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The Effect of a Deep Learning–Based Multisensory Approach on Primary School Students' Counting Skills*: A literature review*

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Abstract
Early mathematics learning is essential for developing elementary students' numeracy skills, yet rote-based instruction often limits conceptual understanding. Therefore, meaningful and active approaches such as multisensory learning within a deep learning framework are needed. This study aims to examine multisensory approaches in supporting deep learning-oriented early mathematics instruction through a narrative literature review of relevant sources published in the last ten years. Data were analyzed using thematic synthesis focusing on theoretical foundations, implementation strategies, and empirical findings. The results show that multisensory approaches enhance conceptual understanding, student engagement, and overall learning quality, while aligning with deep learning principles that emphasize meaningful and joyful learning. However, studies explicitly integrating both approaches in early mathematics remain limited. Thus, further development of integrative instructional models is recommended to support meaningful and sustainable mathematics learning.
Keywords*: multisensory approach,* deep learning*, early mathematics learning, literature review, numeracy*

Abstrak
Pembelajaran matematika dini sangat penting untuk mengembangkan keterampilan berhitung siswa sekolah dasar, namun pengajaran berbasis hafalan seringkali membatasi pemahaman konseptual. Oleh karena itu, pendekatan yang bermakna dan aktif seperti pembelajaran multisensori dalam kerangka pembelajaran mendalam sangat dibutuhkan. Studi ini bertujuan untuk meneliti pendekatan multisensori dalam mendukung pengajaran matematika dini yang berorientasi pada pembelajaran mendalam melalui tinjauan literatur naratif dari sumber-sumber relevan yang diterbitkan dalam sepuluh tahun terakhir. Data dianalisis menggunakan sintesis tematik yang berfokus pada landasan teoritis, strategi implementasi, dan temuan empiris. Hasil menunjukkan bahwa pendekatan multisensori meningkatkan pemahaman konseptual, keterlibatan siswa, dan kualitas pembelajaran secara keseluruhan, sekaligus selaras dengan prinsip-prinsip pembelajaran mendalam yang menekankan pembelajaran yang bermakna dan menyenangkan. Namun, studi yang secara eksplisit mengintegrasikan kedua pendekatan tersebut dalam matematika dini masih terbatas. Dengan demikian, pengembangan lebih lanjut model pengajaran integratif direkomendasikan untuk mendukung pembelajaran matematika yang bermakna dan berkelanjutan.
Kata Kunci: Pembelajaran multisensori, *deep learning*, matematika awal, sekolah dasar

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INTRODUCTION

Primary education plays a strategic role in developing students' numeracy skills as a fundamental foundation for academic success at higher levels of education. At the early stage of formal schooling, particularly in early mathematics learning, counting ability serves as a basic skill that supports cognitive development and facilitates the understanding of more complex mathematical concepts. However, various studies indicate that mathematics learning in primary schools still faces persistent challenges, especially in helping students develop a meaningful and contextual understanding of number concepts.

Early mathematics instruction often remains oriented toward procedural practice and memorization. As a result, students may be able to solve problems mechanically, yet encounter difficulties when required to connect mathematical concepts with real-life situations. This condition suggests that the learning process has not fully encouraged deep conceptual understanding. Therefore, there is a need for instructional approaches that focus not only on learning outcomes but also on students' thinking processes and meaningful learning experiences.

One approach that aligns with this need is the deep learning approach in education. This approach emphasizes learning that is mindful, meaningful, and joyful, enabling students to actively construct knowledge through connections among concepts and reflection on learning experiences (Feriyanto & Anjariyah, 2024). In the context of early mathematics learning, deep learning is particularly important because understanding number concepts and basic operations requires a process of internalizing meaning that cannot be achieved through rote memorization alone.

