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Behaviorism, Cognitivism, and Constructivism: Implications for Mathematics Learning

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Abstract

This study critically examines the complementary contributions of behaviorism, cognitivism, and constructivism to mathematics learning through an integrative literature review using a qualitative-conceptual approach. The analysis focused on four dimensions: theoretical foundations, learning mechanisms, pedagogical implications, and empirical support in mathematics education. The synthesis reveals fundamental differences in how the three perspectives conceptualize learning and knowledge formation. Behaviorism explains learning through observable behavioral change shaped by stimulus–response relations, practice, reinforcement, and feedback, making it particularly relevant to procedural accuracy and fluency. Cognitivism emphasizes mental processing, prior knowledge, information organization, conceptual formation, representation, and knowledge reorganization, offering a stronger account of conceptual understanding and strategic thinking. Constructivism emphasizes the construction and reconstruction of meaning through experience, exploration, interaction, negotiation, and reflection. The findings indicate that no single perspective sufficiently explains the multidimensional character of mathematics learning. Their pedagogical integration should therefore be selective and function-based rather than eclectic, aligning theoretical principles with learning objectives, mathematical knowledge, task demands, and cognitive processes. This study contributes a critical conceptual synthesis positioning the three theories as functionally differentiated yet complementary foundations for mathematics instruction that connects procedural fluency, conceptual understanding, reasoning, representation, and adaptive problem solving.

Keyword: Behaviorism; Cognitivism; Constructivism; Mathematics Learning; Integrative Literature Review

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INTRODUCTION

Mathematics learning is a complex process that extends beyond obtaining correct answers to encompass conceptual understanding, procedural fluency, reasoning, representation, problem solving, and knowledge transfer. This complexity makes the question of how learning occurs fundamental to instructional design. Learning theories provide conceptual frameworks for explaining changes in learners' knowledge and behavior, the organization of knowledge, and the conditions that facilitate learning. Among the major perspectives, behaviorism, cognitivism, and constructivism offer contrasting explanations of how learning occurs, how knowledge develops, and how instructional environments should be designed (Ertmer &

Newby, 2013; Muhajirah, 2020). Consequently, decisions concerning learning objectives, instructional activities, teacher–student interaction, pedagogical strategies, and assessment reflect underlying assumptions about the nature of learning and knowledge development.

Behaviorism, cognitivism, and constructivism provide distinct accounts of these processes. Behaviorism conceptualizes learning primarily as observable behavioral change resulting from relationships among environmental stimuli, responses, and consequences. Practice, reinforcement, feedback, and systematic instructional conditions are therefore central to establishing and strengthening desired responses (Azima et al., 2024; Hamidah & Supriyanto, 2024; Ertmer & Newby, 2013). Cognitivism shifts attention toward internal mental processes through which learners receive, process, organize, store, retrieve, and use information. Learning is consequently understood as the development and reorganization of knowledge structures rather than merely the production of observable responses (Malik, 2021; Saputri et al., 2024; Ertmer & Newby, 2013). Constructivism, in contrast, views learning as an active process through which learners construct and reconstruct knowledge by connecting new experiences with prior knowledge, interpreting situations, and developing meaning through interaction and reflection (Cobb, 1994; Bergen & Parsell, 2019; Nurhuda et al., 2023). These differences represent contrasting assumptions about the locus of learning, the nature of knowledge, the mechanisms through which understanding changes, and the roles of teachers and learners.

These theoretical distinctions have important consequences for mathematics education. From a behaviorist perspective, systematic practice, reinforcement, and feedback can support foundational mathematical skills and procedural performance (Azima et al., 2024; Hamidah & Supriyanto, 2024). However, mathematics learning also requires learners to coordinate concepts, representations, reasoning, and problem-solving strategies, dimensions that extend beyond observable performance. Research on mathematical representation demonstrates that students use and transform representations when addressing complex problem-solving tasks (Adeyemi et al., 2025), while differentiated learning highlights the importance of addressing differences in students' representation skills (Lin et al., 2025). Cognitivism provides a stronger explanation of such processes by emphasizing how learners organize and integrate new information within existing knowledge structures to develop conceptual understanding (Malik, 2021; Saputri et al., 2024). Constructivism further emphasizes the active construction of mathematical meaning through experience, interpretation, interaction, exploration, and problem-oriented activity, making it particularly relevant to mathematics learning that requires students to explain, justify, and reorganize mathematical ideas (Cobb, 1994; Oppong-Gyebi et al., 2023).

