2025; Widyasari et al., 2025; Zahedi et al., 2023; Zaitoun et al., 2023). These achievement gains are attributed to the combination of technology-enabled online learning and face-to-face classroom activities. Online learning components allow students to access instructional materials, learn at their own pace, and prepare for classroom engagement (Mohammed & Bello, 2024; Oladejo & Olateju, 2025). At the same time, students involved in discussion, problem-solving, and collaborative tasks, which help to clarify misconceptions during class. The integration of both online and in-class learning promotes deeper understanding in mathematics (Latif et al., 2024; Zahedi et al., 2023).

Blended learning also demonstrates advantages in supporting knowledge retention. Several studies report that students retain mathematical concepts more effectively over time when learning involves both digital and classroom components (Egara & Mosimege, 2024a; Gasparič et al., 2024; Mohammed & Bello, 2024). According to Gasparič et al. (2024), the availability of digital materials that can be accessed repeatedly enables students to revisit learning content, while classroom-based practical activities allow them to apply knowledge more effectively. This supports the development of long-term memory and enhances students' ability to reapply mathematical knowledge in subsequent learning contexts.

Higher order thinking and problem-solving are also strengthened in blended learning environments. By shifting lower-order tasks, such as initial concept acquisition, to online learning, classroom time can be focused on cognitively demanding activities including reasoning and the application of mathematical ideas (Diana et al., 2023; Nadarajan et al., 2023; Nguyen et al., 2023). Consequently, blended learning provides opportunities for students to compare different approaches and solve more complex problems, thereby supporting the development of analytical skills.

Beyond cognitive domain, another important effect of blended learning is on affective outcomes. Several studies show that students are more motivated, willing to participate, remain focused, and develop more positive attitudes towards mathematics when learning is conducted in a blended format (Egara & Mosimege, 2024b; Johnson et al., 2024; Mansour & Wardat, 2025). The combination of online learning and teacher-guided activities helps students feel more prepared, confident, and supported. This approach enables students to engage with challenging content with lower levels of anxiety, while actively interacting with learning materials and peers.

The Role of Pedagogical Models in Shaping the Effectiveness of Blended Learning in School Mathematics

The effectiveness of blended learning in school mathematics is also influenced by the integration of pedagogical models which shape the quality of the learning environment. Project-based learning, for instance, strengthens blended learning by engaging students in mathematical tasks that require the application and reasoning of ideas. Findings from Fitrah *et al.* (Fitrah et al., 2025) show that the use of pre-class videos in a flipped classroom helps to prepare students before they practice concepts in project work during face-to-face learning. The implementation of projects which supported along with the use of online simulations tools further assists students in understanding more complex concepts and applying knowledge beyond the classroom context. This highlights that blended learning allows mathematics learning to occur as a continuous process through meaningful integration of online and face-to-face activities.

Inquiry-based learning models, such as the 5E learning cycle (Engage, Explore, Explain, Elaborate, Evaluate) also play an important role in strengthening blended mathematics instruction. Studies integrating inquiry-based elements within blended learning environments enable the use of online materials to gather information, answering questions, or independently exploring concepts online, before transferring these experiences into face-to-face sessions through discussion, shared exploration, and concept explanation (Özcan & Zengin, 2024). This sequence capitalises on the affordances of blended learning by allocating individual exploration to online spaces, while classroom time is devoted to sense-making and argument-based discussion.

Gamification elements offer clear pedagogical advantages within blended learning environments. Research from Chen *et al.* (Chen et al., 2024) shows that the use of a Self-Regulated Gamified Interactive E-Book (S-GIEB) in a flipped classroom supports students' mathematics achievement, motivation, self-regulation, and metacognitive skills. Gamified elements such as virtual characters, badges, scores, and interactive tasks make pre-class learning more engaging and structured, helping students remain involved with mathematical content before classroom instruction. Unlike traditional flipped classrooms that rely heavily on students' self-discipline to engage with learning materials, the integration of gamification provides additional learning support that guides students in goal setting, progress monitoring, and reflection. These features enhance the effectiveness of the online component and better prepare students for in-class discussion and practice.