Nevertheless, implementing deep learning-oriented instruction requires strategies that are appropriate to the characteristics of primary school learners. One approach considered capable of supporting this process is the multisensory approach. Multisensory learning involves the simultaneous use of multiple sensory modalities—visual, auditory, kinesthetic, and tactile—during instructional activities (Baines, 2008). Engaging multiple senses in learning is believed to strengthen information-processing pathways and support students in developing a deeper understanding of concepts (Ritchey & Goeke, 2006).

Theoretically, the effectiveness of multisensory learning can be explained through dual coding theory, which states that information processed through both verbal and visual channels simultaneously is more easily understood and retained (Clark & Paivio, 1991). In early mathematics learning, combining numerical symbols, visual representations, movement-based activities, and manipulation of concrete objects enables students to build strong connections between abstract concepts and real experiences. This is supported by research indicating that multisensory learning environments can enhance students' understanding of basic mathematical concepts through concrete and manipulative experiences (Cuturi et al., 2022).

Previous studies also demonstrate that multisensory approaches contribute positively to the quality of the learning process. This approach not only increases students' engagement and focus but also promotes more meaningful learning that is oriented toward conceptual understanding (Ameran & Zainal, 2024). However, most studies have examined multisensory approaches or deep learning-based instruction separately. Research that systematically integrates multisensory approaches within a deep learning framework, particularly in early mathematics instruction, remains relatively limited (Solichah & Fardana, 2024).

Based on this context, this literature review focuses on a conceptual and empirical examination of multisensory approaches within a deep learning framework in early mathematics learning. Through the synthesis of relevant theories and findings from previous research, this study aims to provide a comprehensive overview of how multisensory approaches can support meaningful mathematics learning, strengthen

conceptual understanding, and enhance the quality of learning experiences among primary school students. This review is expected to serve as a conceptual foundation for the development of more effective and adaptive instructional strategies in early mathematics education.

METHODS

This article employed a literature review approach to analyze and synthesize previous studies discussing multisensory approaches within a deep learning framework in early mathematics instruction. A literature review was selected because it enables researchers to obtain a comprehensive understanding of conceptual developments, theoretical foundations, and relevant empirical findings without conducting direct field data collection.

Review Approach

The approach used in this study was a narrative literature review. This type of review aims to systematically integrate and interpret findings from previous research through thematic analysis, thereby providing a holistic overview of the role of multisensory approaches in supporting deep learning-oriented early mathematics learning. A narrative review was chosen due to its flexibility in conceptually linking theories, research findings, and instructional contexts.

Data Sources and Review Materials

The data consisted of relevant literature sources related to the topic of the review, including reputable national and international journal articles, academic books, and conference proceedings addressing multisensory learning, deep learning, numeracy, and early mathematics education. The literature was retrieved from credible scientific databases and journal repositories, particularly those focusing on education, educational psychology, and learning technology.

The literature included in this review was limited to publications that were directly relevant to the topic, either in terms of conceptual discussion, instructional approaches, or empirical evidence. The references analyzed encompassed theoretical studies, empirical research findings, and prior reviews examining multisensory approaches and meaningful learning in primary education.

Data Collection Procedures

Data collection was conducted through a systematic literature search using keywords relevant to the review topic, such as *multisensory learning*, *deep learning*, *early mathematics*, and *elementary education*. The search process involved identifying titles, abstracts, and keywords to ensure alignment with the focus of the review.

The retrieved literature was then screened based on inclusion criteria: (1) addressing multisensory approaches or deep learning in an educational context, (2) being relevant to primary education or early mathematics learning, and (3) being published in credible and accountable academic sources. Literature that did not match the focus of the review or lacked direct relevance to the topic was excluded from the analysis.

Data Analysis Techniques

Data analysis was conducted through content analysis of the selected literature. Each source was examined to identify key concepts, instructional approaches applied, and major findings related to the implementation of multisensory approaches and deep learning. The results were then categorized into major themes, such as the theoretical foundations of multisensory learning, the characteristics of deep learning in primary education, and the implications of multisensory approaches for early mathematics instruction.