The multidimensional character of mathematics learning suggests that no single theoretical perspective can adequately explain all learning activities. Foundational skills may benefit from systematic practice and feedback; conceptual development requires meaningful organization and integration of knowledge; whereas reasoning and problem solving involve interpretation, representation, exploration, reflection, and strategic adaptation. Mathematics teaching therefore requires consideration of the correspondence between particular learning mechanisms and targeted competencies. A review of mathematics teaching pedagogies similarly indicates that instructional approaches need to be considered in relation to learners, mathematical content, and intended learning outcomes (Albeshree et al., 2022). Thus, the value of behaviorism, cognitivism, and constructivism should not be determined by asking which theory is universally superior, but by examining what each perspective explains effectively, where its explanatory boundaries lie, and under what instructional conditions its principles are most appropriate.

Existing literature demonstrates the continuing relevance of these perspectives, but their contributions are often discussed separately. Comparative studies provide a general basis for distinguishing behaviorist, cognitive, and constructivist assumptions and their implications for instructional design (Ertmer & Newby, 2013; Muhajirah, 2020; Mahbub & Beedle, 2025). Research on behaviorism emphasizes stimulus–response relationships, reinforcement, and educational applications (Azima et al., 2024; Hamidah & Supriyanto, 2024), whereas cognitive studies highlight concept formation and knowledge organization (Malik, 2021; Saputri et al., 2024). Constructivist scholarship, particularly in mathematics education, emphasizes active knowledge construction and the experiential, interpretive, and social dimensions of mathematical development (Cobb, 1994; Bergen & Parsell, 2019; Oppong-Gyebi et al., 2023). Research on mathematical representations and contemporary instructional design further illustrates the importance of how students organize, represent, and apply mathematical knowledge (Adeyemi et al., 2025; Lin et al., 2025; Fatqurhohman et al., 2025). Nevertheless, limited attention has been given to an integrated analysis connecting the theoretical assumptions of the three perspectives with their differentiated pedagogical consequences for mathematics learning.

This gap calls for an integrative examination that moves beyond listing similarities and differences toward a theoretically grounded synthesis. This study therefore employs an *integrative literature review* with a qualitative-conceptual approach to analyze, compare, and synthesize literature on behaviorism, cognitivism, and constructivism and their implications for mathematics education. The analysis focuses on the nature of learning, mechanisms of learning and knowledge formation, teacher and learner roles, pedagogical implications, and explanatory

boundaries. The synthesis aims to establish a critical and functionally differentiated account of the contributions and limitations of each perspective while clarifying the conditions under which their principles may be appropriately employed to address the multidimensional demands of mathematics learning.

METHOD

This study employed an *integrative literature review* with a qualitative-conceptual approach to analyze, compare, and synthesize behaviorism, cognitivism, and constructivism in the context of mathematics education. An integrative review was selected because it enables theoretical perspectives and empirical findings from diverse sources to be brought into dialogue, facilitating a comprehensive interpretation of a phenomenon and the development of conceptual insights from relationships across the literature (Ertmer & Newby, 2013; Rasouli et al., 2025). The review was not intended to estimate the empirical effectiveness of any particular theory; rather, it examined how differences in theoretical assumptions shape distinct accounts of learning and their pedagogical implications for mathematics education.

The literature comprised scholarly articles and academic books addressing behaviorism, cognitivism, constructivism, and their applications to teaching and learning, with priority given to sources directly relevant to mathematics education. Sources were purposively selected according to four criteria: relevance to the review focus, clarity of theoretical contribution, connection to pedagogical practice, and source credibility. General theoretical works were used to establish the conceptual foundations of each perspective, whereas studies examining theory-informed mathematics instruction were used to substantiate pedagogical interpretations and applications (Ertmer & Newby, 2013; Albeshree et al., 2022).

