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META-ANALYSIS ON EFFECTS OF TEACHING METHODS ON STUDENTS' ACADEMIC ACHIEVEMENT, RETENTION AND INTEREST IN MATHEMATICS

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Abstract

This study conducted a meta-analytic review of the effects of teaching methods on students' academic achievement, retention, and interest in mathematics. The primary aim was to synthesize existing empirical and opinion-based selected research from 2020 to 2025 to provide a comprehensive understanding of how instructional approaches influence learning outcomes. The review examined a range of teaching methods, including activity-based learning, collaborative problem-solving, inquiry-based approaches, and ethnomathematics, and assessed their reported impacts on cognitive, affective, and motivational dimensions of mathematics learning. The meta-analysis indicated that student-centered methods consistently produced higher academic achievement compared to traditional lecture-based instruction, as they engaged learners actively, promoted critical thinking, and facilitated meaningful knowledge construction. Moreover, approaches that incorporated cultural relevance, and interactive engagement were found to enhance long-term retention by allowing students to revisit and apply concepts in multiple contexts. The study also revealed that learners' interest in mathematics was strongly influenced by instructional methods that provided autonomy, relevance, and interactive opportunities, which in turn reinforced both achievement and retention. Implications for teaching emphasized the necessity of adopting multi-dimensional instructional strategies, integrating formative assessments. Suggestions included professional development for teachers, curriculum designs that support active and culturally responsive learning, and policy interventions to facilitate resources and training. Limitations of the study were noted in its reliance on secondary sources, variability of contexts among reviewed studies, and the broad categorization of teaching methods without topic-specific detail. The study contributed to the educational sector by informing teachers, curriculum designers, policymakers, and researchers about effective strategies for enhancing mathematics learning. Overall, the review underscored the importance of evidence-based, learner-centered approaches that simultaneously promote academic achievement, retention, and interest, thereby supporting the development of holistic and sustainable mathematics education practices.

Keywords: Teaching Methods, Learning outcome, Mathematics, Meta-Analysis, Students.

Introduction

The persistent concern over students' performance in mathematics continues to fuel extensive scholarly debate, particularly regarding how teaching methods shape learning outcomes such as academic achievement, retention, and interest. In recent years, studies have increasingly emphasized that the quality of mathematics learning depends less on the content itself and more on the pedagogical approaches used in the classroom (In'am & Hajar, 2019; Sukirwan et al., 2018; García-Carrión et al., 2020). From the outset, contemporary researchers have questioned the continued dominance of teacher-centered instructional practices, arguing that such methods often fail to produce meaningful, lasting, and engaging learning experiences for students (Lo & Hew, 2019; Wahyuni et al., 2020).

A growing body of literature from this period consistently shows that traditional lecture-based approaches, while efficient for content delivery, often emphasize procedural knowledge at the expense of conceptual understanding. According to Lo and Hew (2019), students exposed primarily to direct instruction often exhibit superficial learning patterns, characterized by memorization rather than comprehension. This limitation is particularly evident in mathematics, where conceptual understanding and the ability to apply knowledge are critical. Similarly, Wahyuni et al. (2020) argue that conventional teaching methods frequently neglect the cognitive processes required for deep learning, thereby limiting students' ability to retain and transfer mathematical knowledge.

In response to these concerns, recent scholarship increasingly advocates learner-centered instructional approaches that actively engage students in the learning process. Sukirwan et al. (2018) observed that when students participate in problem-solving, discussion, and collaborative activities, they develop stronger conceptual understanding and demonstrate improved academic achievement. Their findings were supported by García-Carrión et al. (2020), who noted that dialogic and interactive teaching methods create opportunities for students to articulate their thinking, challenge ideas, and construct knowledge collectively. Such engagement not only enhances achievement but also fosters a deeper connection with the subject matter.

Beyond academic achievement, recent studies have drawn attention to the importance of retention as a fundamental outcome of effective teaching. Retention, as conceptualized in contemporary research, extends beyond the ability to recall information; it encompasses the capacity to apply learned concepts in new and varied contexts (Fauth et al., 2019). Teaching methods that promote active engagement, reflection, and repeated exposure to concepts have been shown to significantly enhance retention. For instance, Fauth et al. (2019) emphasized that instructional quality, particularly in terms of cognitive activation and classroom discourse, plays a crucial role in determining how well students retain mathematical knowledge over time.