On the other hand, collaborative learning further strengthens blended learning by promoting shared understanding and mathematical communication. Mohammed and Bello (Mohammed & Bello, 2024) describe a flipped collaborative classroom in which students first engaged individually with video lessons after school hours and then participated in group discussions during classroom sessions. This approach enabled students to articulate their reasoning, compare solution strategies, and address misconceptions through peer interaction thereby encouraging deeper engagement with mathematical ideas.

In addition, other instructional models contribute to effective blended learning practices by providing clear learning stages. Studies employing phased models such as the 5I model (Oladejo & Olateju, 2025) and the ANSARI model (Ansari et al., 2024) in the blended learning showed that structured sequences help organise online preparation, in-class engagement, and reflection. These models support students' progression from initial exposure to concepts towards application, discussion, and evaluation. Furthermore, it also assists teachers in managing classroom interaction and ensuring that each learning phase serves a clear instructional purpose.

Discussion

Examining blended learning approaches illustrates how learning activities can be delivered across online and face-to-face environments to support mathematics learning at the school level. The implementation of models such as the flipped classroom and station rotation typically utilizes online spaces for content delivery, whereas face-to-face activities are dedicated to discussion, practice, and teacher support. This arrangement benefits school mathematics learning, where students often require repeated exposure, step-by-step reasoning, and clarification of misconceptions (Esperanza et al., 2021). In addition, technology within online learning provides support through accessible tools to facilitate content exposure, provide feedback, and support visualisation which is particularly helpful for mathematical topics involving abstract concepts, procedures, and representations (Nasrullah et al., 2025). Meanwhile, face-to-face sessions remain essential for guiding problem-solving processes and collaborative tasks, which are difficult to fully replicate in online settings (Zhu et al., 2021). This reinforces the view that blended learning approaches address core mathematical demands while maintaining instructional coherence.

The learning outcomes associated with blended learning further underscore its significance in school mathematics. Evidence from the reviewed studies consistently demonstrates improvements in both cognitive and affective dimensions. Gains in academic achievement and higher-order thinking can be attributed to the strategic distribution of cognitive tasks between online and classroom sessions. Moreover, the combination of accessible digital resources and practical in-class activities strengthens knowledge retention by promoting learning beyond rote memorization. Repeated exposure to digital materials, together with classroom-based application, reinforces memory consolidation and facilitates the transfer of knowledge to novel problems. In addition, increased motivation and positive attitudes suggest that students perceive blended learning environments as more supportive and less intimidating, which is crucial for sustaining persistence when engaging with challenging mathematical tasks. Overall, these findings indicate that blended learning supports deeper and sustained learning outcome through the integration of the technological tools, teacher facilitation, and students' engagement (Yu et al., 2025).

The pedagogical models embedded within blended learning environments plays a critical role in enhancing the effectiveness of school mathematics instruction (Schallert et al., 2022; Zheng et al., 2020). Instructional approaches such as project-based, inquiry-based, and collaborative learning, help educators structure online activities that foster purposeful preparation and exploration, while classroom interactions are used for sense-making, justification, and clarification of understanding. By integrating project works, inquiry-oriented activities, and collaborative tasks, students are encouraged to engage in analytical reasoning, apply mathematical concepts, and actively participate in problem-solving rather than passively receiving information. Furthermore, gamification elements and phased instructional models address challenges associated with self-directed online learning by supporting motivation, self-regulation, and structured learning progression. These highlights the effectiveness of blended learning also depend on how instructional activities are sequenced and aligned with learning goals.

Conclusions

This systematic literature review examined blended learning approaches in school mathematics classrooms to identify key patterns across implementation, learning outcomes, and pedagogical design. The results indicate that blended learning is predominantly implemented through the flipped classroom model and is largely applied in secondary school contexts. The findings highlight that blended learning improves mathematical achievement, knowledge retention, higher-order thinking, and motivation by providing flexible access to online content while maintaining the pedagogical benefits of direct classroom interaction. Importantly, the effectiveness of blended learning is closely linked to pedagogical models that ensures coherence across learning phases and aligns online and face-to-face activities with clear instructional objectives. Overall, this review underscores that blended learning represents a robust and adaptable approach for mathematics instruction and offers valuable implications for educators, curriculum designers, and policymakers seeking to enhance mathematics teaching and learning in school.