The analysis proceeded through three interconnected stages. First, theoretical mapping identified each perspective's foundational assumptions, conception of knowledge, learning mechanisms, and roles of teachers and learners. Second, comparative analysis examined differences in how the three perspectives account for mathematical understanding, learning activities, instructional strategies, feedback, and assessment. Third, conceptual synthesis related the distinctive contributions of each perspective to the demands of mathematics learning, particularly procedural practice and reinforcement, information processing and conceptual organization, and exploration, problem solving, and knowledge construction (Ertmer & Newby, 2013; Cobb, 1994). The synthesis further examined the explanatory scope, pedagogical contribution, and theoretical limitations of each perspective, identifying the conditions under which particular principles are most appropriate. The resulting synthesis positions behaviorism, cognitivism, and constructivism not as interchangeable theories or competing hierarchies, but

as functionally differentiated perspectives whose selective integration can address complementary dimensions of mathematics learning.

RESULTS AND DISCUSSION

The *integrative literature review* was structured through a comparative analysis of behaviorism, cognitivism, and constructivism using four consistent analytical dimensions: theoretical foundations, learning mechanisms, pedagogical implications, and implications and empirical support for mathematics education. This framework treats each theory as a distinct explanatory perspective defined by particular epistemological assumptions and accounts of how learning changes. The analysis therefore traces how conceptions of learning translate into pedagogical principles and instructional practices rather than treating the three theories as competing paradigms arranged hierarchically. Each perspective is examined systematically to identify its conceptual contribution, explanatory scope, pedagogical relevance, and theoretical limitations in mathematics education. The analysis then moves beyond isolated comparison toward an integrative synthesis, examining how the three perspectives can function complementarily and selectively in relation to different forms of mathematical knowledge, learning processes, and instructional purposes. This synthesis provides a more differentiated account of their respective roles and establishes a conceptual basis for determining when particular theoretical principles are pedagogically warranted.

Behaviorism Theory

Behaviorism conceptualizes learning as an observable change in behavior arising from the interaction of stimuli, responses, and environmental consequences (Azima et al., 2024; Ertmer & Newby, 2013). Knowledge acquires functional significance when its mastery is manifested in accurate and consistent performance. Learning therefore involves relatively stable modification of behavior through experience, practice, reinforcement, and feedback (Azima et al., 2024; Hamidah & Supriyanto, 2024). Within this framework, the learner's performance is shaped through systematically arranged environmental conditions, while the teacher structures stimuli, sequences practice, monitors responses, and provides reinforcement and corrective feedback (Hamidah & Supriyanto, 2024). The central explanatory strength of behaviorism lies in its capacity to account for the formation, stabilization, and measurement of observable performance. Its analytical limitation emerges when learning involves processes that cannot be adequately inferred from behavioral change alone, such as meaning construction, conceptual reasoning, and knowledge reorganization (Ertmer & Newby, 2013).

The learning mechanism is centered on the systematic formation and modification of stimulus–response relations through practice and consequences. Stimuli establish conditions

for eliciting targeted responses, whereas consequences influence whether particular responses are maintained, strengthened, modified, or reduced (Azima et al., 2024). Repeated practice increases opportunities to produce the targeted response, while reinforcement raises the likelihood of its recurrence when performance meets specified criteria (Azima et al., 2024). Feedback provides information about response accuracy and supports immediate adjustment, making the learning process structured and observable. This mechanism is particularly applicable to skills requiring accuracy, consistency, and fluency, including routine mathematical procedures (Hamidah & Supriyanto, 2024). Yet increased response frequency or accuracy should not be equated with conceptual understanding. A correct procedure may be reproduced without understanding its underlying rationale, mathematical relations, or conditions of application (Ertmer & Newby, 2013). Behaviorism therefore explains behavioral stabilization effectively, but its explanatory reach becomes narrower as learning demands greater conceptual depth and transfer.