Closely linked to retention is the issue of students' interest in mathematics, which has emerged as a critical focus in recent educational research. Interest is widely recognized as both a driver and an outcome of effective learning. When students are interested in mathematics, they are more likely to engage deeply with content, persist through challenges, and invest effort in learning activities (Schukajlow et al., 2017; although earlier, extended in later works such as Rakoczy et al., 2021). More recent studies, such as Rakoczy et al. (2021), have demonstrated that teaching methods that incorporate autonomy, relevance, and interactive elements significantly enhance students' motivation and interest. These

researchers suggest that interest is not an inherent trait but can be cultivated through appropriate instructional practices.

Furthermore, the integration of innovative and technology-enhanced teaching methods has gained prominence in the literature in recent years. Studies have shown that digital tools, when effectively integrated into instruction, can enhance students' engagement, provide immediate feedback, and support personalized learning experiences (Chiu, 2021; Hillmayr et al., 2020). Hillmayr et al. (2020), in particular, highlighted that digital interventions in mathematics education have a positive impact on both achievement and motivation, especially when they are aligned with pedagogical goals and actively involve students in the learning process. Similarly, Chiu (2021) argued that technology-supported learning environments can facilitate deeper understanding and improve retention by enabling students to visualize and interact with mathematical concepts.

Another significant development in recent research is the emphasis on metacognitive and self-regulated learning strategies as integral components of effective teaching methods. Studies have shown that when students are encouraged to reflect on their learning processes, set goals, and monitor their progress, they achieve better learning outcomes and retain knowledge more effectively (Broadbent & Poon, 2018; Theobald, 2021). These strategies not only enhance achievement but also foster independence and sustained interest in learning mathematics. Theobald (2021) further argued that inclusive and engaging teaching practices, which incorporate metacognitive elements, are essential for addressing diverse learners' needs and promoting equitable learning outcomes.

In addition, recent meta-analyses have highlighted the importance of contextual and culturally relevant teaching methods in mathematics education. In'am and Hajar (2019) found that when mathematical concepts are linked to students' real-life experiences and cultural backgrounds, learners are more likely to understand, retain, and appreciate the subject. This perspective aligns with broader educational theories that emphasize the role of context and relevance in learning. By making mathematics meaningful and relatable, teachers can enhance both students' interest and their ability to retain knowledge over time.

Despite these advancements, scholars have noted that the implementation of effective teaching methods remains uneven across educational contexts. Factors such as teacher preparedness, availability of resources, and institutional support often influence the extent to which innovative instructional practices are adopted (Hillmayr et al., 2020; Theobald, 2021). This highlights the need for continuous professional development and policy support to ensure that teachers are equipped with the skills and resources necessary to implement effective teaching methods.

Importantly, recent meta-analytic and review studies have underscored the interconnected nature of academic achievement, retention, and interest. Rather than viewing these outcomes in isolation, contemporary research suggests that they are mutually reinforcing. Teaching methods that enhance interest often lead to increased engagement, which in turn improves achievement and retention. Similarly, methods that promote deep understanding and retention can foster a sense of competence and confidence, thereby enhancing interest (Fauth et al., 2019; Rakoczy et al., 2021). This holistic perspective has significant implications for mathematics teaching, as it calls for instructional approaches that address cognitive, affective, and motivational dimensions simultaneously.

Within this context, the present study adopts an opinion-based meta-analytic perspective to examine the effects of teaching methods on students' academic achievement, retention, and

interest in mathematics. Unlike purely empirical studies, this paper seeks to synthesize and interpret existing research findings, drawing connections across studies and offering a reasoned perspective on the implications for teaching practice. The choice of an opinion paper is particularly appropriate given the complexity and diversity of the literature, as it allows for a more nuanced and integrative analysis of the topic.

In summary, the meta-analysis from recent studies provides compelling evidence that teaching methods play a critical role in shaping students' learning outcomes in mathematics. There is a clear shift from traditional, teacher-centered approaches towards more interactive, student-centered, and technology-enhanced methods. These approaches not only improve academic achievement but also enhance retention and foster sustained interest in mathematics. However, the successful implementation of these methods requires careful consideration of contextual factors, as well as ongoing support for teachers and educational institutions. This study, therefore, seeks to contribute to this ongoing discourse by providing a comprehensive and reflective synthesis of the effects of teaching methods on key learning outcomes in mathematics.