Subsequently, a synthesis process was carried out by comparing and integrating findings across studies to identify patterns, trends, and existing research gaps. This synthesis aimed to generate a comprehensive conceptual understanding of

how multisensory approaches can support meaningful early mathematics learning within a deep learning framework. The results of the analysis and synthesis are presented descriptively and analytically in the Results and Discussion section.

RESULTS AND DISCUSSION

Findings of the Literature Review

The results of the literature review over the past ten years indicate that the multisensory approach has been consistently reported as an effective instructional strategy for improving the quality of learning in primary education. This approach emphasizes the engagement of multiple sensory modalities visual, auditory, kinesthetic, and tactile allowing students to experience learning in a more concrete and meaningful way. These findings suggest that multisensory learning can bridge abstract concepts with students' real-life experiences (Carreker & Birsh, 2019).

In the context of early mathematics learning, multisensory approaches have been reported to contribute positively to students' understanding of foundational concepts, learning engagement, and thinking processes. Cuturi et al. (2022) demonstrated that multisensory learning environments in primary mathematics support students' conceptual understanding through manipulative activities and multimodal interaction. This approach enables learners not only to master procedures but also to grasp the underlying meaning of the mathematical concepts being learned.

Other studies emphasize that multisensory approaches support inclusive and adaptive learning by accommodating students' diverse learning characteristics. Busari et al. (2025) reported that multisensory instruction provides opportunities for students with different learning styles to actively participate in the learning process. This is particularly relevant in early mathematics learning, which often requires students to simultaneously develop symbolic and conceptual understanding.

In addition, multisensory approaches have also been associated with improved assessment quality and student engagement. Ameran and Zainal (2024) found that integrating multisensory elements into mathematics assessment enables students to express their understanding through multiple modalities, thereby offering a more comprehensive representation of their abilities. This reinforces the view that multisensory strategies function not only as instructional approaches but also as supportive frameworks for learning evaluation.

Thematic Synthesis of Research Findings

Based on the literature analysis, research findings from the last ten years can be synthesized into four main themes: (1) multisensory approaches as a foundation for meaningful learning, (2) multisensory implementation in primary education, (3) the relationship between multisensory approaches and deep learning, and (4) opportunities for developing multisensory approaches in early mathematics learning.

The first theme highlights that multisensory approaches support meaningful learning through concrete learning experiences. Faruq and Pratisti (2022) emphasized that multisensory instruction helps students develop more stable understanding by engaging multiple sensory channels simultaneously. This principle is particularly relevant to early mathematics learning, which requires deep understanding of number concepts.

The second theme concerns the implementation of multisensory approaches in primary education. Khaq et al. (2023) and Wijaya et al. (2023) reported that multisensory-based instruction can increase students' engagement and focus during learning activities. Although these studies were largely conducted within literacy domains, the multisensory learning principles applied remain highly relevant for early mathematics instruction.

The third theme demonstrates a strong relationship between multisensory approaches and deep learning. Feriyanto and Anjariyah (2024) explained that deep

learning emphasizes learning that is meaningful, mindful, and joyful. Multisensory approaches support these principles by creating active, reflective, and enjoyable learning experiences. These findings suggest that multisensory instruction can serve as a pedagogical strategy for implementing deep learning in primary education.

The fourth theme highlights opportunities for further development of multisensory approaches in early mathematics learning. Solichah and Fardana (2024) reported that research on multisensory programs has been dominated by literacy-focused studies, indicating that multisensory applications in numeracy learning still require further exploration. This is supported by Noreen et al. (2025), who found that multisensory approaches have significant potential to improve mathematics achievement in primary education.