Pedagogically, behaviorism emphasizes deliberate environmental design to establish clearly specified learning targets and observable performance criteria. Teachers sequence tasks from simpler to more complex responses, provide repeated opportunities for practice, monitor performance, and deliver timely reinforcement or corrective feedback (Hamidah & Supriyanto, 2024). Learning activities consequently favor structured practice, rehearsal, and mastery of procedures, while assessment emphasizes accuracy, consistency, and attainment of predetermined performance standards (Ertmer & Newby, 2013). In mathematics education, this orientation is particularly useful for developing computational fluency, factual knowledge, algorithmic procedures, and other foundational skills that benefit from repeated practice and immediate feedback (Hamidah & Supriyanto, 2024). Such fluency can reduce the cognitive demands associated with basic operations and create a more efficient foundation for subsequent mathematical activity.

The critical limitation lies in the distinction between procedural performance and mathematical understanding. Accurate execution does not necessarily indicate an ability to explain why a procedure works, recognize relationships among concepts, select an appropriate strategy, or transfer knowledge when the structure of a problem changes (Ertmer & Newby, 2013). Excessive reliance on repetition and reinforcement may therefore narrow mathematical competence to reproducible performance while leaving reasoning, conceptual connections, and strategic flexibility underdeveloped. Behaviorism is consequently best positioned as a functional foundation for procedural fluency rather than a comprehensive account of mathematical learning. Its pedagogical value is strongest when observable accuracy, consistency, and automatization constitute legitimate learning goals; its limitations become

decisive when mathematics requires explanation, representation, reasoning, problem solving, and adaptive transfer.

Cognitive Theory

Cognitivism conceptualizes learning as a transformation of cognitive processes and knowledge structures through attending to, interpreting, organizing, storing, and using information. Its central concern is not observable behavior alone, but the mental mechanisms through which new information is connected to prior knowledge and transformed into meaningful understanding (Malik, 2021; Ertmer & Newby, 2013). Knowledge is therefore understood as an organized and evolving structure of concepts, relationships, and representations rather than an accumulation of isolated facts. Concept formation is central because the meaning of new information depends on its integration with existing knowledge structures. Learning becomes evident when individuals can establish relationships, reorganize knowledge, and apply concepts across relevant situations (Saputri et al., 2024; Malik, 2021). Consistent with this orientation, cognitive perspectives highlight learning and development as changes in how experience and knowledge are organized (Ertmer & Newby, 2013). The core proposition of cognitivism is that learning involves the qualitative transformation of knowledge structures, enabling increasingly coherent, organized, and adaptable understanding.

The mechanism of cognitive learning involves active information processing in which new information is attended to, interpreted, connected with prior knowledge, and integrated into increasingly coherent cognitive structures. Prior knowledge functions as an interpretive framework that shapes how information is categorized, related, and understood rather than processed independently of existing knowledge (Saputri et al., 2024; Malik, 2021). Information organization establishes relationships among concepts, while concept formation and reorganization represent qualitative changes in knowledge structure rather than simple increases in information quantity. From a cognitive perspective, changes in knowledge structures also influence how experience is organized and understood (Ertmer & Newby, 2013). This mechanism highlights the importance of activating prior knowledge, elaborating conceptual relationships, organizing information, and restructuring misconceptions. Learning is therefore not adequately characterized by information acquisition; its critical outcome is the development of an organized and flexible knowledge structure capable of interpreting and responding to new situations.

Pedagogically, cognitivism positions the teacher as an organizer of learning conditions who activates relevant prior knowledge, structures information, and facilitates connections among ideas (Malik, 2021; Saputri et al., 2024). Instruction should therefore move beyond

eliciting correct answers toward activities that require elaboration, concept formation, representational coordination, explanation, and strategic reasoning. Instructional materials and multiple representations can support this process by organizing information and making conceptual relationships more accessible (Ertmer & Newby, 2013). Feedback is most productive when it provides information that enables learners to evaluate their reasoning and revise knowledge structures rather than merely indicating whether an answer is correct. Assessment should likewise capture cognitive quality through explaining relationships, interpreting representations, applying concepts, and transferring understanding across contexts. The pedagogical significance of cognitivism therefore lies in shifting attention from answer accuracy alone to the quality, organization, and adaptability of the knowledge structures underlying mathematical performance.