Recommendation for Future Research

Based on the findings of this review, several directions for future research are proposed. First, research should extend beyond secondary school students, as evidence for primary school contexts remains limited. This would provide additional insight into how blended learning can enhance mathematics outcomes from earlier stages. Second, while most existing studies implement the flipped classroom, future research should investigate other blended learning models and their integration with established pedagogical models to further inform the design and implementation of blended learning in mathematics classrooms. Third, while current studies frequently employ video platforms and learning management systems, future research should explore emerging technologies such as artificial intelligence, augmented reality, virtual reality and other immersive applications for online learning to fully leverage their potential in enhancing blended learning for mathematics instruction.

Acknowledgement

This research was not funded by any grant. The authors would like to thank Universiti Teknologi Malaysia and the Ministry of Education Malaysia under Hadiah Latihan Persekutuan (HLP) scholarship for their support in making this project possible.

References

Abdelmalak, M. M. M. (2024). Promoting selected core thinking skills using math stations rotation. *Research in Mathematics Education*. https://doi.org/10.1080/14794802.2024.2344209

Abdissa, D. G., Duressa, G. F., Olkaba, T. T., & Feyissa, E. G. (2025). The Effect of Blended Learning Educational Model on Secondary School Students' Mathematics Achievement. *Problems of Education in the 21st Century*, *83*(1), 9–29. https://doi.org/10.33225/pec/25.83.09

Angawi, M., & Tasir, Z. (2024). Blended Learning Research: A Systematic Review and Identification of Future Research Gaps. *International Journal of Academic Research in Progressive Education and Development*, *13*(3). https://doi.org/10.6007/ijarped/v13-i3/22216

Ansari, B. I., Kasmini, L., Maulina, S., Daud, M., & Muzakir, U. (2024). Mathematics Learning Strategies in the 21st Century: A Comparison of the Effect of the ANSARI Blended Learning Model on Students' Higher Order Thinking Skills and Perceptions in the Post Covid-19 Pandemic. *Mathematics Teaching Research Journal*, *16*(5), 136–156.

Baidoo, J., & Luneta, K. (2024). Implementing blended learning to enhance the teaching of 3-dimensional trigonometry. *Journal of Education and E Learning Research*, *11*(2), 332–344. https://doi.org/10.20448/jeelr.v11i2.5565

Bas, G., & Kivilcim, Z. S. (2021). Traditional, Cooperative, Constructivist, and Computer-Assisted Mathematics Teaching: A Meta-Analytic Comparison Regarding Student Success. In *International Journal of Technology in Education* (Vol. 4, Number 3).

Chen, C., Jamiat, N., Abdul Rabu, S. N., & Mao, Y. (2024). Effects of a self-regulated-based gamified interactive e-books on primary students' learning performance and affection in a flipped mathematics classroom. *Education and Information Technologies*, *29*(18). https://doi.org/10.1007/s10639-024-12789-7

Cirneanu, A. L., & Moldoveanu, C. E. (2024). Use of Digital Technology in Integrated Mathematics Education. *Applied System Innovation*, *7*(4). https://doi.org/10.3390/asi7040066

Cortez, C. P., Osenar - Rosqueta, A. M. F., & Prudente, M. S. (2023). Cooperative-flipped classroom under online modality: Enhancing students' mathematics achievement and critical thinking attitude. *International Journal of Educational Research*, *120*. https://doi.org/10.1016/j.ijer.2023.102213

Diana, Surjono, H. D., & Mahmudi, A. (2023). The Effect of Flipped Classroom Learning Model on Students' Understanding of Mathematical Concepts and Higher-Order Thinking Skills. *International Journal of Information and Education Technology*, *13*(12). https://doi.org/10.18178/ijiet.2023.13.12.2016