META-ANALYSIS OF THE SELECTED EMPIRICAL REVIEW

META ANALYSIS 1: CHINELO BLESSING ORIBHABOR (2020) THE EFFECT OF ACTIVITY-BASED METHOD OF TEACHING MATHEMATICS.

A relevant empirical study that fits this seminar topic is the work of Oribhabor (2020), titled "Evaluating the Effect of Activity-Based Method of Teaching Mathematics on Nigerian Secondary School Students' Achievement in Mathematics." This study provides a clear scholarly position on how teaching methods influence students' academic achievement and, indirectly, their retention and interest.

In her 2020 study, Oribhabor investigated the effect of the activity-based teaching method on students' achievement in mathematics. The study emerged from the persistent concern that students' poor performance in mathematics is largely attributable to ineffective, teacher-centered instructional approaches. The author therefore sought to examine whether a more learner-centered strategy could improve outcomes.

The study adopted a quasi-experimental pretest-posttest design, involving two groups: an experimental group exposed to the activity-based method and a control group taught using the conventional lecture method. This design allowed for a systematic comparison of the effectiveness of the two teaching approaches in enhancing students' learning outcomes.

The teaching method used is activity-based learning, which is grounded in constructivist principles. It emphasizes students' active participation in the learning process through hands-on tasks, problem-solving activities, and collaborative engagement. Unlike the conventional lecture method, which positions students as passive recipients of knowledge, the activity-based method encourages exploration, interaction, and critical thinking.

The findings of her study revealed that students exposed to the activity-based method performed significantly better than those taught using the traditional lecture method. Specifically, there was a statistically significant difference in post-test mean scores, favouring the experimental group.

Although the study primarily focused on academic achievement, the author implied that the improved performance was linked to increased engagement and participation, which are closely associated with students' interest and retention in mathematics. The active

involvement of learners in constructing knowledge was seen as enhancing understanding and long-term retention of mathematical concepts.

In terms of conclusion and opinion, Oribhabor strongly advocated for a shift from conventional teaching methods to more interactive and student-centered approaches. The author concluded that activity-based teaching is not only more effective in improving achievement but also makes mathematics learning more meaningful and engaging. Consequently, she recommended that mathematics teachers should be trained and retrained to adopt such innovative instructional strategies in order to improve students' academic outcomes and sustain their interest in the subject.

META ANALYSIS 2: HWANG ET AL. (2021), THE EFFECTS OF TECHNOLOGY-SUPPORTED INSTRUCTIONAL APPROACHES, SPECIFICALLY MOBILE AND GAME-BASED LEARNING, ON STUDENTS' ACADEMIC OUTCOMES IN MATHEMATICS

A relevant empirical contribution in 2021 that aligns with the present meta-analytic focus is the study by Hwang et al. (2021), which examined the effects of technology-supported instructional approaches, specifically mobile and game-based learning, on students' academic outcomes in mathematics. Their work provides a strong basis for synthesizing how innovative teaching methods influence achievement, retention, and interest. Hwang et al. (2021) argued that traditional, teacher-centered approaches often limit students' active engagement and consequently reduce both retention and sustained interest in mathematics.

In contrast, they emphasized learner-centered, technology-enhanced pedagogies that integrate interactive and problem-based elements. According to the authors, mobile and game-based learning environments create opportunities for immediate feedback, self-paced exploration, and contextualized problem-solving, all of which are critical for deep conceptual understanding.

Empirically, their findings demonstrated that students exposed to game-based and mobile learning strategies performed significantly better in terms of academic achievement compared to those taught using conventional expository methods. The authors attributed this improvement to increased cognitive engagement and the multimodal representation of mathematical concepts.

Furthermore, retention was found to be higher among students in the experimental groups, as the interactive nature of these approaches facilitated repeated practice and reinforced learning over time.

In terms of interest, Hwang et al. (2021) reported a marked increase in students' motivation and positive attitudes toward mathematics. The gamified elements, such as challenges, rewards, and progression systems were identified as key drivers of students' sustained interest and willingness to engage with mathematical tasks.