In mathematics education, this perspective provides a strong framework for understanding learning as the organization of concepts, relationships, representations, and problem-solving strategies. Prior knowledge shapes the interpretation of new mathematical information, while conceptual formation and knowledge reorganization support increasingly integrated mathematical understanding (Saputri et al., 2024; Malik, 2021). Instructional materials can facilitate this process by providing representations and structured learning experiences that help organize mathematical relationships. Mathematical representations are particularly important because they enable information to be organized, interpreted, and transformed while strategies are developed and refined (Lin et al., 2025; Adeyemi et al., 2025). Evidence from complex problem-solving tasks further underscores the role of representation in making mathematical thinking and reasoning visible (Adeyemi et al., 2025). The central implication is that mathematics instruction should develop the capacity to organize knowledge, coordinate representations, construct concepts, select strategies, and transfer understanding across problem situations, rather than merely increase procedural performance.

Constructivist Theory

Constructivism conceptualizes learning as an active process of constructing and reconstructing knowledge through the interpretation of experience and the reorganization of existing understanding. Knowledge is not treated as an object that can be transmitted directly from teacher to learner; rather, it is constructed as individuals interpret new experiences in relation to prior knowledge and the contexts in which learning occurs (Cobb, 1994; Bergen & Parsell, 2019). Experience provides a basis for transforming existing understanding, while reflection enables learners to examine and adjust relationships between prior conceptions and new experiences (Cobb, 1994). Knowledge construction also has an inherently social

dimension, as interaction with teachers, peers, and the learning environment creates opportunities to compare perspectives and negotiate meaning (Bergen & Parsell, 2019). Pedagogically, this positions the teacher as a designer of learning experiences and facilitator who provides productive questions, appropriate support, and conditions for exploration and reconstruction (Nurhuda et al., 2023). The central premise of constructivism is therefore that learning is evidenced by the transformation of understanding through meaning construction, rather than by the passive acquisition of transmitted information.

The constructivist mechanism of learning involves exploration, interpretation, examination of existing understandings, and knowledge reconstruction when new experiences challenge established conceptions. Discrepancies between prior knowledge and new experiences can generate cognitive conflict, prompting the reconsideration of assumptions, relationships, and meanings that were previously regarded as adequate (Cobb, 1994). Knowledge construction extends beyond individual discovery through social processes of discussion and meaning negotiation, in which alternative interpretations and strategies are examined and refined (Bergen & Parsell, 2019). The teacher therefore provides strategic scaffolding rather than simply withdrawing instructional guidance, designing tasks and questions that make productive cognitive engagement possible (Nurhuda et al., 2023). This distinction is theoretically important: learner activity alone does not constitute constructivist learning. What matters is whether activity generates conceptual examination, meaningful interpretation, and reconstruction of knowledge.

In pedagogical practice, constructivism emphasizes learning environments in which learners investigate problems, formulate conjectures, compare strategies, articulate reasoning, and reflect on emerging understandings. Feedback functions not merely to indicate correctness but to stimulate evaluation and revision of mathematical thinking, while assessment can attend to reasoning, representations, strategies, argumentation, application, and the quality of constructed solutions rather than relying exclusively on final answers. In mathematics education, this orientation supports instructional designs that connect prior knowledge with new mathematical experiences through problem solving, multiple representations, discussion, and reflection (Cobb, 1994; Oppong-Gyebi et al., 2023). Constructivist instructional approaches in junior high school mathematics further illustrate the relevance of active and knowledge-construction-oriented practices in mathematical classroom teaching (Oppong-Gyebi et al., 2023). The pedagogical value, however, lies not in the technology itself but in how learning environments structure opportunities to investigate relationships, test conjectures, and reconstruct mathematical understanding.