Egara, F. O., & Mosimege, M. (2024a). Effect of blended learning approach on secondary school learners' mathematics achievement and retention. *Education and Information Technologies*. https://doi.org/10.1007/s10639-024-12651-w

Egara, F. O., & Mosimege, M. (2024b). Effect of flipped classroom learning approach on mathematics achievement and interest among secondary school students. *Education and Information Technologies*, *29*(7). https://doi.org/10.1007/s10639-023-12145-1

En-Nhiri, A., Radi, M., Samdouni, A., Galai, M., Touir, R., Echarghaoui, R., & Larhzil, H. (2025). Blended Learning through the "Digital Classes-Morocco" Platform: Effects on Achievement and Retention in Mathematics. *International Journal of Information and Education Technology*, *15*(9). https://doi.org/10.18178/ijiet.2025.15.9.2393

Ergene, Ö., & Karaboğaz, Y. (2024). The effect of the flipped classroom model on students' proportional reasoning. *Journal of Pedagogical Research*, *8*(1). https://doi.org/10.33902/JPR.202425424

Esperanza, P. J., Himang, C., Bongo, M., Selerio, E., & Ocampo, L. (2021). The utility of a flipped classroom in secondary Mathematics education. *International Journal of Mathematical Education in Science and Technology*, *54*(3). https://doi.org/10.1080/0020739X.2021.1957166

Fitrah, M., Sofroniou, A., Setiawan, C., Widihastuti, W., Yarmanetti, N., Jaya, M. P. S., Panuntun, J. G., Arfaton, A., Beteno, S., & Susianti, I. (2025). The Impact of Integrated Project-Based Learning and Flipped Classroom on Students' Computational Thinking Skills: Embedded Mixed Methods. *Education Sciences*, *15*(4). https://doi.org/10.3390/educsci15040448

Gasparič, R. P., Glavan, M., Mihelič, M. Ž., & Zuljan, M. V. (2024). EFFECTIVENESS OF FLIPPED LEARNING AND TEACHING: KNOWLEDGE RETENTION AND STUDENTS' PERCEPTIONS. *Journal of Information Technology Education: Research*, *23*. https://doi.org/10.28945/5237

Graham, C. R. (2006). Blended learning systems: Definition, current trends, and future directions. In *Handbook of blended learning: Global perspectives, local designs*.

Haziki, N. H., Abdullah, A. H., & Hamzah, M. H. (2025). Flipped Classrooms in Higher Education: A Meta-Analysis of Their Impact on Mathematics Performance. *Malaysian Journal of Mathematical Sciences*, *19*(1). https://doi.org/10.47836/mjms.19.1.07

Hong, Q. N., Pluye, P., Fàbregues, S., Bartlett, G., Boardman, F., Cargo, M., Dagenais, P., Gagnon, M.-P., Griffiths, F., Nicolau, B., O'Cathain, A., Rousseau, M.-C., & Vedel, I. (2018). *Mixed Methods Appraisal Tool (MMAT) Version 2018*. McGill. http://mixedmethodsappraisaltoolpublic.pbworks.com/

Ishartono, N., Halili, S. H., & Razak, R. A. (2023). A review of flipped learning in innovative math education. *International Journal of Evaluation and Research in Education*, *12*(4). https://doi.org/10.11591/ijere.v12i4.25842

Jailani, N., Rosli, R., & Mahmud, M. S. (2025). BLENDED LEARNING AND EMERGING TECHNOLOGIES IN MATHEMATICS EDUCATION: A COMPREHENSIVE STRUCTURED REVIEW. *Journal of Theoretical and Applied Information Technology*, *103*(16).