Overall, the study supports the effectiveness of game-based mobile learning as a teaching method that enhances students' academic achievement, improves retention, and stimulates interest in mathematics, thereby providing a solid empirical foundation for meta-analytic synthesis.

META ANALYSIS 3: KNOGLER (2022) MULTIPLE META-ANALYSES ON EFFECTIVE

EDUCATIONAL PRACTICES, INCLUDING MATHEMATICS TEACHING

In 2022, Knogler conducted a scholarly work that focuses on effects of teaching methods (as an opinion-based synthesis). In the study, Knogler (2022), reviewed multiple meta-analyses on effective educational practices, including mathematics teaching. He conducted a systematic review of 41 meta-analyses examining the effectiveness of different instructional approaches across educational contexts. Although the study was broad, it provided important insights into mathematics teaching by synthesizing prior meta-analytic evidence on how teaching methods influence students' learning outcomes.

His study did not focus on a single teaching method; rather, it examined a range of instructional strategies such as student-centered learning, inquiry-based approaches, feedback-driven instruction, and collaborative learning. These methods were consistently identified across the reviewed meta-analyses as central to improving learning outcomes in mathematics and related subjects.

From the author's perspective, the key argument was that no single teaching method operates in isolation as the most effective. Instead, effectiveness lies in the combination of strategies that actively engage learners, promote understanding, and sustain motivation.

The author emphasized that teaching methods that involve active participation, interaction, and feedback mechanisms tend to produce stronger academic outcomes.

In relation to academic achievement, the review showed that teaching approaches grounded in active learning and formative assessment consistently yielded positive effects on students' performance.

Furthermore, these approaches were linked to deeper understanding, which naturally enhances retention of mathematical concepts over time.

Although interest was not always measured directly in all the meta-analyses reviewed, Knogler argued that teaching methods that promote engagement and autonomy such as inquiry-based and collaborative learning are inherently connected to students' positive attitudes and sustained interest in mathematics. This implies that when students are actively involved in constructing knowledge, they are more likely to develop lasting interest in the subject.

In conclusion, the author's opinion strongly supports the idea that effective mathematics teaching is multi-dimensional, requiring a blend of strategies rather than reliance on traditional lecture methods. The study advocates for evidence-based teaching practices that integrate cognitive, motivational, and interactive elements to improve achievement, retention, and interest simultaneously.

META ANALYSIS 4: WANG ET AL. (2023) THE EFFECTS OF INNOVATIVE INSTRUCTIONAL APPROACHES PARTICULARLY PROBLEM-BASED LEARNING (PBL) AND BLENDED LEARNING ON STUDENTS' ACADEMIC ACHIEVEMENT AND RELATED LEARNING OUTCOMES IN MATHEMATICS AND OTHER STEM DOMAINS

Another recent meta-analytic review that strengthens the position is provided by Wang et al. (2023). He conducted a comprehensive study examining the effects of innovative

instructional approaches particularly problem-based learning (PBL) and blended learning on students' academic achievement and related learning outcomes in mathematics and other STEM domains. Their study offers a robust conceptual basis for understanding how teaching methods shape students' performance, retention, and interest. Wang et al. (2023) contended that the effectiveness of any instructional method is fundamentally tied to the degree to which it promotes active cognitive engagement and meaningful knowledge construction. In their view, traditional lecture-based approaches often produce surface learning, which may yield short-term performance gains but does not sufficiently support long-term retention or sustained academic interest. By contrast, they argued that student-centered pedagogies especially problem-based and blended learning create conditions that foster deeper understanding and transferable skills.

Drawing on a wide range of empirical studies, the authors reported that problem-based learning significantly improved students' academic achievement. This improvement was attributed to the method's emphasis on real-life problem solving, collaborative inquiry, and critical thinking, which collectively enhance conceptual clarity in mathematics.

In addition, the meta-analysis showed that blended learning environments where face-to-face instruction is integrated with digital resources had a positive significant effect on students' retention. The flexibility inherent in blended models allows learners to revisit instructional materials, thereby reinforcing learning and promoting long-term memory consolidation.

With respect to students' interest, Wang et al. (2023) emphasized that teaching methods incorporating interactivity, autonomy, and contextual relevance tend to increase learners' intrinsic motivation. They observed that when students are actively involved in constructing knowledge rather than passively receiving information, their disposition toward mathematics becomes more positive, which in turn enhances persistence and overall academic performance.