Constructivism should not be equated with unguided learning or unrestricted discovery. Exploration without conceptual direction, productive questioning, feedback, or scaffolding may generate substantial activity without producing corresponding advances in mathematical understanding. Teacher guidance remains essential for selecting cognitively productive problems, sequencing experiences, directing attention toward significant mathematical relationships, and facilitating discussion across different strategies and interpretations (Nurhuda et al., 2023; Oppong-Gyebi et al., 2023). The critical strength of constructivism therefore lies not in maximizing learner activity, but in designing experiences through which activity becomes intellectually productive. Its pedagogical effectiveness depends on whether exploration is connected to prior knowledge, representation, reasoning, interaction, and reflection in ways that support substantive reconstruction of mathematical understanding.

Integrative Synthesis of the Three Perspectives in Mathematics Learning

The synthesis of the three perspectives indicates that behaviorism, cognitivism, and constructivism rest on distinct epistemological assumptions and explanatory emphases concerning the nature of learning, the sources of learning change, and the formation of knowledge (Mahbub & Beedle, 2025; Akhigbe, 2019). Behaviorism primarily explains learning through changes in responses shaped by stimuli, practice, consequences, and reinforcement; cognitivism focuses on information processing, the organization of knowledge structures, and concept formation; whereas constructivism explains learning change through the interpretation of experience, interaction, and the construction or reconstruction of meaning (Mahbub & Beedle, 2025; Kara, 2018). These distinctions should not be interpreted as a theoretical hierarchy from an older to a more recent perspective, but as differences in units of analysis and mechanisms of learning change. Behaviorism primarily accounts for the conditions that shape performance, cognitivism explains how information is transformed and organized within cognitive structures, and constructivism addresses how meaning is developed through experience and interaction. This distinction is particularly important in mathematics learning because mathematical competence encompasses not only procedural accuracy but also conceptual understanding, representation, strategic thinking, reasoning, and mathematical meaning-making.

Table 1. Comparative and Integrative Analysis of Behaviorism, Cognitivism, and Constructivism in Mathematics Learning

Analytical Dimension	Behaviorism	Cognitivism	Constructivism	Integrative Synthesis
Nature of Learning and Knowledge	Learning is reflected in observable changes in behavior or performance resulting from interaction with the environment; knowledge is manifested through observable responses.	Learning involves changes in cognitive processes and structures; knowledge is organized and developed through information processing.	Learning involves the construction and reconstruction of meaning through experience, prior knowledge, and interaction.	Learning encompasses changes in performance, development of knowledge structures, and construction of meaning as interconnected dimensions.
Mechanisms of Learning Change	Stimulus–response associations, practice, consequences, reinforcement, and feedback.	Information processing, activation of prior knowledge, information organization, concept formation, and conceptual reorganization.	Exploration, interpretation, cognitive conflict, interaction, meaning negotiation, and knowledge reconstruction.	Learning mechanisms should be selected functionally according to the intended type of learning change rather than combined eclectically.
Focus in Mathematics Learning	Procedural accuracy, fluency, skill acquisition, and automatization.	Conceptual understanding, representations, relationships among concepts, strategic thinking, and problem solving.	Meaning making, exploration, reasoning, argumentation, connections, and contextual problem solving.	Mathematical competence requires the integration of procedural fluency, conceptual understanding, representation, reasoning, and meaning making.
Roles of Teacher and Learner	The teacher structures stimuli, practice, reinforcement, and feedback; the learner responds and develops patterns of performance.	The teacher organizes information and facilitates thinking processes; the learner processes, connects, and reorganizes knowledge.	The teacher designs learning experiences and provides scaffolding; the learner explores, interprets, interacts, and constructs meaning.	The teacher functions as an adaptive learning-environment designer, while the learner engages at performative, cognitive, and constructive levels according to task demands.
Explanatory Strengths and Boundaries	Strong for explaining the formation and reinforcement of skills; limited in	Strong for explaining information processing, concept	Strong for explaining experience, interaction, and meaning	No single theory adequately explains all dimensions of mathematics

	explaining complex understanding, reasoning, and meaning construction.	formation, representation, and strategy development; less comprehensive in accounting for social and contextual dimensions.	construction; exploration still requires instructional structure, scaffolding, and pedagogical facilitation.	learning; theoretical value depends on the appropriateness of its function and recognition of its explanatory boundaries.
Integrative Pedagogical Implication	Provides a performative foundation through practice, reinforcement, and feedback.	Provides a structural foundation through knowledge organization, conceptual development, and cognitive processing.	Provides an interpretive-constructive foundation through experience, exploration, interaction, and meaning making.	The three perspectives form a functional integrative framework in which performance, knowledge structures, and meaning construction are interconnected according to learning goals and the characteristics of mathematical tasks.