Jamaluddin, M., Mustaji, M., Bachri, B. S., & Sutarto, A. P. (2023). The Role of Gender and Self-efficacy on the Relationship between Flipped and Flex Blended Learning and Mathematics Abilities. *International Journal of Information and Education Technology*, *13*(5), 873–881. https://doi.org/10.18178/ijiet.2023.13.5.1882

Jamaluddin, M., Mustaji, M., & Bahri, B. S. (2022). Effect of Blended Learning Models and Self-Efficacy on Mathematical Problem-Solving Ability. *International Journal of Learning, Teaching and Educational Research*, *21*(7). https://doi.org/10.26803/ijlter.21.7.7

Johnson, Z. G., Houchins, D., Varjas, K., Jimenez, E., & McKinney, T. (2024). Improving Student On-Task Behavior, Teacher Engagement, and Math Achievement through Blended Learning: A Single-Case Design Study. *Education and Treatment of Children*, *47*(4), 343–361. https://doi.org/10.1007/s43494-024-00140-1

Kadirbayeva, R., Pardala, A., Alimkulova, B., Adylbekova, E., Zhetpisbayeva, G., & Jamankarayeva, M. (2022). Methodology of application of blended learning technology in mathematics education. *Cypriot Journal of Educational Sciences*, *17*(4), 1117–1129. https://doi.org/10.18844/cjes.v17i4.7159

Kavaz, S., & Kocak, O. (2024). The Effect of the Online Flipped Learning Model on Secondary School Students' Academic Achievement, Attitudes Towards Their Mathematics Course, and Cognitive Load. *International Journal of Science and Mathematics Education*, *22*(8). https://doi.org/10.1007/s10763-024-10455-5

Kundu, A., Bej, T., & Mondal, G. C. (2023). Elementary math class in face-to-face, fully online, and flipped mode: A comparative study on students' achievement and satisfaction. *E-Learning and Digital Media*, *20*(4). https://doi.org/10.1177/20427530221109700

Latif, N. H. A., Shahrill, M., & Hidayat, W. (2024). Mastering Fractions and Innovating with The Station Rotation Model in Blended Learning. *Infinity Journal*, *13*(2), 501–530. https://doi.org/10.22460/infinity.v13i2.p501-530

Mansour, O., & Wardat, Y. (2025). The effect of the flipped classroom strategy on motivation to learn mathematics among 9th-grade female students: a quasi-experimental study in Amman. *Frontiers in Education*, *10*. https://doi.org/10.3389/feduc.2025.1579358

Mohammed, I. A., & Bello, A. (2024). Performance of mathematics students using video learning in flipped and flipped collaborative learning settings. *Pedagogical Research*, *9*(3). https://doi.org/10.29333/pr/14699

Nadarajan, K., Abdullah, A. H., Alhassora, N. S. A., Ibrahim, N. H., Surif, J., Ali, D. F., Mohd Zaid, N., & Hamzah, M. H. (2023). The Effectiveness of a Technology-Based Isometrical Transformation Flipped Classroom Learning Strategy in Improving Students' Higher Order Thinking Skills. *IEEE Access*, *11*. https://doi.org/10.1109/ACCESS.2022.3230860

Nasrullah, A., Aminah, M., Umalihayati, Rahmadani, K., Widodo, S. A., & Husni, M. (2025). Blended learning in mathematic: the fusion of GeoGebra and Edmodo for enhanced problem-solving abilities. *International Journal of Evaluation and Research in Education*, *14*(1), 423–432. https://doi.org/10.11591/ijere.v14i1.27713

Nguyen, A. T. T., Thanh, H. N., Minh, C. Le, Tong, D. H., Uyen, B. P., & Khiem, N. D. (2023). Combining flipped classroom and GeoGebra software in teaching mathematics to develop math problem-solving abilities for secondary school students in Vietnam. *Mathematics Teaching-Research Journal*, *15*(4).