The authors therefore concluded that teaching methods are not merely instructional choices but critical determinants of students' academic success. Their research work provides compelling evidence that learner-centered approaches particularly problem-based and blended learning consistently yield superior outcomes in terms of achievement, retention, and interest. This position reinforces the argument that the selection and implementation of appropriate teaching methods should remain central to pedagogical reforms and meta-analytic investigations in mathematics education.

META ANALYSIS 5: SULISTYOWATI (2024) THE EFFECTIVENESS OF THE ETHNOMATHEMATICS TEACHING APPROACH ON STUDENTS' LEARNING OUTCOMES IN MATHEMATICS

A relevant 2024 contribution to this discourse is the meta-analytic study by Sulistyowati (2024), which examined the effectiveness of the ethnomathematics teaching approach on students' learning outcomes in mathematics. In this study, the author synthesized several primary studies to determine how culturally responsive teaching influences students' mathematics learning. The teaching method employed ethnomathematics integrates cultural context, local knowledge, and everyday experiences into mathematics instruction, thereby making learning more meaningful and relatable to students.

From the author's standpoint, the central argument is that students learn mathematics more effectively when instruction is connected to their socio-cultural environment.

The meta-analysis of their work indicated that ethnomathematics has a significant positive effect on students' academic achievement when compared with conventional teaching methods.

Beyond achievement, the author implicitly linked this improvement to enhanced retention, noting that meaningful and contextualized learning helps students to better understand and recall mathematical concepts.

When learners see mathematics as part of their lived experiences, knowledge is not merely memorized but internalized.

Similarly, the study suggested that such culturally grounded instruction contributes to increased interest in mathematics, as students become more engaged and motivated when the subject reflects familiar realities rather than abstract, disconnected content.

In conclusion, Sulistyowati's opinion strongly supports the position that innovative, context-based teaching methods are more effective than traditional approaches, particularly in fostering not only achievement but also sustained interest and retention. The study advocates for the integration of learners' cultural backgrounds into mathematics instruction as a means of improving overall learning outcomes.

META ANALYSIS 6: RAHMAN AND ADEYEMI (2025)EFFECTS OF COLLABORATIVE AND PROBLEM-BASED LEARNING STRATEGIES ON STUDENTS' RETENTION AND INTEREST IN MATHEMATICS

A more recent contribution that shifts attention from mere performance to the durability of learning is the work of Rahman and Adeyemi (2025), which examined the effects of collaborative and problem-based learning strategies on students' retention and interest in mathematics. Unlike earlier studies that were largely achievement-driven, this study foregrounded how instructional methods influence the long-term stability of knowledge and students' disposition towards mathematics.

The authors adopted a meta-analytic perspective, drawing on a range of empirical studies that compared traditional lecture methods with more interactive approaches such as problem-based learning (PBL) and collaborative group work. Their central argument was that retention is not merely a by-product of achievement but a distinct outcome that is strongly shaped by the quality of cognitive engagement during instruction.

The teaching methods emphasized in the study, particularly problem-based and collaborative learning, are rooted in active knowledge construction and peer interaction. According to the authors, these approaches compel learners to revisit, reorganize, and apply mathematical ideas in varied contexts, thereby strengthening memory traces and improving retention over time. In contrast, conventional expository teaching was found to promote short-term performance with limited lasting understanding.

Concerning interest, the authors maintained that teaching methods that give students agency, allowing them to explore problems, make decisions, and interact with peers, tend to cultivate a more positive attitude towards mathematics. They argued that interest is sustained when learners perceive mathematics not as a rigid body of rules but as a dynamic and meaningful activity.

In their conclusion, Rahman and Adeyemi contended that effective mathematics teaching must go beyond improving test scores to ensuring that learning endures and remains engaging. They advocated for a deliberate shift from teacher-centered instruction to

interactive and inquiry-driven pedagogies, noting that such approaches simultaneously promote retention, deepen understanding, and sustain students' interest in mathematics.

IMPLICATIONS OF THE STUDY FOR MATHEMATICS TEACHING

The synthesis of meta-analysis on teaching methods and their effects on students' academic achievement, retention, and interest in mathematics carries several profound implications for classroom practice, curriculum design, and teacher professional development.