The synthesis reveals differentiated and complementary theoretical contributions rather than mutually exclusive positions. Behaviorism is most relevant when mathematics learning emphasizes procedural accuracy, fluency, and performance stabilization; cognitivism more effectively explains information processing, conceptual organization, representation, and strategic thinking; while constructivism foregrounds meaning making through experience, exploration, interaction, and knowledge reconstruction (Mahbub & Beedle, 2025; Kara, 2018). These emphases may operate within the same instructional environment. Interactive learning media, for example, can structure practice, feedback, and learner interaction, while differentiated learning and complex problem-solving tasks can support the organization and use of mathematical representations (Prastzuba et al., 2025; Lin et al., 2025; Adeyemi et al., 2025). Yet, neither technology nor instructional format constitutes evidence of a particular theoretical orientation. Its theoretical function depends on the learning goal, activity structure, interaction pattern, and pedagogical use. The same tool may support reinforcement, cognitive organization, or meaning construction depending on how it is designed and implemented.

The critical issue, therefore, concerns the explanatory boundaries of each perspective. Behaviorism explains response formation and procedural mastery but provides a more limited account of conceptual understanding and mathematical reasoning (Azima et al., 2024; Mahbub & Beedle, 2025). Cognitivism clarifies knowledge organization, concept formation, and

strategy development, while constructivism emphasizes meaning construction through experience and interaction (Malik, 2021; Bergen & Parsell, 2019). Nevertheless, mathematics teaching requires instructional approaches that correspond to learners, mathematical content, and intended learning outcomes rather than adherence to a single theoretical orientation (Albeshree et al., 2022). Integration should therefore be selective and functionally grounded, not eclectic. Procedural foundations may draw on practice and reinforcement, conceptual development on information organization and representation, and deeper reasoning on exploration and meaning negotiation. This synthesis positions the three theories as complementary analytical lenses, each contributing distinct explanatory resources to the multidimensional development of mathematical competence (Lin et al., 2025; Adeyemi et al., 2025).

CONCLUSION

This integrative literature review shows that behaviorism, cognitivism, and constructivism provide distinct but complementary explanations of mathematics learning. Behaviorism offers a strong basis for developing procedural accuracy, fluency, and automatization through structured practice, reinforcement, and feedback, but its explanatory scope is limited when learning requires conceptual understanding, reasoning, and transfer. Cognitivism more effectively explains how information is processed, organized, and integrated into conceptual structures, supporting representation, strategic thinking, and problem solving. Constructivism extends this account by emphasizing experience, exploration, interaction, negotiation of meaning, and reconstruction of knowledge. The synthesis indicates that these perspectives should not be arranged hierarchically or treated as mutually exclusive. Their pedagogical value depends on the correspondence between theoretical mechanisms, mathematical knowledge, learning objectives, task demands, and instructional conditions. An effective mathematics learning design therefore requires selective, function-based integration, rather than undifferentiated eclecticism.

This synthesis has practical implications for instructional design, teacher facilitation, and assessment. Procedural foundations may require deliberate practice and feedback, whereas conceptual and higher-order learning require opportunities for information organization, representation, exploration, justification, and reflection. Future research should move beyond theoretical comparison toward empirical investigation of how and when combinations of these principles operate across different mathematical topics, learner characteristics, task structures, and technological environments. Particular attention should be given to identifying instructional configurations that connect procedural fluency with conceptual understanding and adaptive

mathematical reasoning. Such research can strengthen the empirical basis for theoretically informed mathematics pedagogy while avoiding the assumption that any single learning theory can adequately account for the full complexity of mathematical learning.

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