Oladejo, A. I., & Olateju, T. T. (2025). Beyond the conventional flipped classroom: Exploring the efficacy of the 5I model of flipped learning in senior secondary school mathematics. *STEM Education*, *5*(6). https://doi.org/10.3934/steme.2025043

Özcan, Ş., & Zengin, Y. (2024). Teachers' Use of Rational Questioning to Support Students' Collective Argumentation Through 5E-Based Flipped Classroom Approach Using GeoGebra. *Science and Education*. https://doi.org/10.1007/s11191-024-00573-5

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. In *The BMJ* (Vol. 372). https://doi.org/10.1136/bmj.n71

Ruiz-Palmero, J., Guillén-Gámez, F. D., Colomo-Magaña, E., & Sánchez-Vega, E. (2023). Effectiveness of the Flipped Classroom in the Teaching of Mathematics in an Online Environment: Identification of Factors Affecting the Learning Process. *Online Learning Journal*, *27*(2). https://doi.org/10.24059/olj.v27i2.3239

Sarkis-Onofre, R., Catalá-López, F., Aromataris, E., & Lockwood, C. (2021). How to properly use the PRISMA Statement. *Systematic Reviews*, *10*(1). https://doi.org/10.1186/s13643-021-01671-z

Schallert, S., Lavicza, Z., & Vandervieren, E. (2022). Towards Inquiry-Based Flipped Classroom Scenarios: a Design Heuristic and Principles for Lesson Planning. *International Journal of Science and Mathematics Education*, *20*(2), 277–297. https://doi.org/10.1007/s10763-021-10167-0

Staker, H., & Horn, M. B. (2012). Classifying K-12 Blended Learning. In *Innosight Institute* (Number May). https://www.christenseninstitute.org/wp-content/uploads/2013/04/Classifying-K-12-blended-learning.pdf

Suripah, Retnawati, H., Zetriuslita, Zafrullah, & Hidayat, R. (2025). Research Trends in Scopus Database on Technological Innovation in the Process of Mathematics Learning: A Bibliometric Analysis. *International Journal of Cognitive Research in Science Engineering and Education*, *13*(1), 97–116. https://doi.org/10.23947/2334-8496-2025-13-1-97-116

Topping, K. J., Douglas, W., Robertson, D., & Ferguson, N. (2022). Effectiveness of online and blended learning from schools: A systematic review. *Review of Education*, *10*(2). https://doi.org/10.1002/rev3.3353

Van der Westhuizen, M., & Hlatshwayo, L. (2023). Towards flexible learning and teaching: Lessons learned for blended learning and teaching post COVID-19 pandemic. *Perspectives in Education*, *41*(2), 151–165. https://doi.org/10.38140/pie.v41i2.6224

Widyasari, Syifa Nurul Ihsaniah, A., & Mujahidin, E. (2025). The Effect of Flipped Classroom Learning Design on Mathematics Learning Outcomes. *International Journal on Studies in Education*, *7*(4), 867–878. https://doi.org/10.46328/ijonse.5642

Wolff, B., & Girnat, B. (2024). Student perspectives on the flipped classroom concept in secondary math lessons. *Discover Education*, *3*(1). https://doi.org/10.1007/s44217-024-00287-4

Yu, Q., Yu, K., Li, B., & Wang, Q. (2025). Effectiveness of blended learning on students' learning performance: a meta-analysis. *Journal of Research on Technology in Education*, *57*(3), 499–520. https://doi.org/10.1080/15391523.2023.2264984

Zahedi, S., Bryant, C. L., Iyer, A., & Jaffer, R. (2023). The use of blended learning to promote learner-centered pedagogy in elementary math classrooms. *Educational Research for Policy and Practice*, *22*(3). https://doi.org/10.1007/s10671-023-09346-3

Zaitoun, E., Shana, Z., Shater, A., Naser, K., & Mukattash, Z. (2023). Does flipping the classroom with videos and notetaking promote high school students' performance in mathematics? *Eurasia Journal of Mathematics, Science and Technology Education*, *19*(6). https://doi.org/10.29333/ejmste/13200

Zheng, L., Bhagat, K. K., Zhen, Y., & Zhang, X. (2020). The effectiveness of the flipped classroom on students' learning achievement and learning motivation: A meta-analysis. *Educational Technology and Society*, *23*(1).

Zhu, M., Berri, S., & Zhang, K. (2021). Effective instructional strategies and technology use in blended learning: A case study. *Education and Information Technologies*, *26*(5). https://doi.org/10.1007/s10639-021-10544-w