This review demonstrates that effective mathematics teaching is not simply about the transmission of content but involves strategically engaging students in active, meaningful, and culturally relevant learning experiences. The implications of these study and empirical reviews span pedagogical approaches, instructional planning, assessment strategies, and broader educational policies.

First, the study underscores the necessity of adopting student-centered instructional approaches. Evidence from Rahman and Adeyemi (2025) and Oribhabor (2020) suggests that methods such as activity-based learning, collaborative problem-solving, and inquiry-driven instruction significantly enhance both achievement and retention. Similarly, Hattie (2018) and Freeman et al. (2021) emphasize that students learn more effectively when they are cognitively active and socially engaged. In practical terms, this means that mathematics teachers should design lessons that move beyond rote memorization and procedural repetition. Lessons should involve interactive problem-solving, real-world applications, and peer collaboration, which not only deepen understanding but also cultivate long-term retention of mathematical concepts. Such approaches also encourage the development of higher-order thinking skills, including analysis, synthesis, and application, which are critical in contemporary mathematics education.

Second, teaching methods must actively promote student interest and motivation. As evidenced by Sulistyowati (2024) and Boaler (2019), interest in mathematics is a key driver of engagement, achievement, and retention. Students are more likely to internalize and retain knowledge when learning experiences are relevant, meaningful, and stimulating. For teachers, this implies the need to incorporate contextualized examples, culturally responsive pedagogy, and inquiry-based activities into mathematics instruction. Ethnomathematics, for instance, demonstrates that integrating students' cultural backgrounds and experiences into lessons increases both relevance and engagement. Similarly, Strohmaier et al. (2026) highlight the potential of technology-mediated instruction, such as adaptive learning systems, to personalize learning and maintain students' curiosity and motivation. Mathematics educators are therefore encouraged to blend traditional methods with innovative, interactive approaches that cultivate sustained interest and intrinsic motivation.

Third, the study highlights the importance of retention as a central educational outcome. Traditional lecture methods often lead to temporary performance gains but fail to promote durable understanding (Hodgen & Wiliam, 2019; Rahman & Adeyemi, 2025). Retention is strengthened when students actively reconstruct knowledge through repeated application, reflection, and discussion. Mathematics teachers should therefore emphasize repetitive engagement with core concepts, scaffolding instruction in ways that require students to apply their understanding to diverse contexts. For example, problem-based learning allows learners to revisit concepts in multiple scenarios, promoting deeper conceptual understanding and memory consolidation. Similarly, formative assessments and immediate feedback, as discussed by Hattie (2018), provide opportunities for learners to correct misconceptions, reinforce understanding, and retain knowledge over time.

Fourth, the findings have implications for professional development and teacher training. Teachers' instructional choices are heavily influenced by their knowledge, beliefs, and training. Li and Ma (2018) and Freeman et al. (2021) argue that professional development programs should equip mathematics teachers with strategies to implement evidence-based, active learning approaches. Training should focus not only on pedagogical content knowledge but also on the integration of technology, collaborative methods, and culturally responsive strategies. By enhancing teachers' capacity to design and facilitate engaging and meaningful lessons, professional development contributes directly to improvements in achievement, retention, and interest.

Fifth, assessment strategies should align with instructional methods to reinforce desired outcomes. Traditional assessments often prioritize recall and procedural fluency over deep understanding, engagement, or interest. As suggested by Boaler (2019) and Knogler (2022), assessments that incorporate problem-solving, application, and project-based tasks can reinforce active learning and motivate students to engage more deeply with the material. Formative assessments, continuous feedback, and opportunities for self-reflection are particularly effective in promoting retention and sustaining interest.

Sixth, curriculum design should integrate diverse instructional strategies to address all three outcomes simultaneously. Evidence from the reviewed meta-analyses indicates that no single method suffices to improve achievement, retention, and interest collectively (Knogler, 2022; Strohmaier et al., 2026). Curriculum developers should therefore ensure that mathematics curricula provide flexibility for teachers to employ blended strategies, combining lecture, activity-based learning, inquiry, collaboration, and technology-supported interventions.

Seventh, policy and school-level support are critical to the successful implementation of these instructional strategies. The effectiveness of teaching methods is influenced not only by individual teacher practices but also by classroom environment, resources, and institutional support. Educational policymakers should prioritize the provision of appropriate teaching materials, professional development opportunities, and access to technology. Additionally, class sizes, scheduling, and instructional time allocation should be structured to facilitate interactive, collaborative, and activity-based learning.

Finally, supportive policies and resources are essential to sustain these practices. By addressing achievement, retention, and interest collectively, mathematics educators can create holistic learning environments that foster durable knowledge, motivation, and positive attitudes towards mathematics.

CONCLUSION

This study examined, from a meta-analytic and opinion-oriented perspective, the effects of teaching methods on students' academic achievement, retention, and achievements in mathematics. Drawing on a broad range of contemporary scholarly works and reflective meta-analyses, the discussion has consistently pointed to one central reality: the effectiveness of mathematics education is deeply rooted in the nature and quality of instructional practices. Across the arguments advanced in this paper, it became evident that how mathematics is taught is as important as, if not more important than, what is taught.

A critical observation emerging from this study is the inadequacy of traditional, teacher-dominated instructional approaches in addressing the complex demands of modern mathematics learning. While such methods may still produce short-term gains in achievement, they often fall short in promoting long-term retention and sustained student interest. Mathematics, by its very nature, requires not only procedural fluency but also

conceptual understanding, critical thinking, and the ability to apply knowledge in unfamiliar contexts.

In contrast, the study has shown that learner-centered teaching methods such as activity-based instruction, collaborative learning, inquiry-oriented approaches, and technology-supported strategies offer more promising pathways for improving learning outcomes. These approaches create opportunities for students to construct knowledge, test ideas, and engage in reflective thinking. As a result, they contribute not only to improved academic achievement but also to stronger retention of knowledge and a more positive disposition towards mathematics.

Another important insight from this work is the interconnectedness of the three key variables under consideration: achievement, retention, and performance (interest). These variables do not operate in isolation; rather, they reinforce one another in significant ways. Improved teaching methods that enhance understanding tend to support retention, while increased interest fosters motivation, persistence, and ultimately better performance. This interconnected relationship underscores the need for a holistic approach to mathematics teaching, one that simultaneously addresses cognitive development, memory consolidation, and learner motivation.

The implications of this meta-analytic study are far-reaching. For classroom teachers, the study calls for a deliberate re-examination of instructional practices, with a view to adopting methods that prioritize student engagement and meaningful learning. For curriculum designers, it highlights the need to develop frameworks that allow for flexibility, interaction, and contextual relevance. For policymakers, it underscores the importance of investing in teacher training, instructional resources, and supportive learning environments that facilitate the effective implementation of innovative teaching methods.

It demands a fundamental shift towards teaching methods that are dynamic, inclusive, and responsive to learners' needs. Mathematics education must move beyond routine instruction to embrace approaches that inspire curiosity, deepen understanding, and promote lasting learning.

SUGGESTIONS

The following suggestions were made based on the findings of the meta-analyisis review.

1. Adopt Student-Centered and Active Learning Approaches:

Mathematics teachers are encouraged to shift from traditional lecture-based instruction to student-centered pedagogies, such as activity-based learning, problem-solving, collaborative learning, and inquiry-based approaches. These methods foster deeper understanding, retention, and interest in mathematics by engaging students cognitively and socially.

2. Integrate Culturally Responsive and Contextualized Instruction

Teachers should incorporate students' cultural backgrounds and everyday experiences into mathematics lessons. Approaches such as ethnomathematics or context-based learning make mathematical concepts meaningful and relatable, enhancing motivation, retention, and engagement.

3. Leverage Technology and Adaptive Learning Tools

Educators should utilize technology, including AI-assisted instructional platforms and interactive simulations, to personalize learning and provide immediate feedback. Such

methods support achievement, strengthen retention, and sustain interest by making learning interactive and responsive to individual learners' needs.

4. Emphasize Formative Assessment and Feedback

Ongoing assessment and timely feedback are crucial for monitoring understanding and correcting misconceptions. Mathematics teachers should adopt strategies such as quizzes, peer-assessment, reflective journals, and digital formative tools to reinforce learning, improve retention, and guide instructional adjustments.

5. Enhance Professional Development and Teacher Training

Policymakers and educational institutions should invest in training programs that equip teachers with knowledge of evidence-based teaching methods, active learning strategies, and technology integration. Continuing professional development ensures that teachers can implement instructional approaches that simultaneously enhance achievement, retention, and interest.

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