Table 1. Summary of Studies on Multisensory Approaches (2019–2025)

No.	Author(s) and Year	Focus of Study	Key Findings
1	Carreker & Birsh (2019)	Multisensory learning	Multisensory instruction strengthens understanding and learning retention
2	Cuturi et al. (2022)	Multisensory mathematics	Multisensory environments enhance conceptual understanding in mathematics
3	Faruq & Pratisti (2022)	Multisensory and special needs	Multisensory approaches support meaningful learning
4	Khaq et al. (2023)	Multisensory in primary education	Multisensory instruction increases students' focus and engagement
5	Wijaya et al. (2023)	Multisensory and learning difficulties	Multisensory strategies are effective in improving basic skills
6	Feriyanto & Anjariyah (2024)	Deep learning	Meaningful and reflective learning improves learning quality
7	Ameran & Zainal (2024)	Multisensory assessment	Multisensory integration improves engagement and assessment accuracy
8	Solichah & Fardana (2024)	Scoping review on multisensory	Multisensory approaches have potential to be developed in numeracy learning
9	Busari et al. (2025)	Multisensory and inclusivity	Multisensory instruction supports adaptive and inclusive learning
10	Noreen et al. (2025)	Multisensory and mathematics	Multisensory approaches improve foundational mathematics achievement

Discussion

This literature review confirms that multisensory approaches play a strategic role in supporting deep learning-oriented early mathematics instruction. Based on the synthesis of studies over the past decade, multisensory learning should not be viewed merely as an alternative teaching method, but as a pedagogical strategy that strengthens conceptual understanding, increases engagement, and enhances the overall quality of learning experiences among primary school students.

Multisensory approaches enable learners to process mathematical concepts through multiple sensory pathways simultaneously. Carreker and Birsh (2019) explain that the involvement of visual, auditory, kinesthetic, and tactile modalities supports students in forming more stable mental representations of mathematical concepts. In early mathematics instruction, this is particularly crucial because number concepts and basic operations are abstract and often difficult to understand when presented only

through symbols. Multisensory learning provides students with concrete experiences that connect mathematical symbols to real quantities and actions, making learning more meaningful and reducing the likelihood of misconceptions.

Cuturi et al. (2022) further strengthen this argument by demonstrating that multisensory learning environments in primary mathematics facilitate conceptual understanding through manipulative activities and multimodal exploration. Students are not positioned as passive recipients of information; instead, they actively construct meaning through interaction with learning materials, movement-based activities, and visual representations. Such learning processes align with deep learning principles, which emphasize active participation, conceptual integration, and meaningful knowledge construction.

Beyond conceptual development, multisensory approaches contribute to improved engagement and motivation. Busari et al. (2025) highlight that multisensory learning supports inclusive and adaptive instruction by accommodating differences in students' learning preferences. In primary classrooms, diversity in learning readiness and cognitive development is a common challenge. Multisensory instruction provides multiple entry points for learners, allowing those with different strengths to engage optimally. This prevents learning from becoming uniform and rigid and promotes a more student-centered learning environment.

The alignment between multisensory approaches and deep learning is also evident in their shared emphasis on meaningful learning. Feriyanto and Anjariyah (2024) argue that deep learning requires instruction that is meaningful, mindful, and joyful. Multisensory approaches support these principles by creating learning experiences that involve emotions, physical activity, and direct interaction with learning objects. These experiences promote mindful attention, strengthen cognitive processing, and encourage joyful engagement, making multisensory instruction a practical strategy for implementing deep learning in primary mathematics education.

In the assessment context, multisensory approaches show significant potential. Ameran and Zainal (2024) found that multisensory integration in mathematics assessment enables students to demonstrate understanding through various modalities. This provides a more comprehensive representation of competence, especially for young learners who may struggle to express reasoning through written formats alone. Such findings indicate that multisensory approaches can support assessment practices that emphasize conceptual understanding and reasoning processes rather than focusing solely on final answers.

Although multisensory research over the past decade has largely focused on literacy domains, its principles remain applicable to early mathematics learning. Khaq et al. (2023) and Wijaya et al. (2023) found that multisensory approaches improve students' focus, engagement, and foundational skills. These outcomes suggest that multisensory strategies can also support numeracy learning by providing concrete and contextual experiences that strengthen conceptual understanding and skill development.

However, this review also reveals a significant research gap. Solichah and Fardana (2024) emphasize that multisensory studies have predominantly examined literacy interventions, while studies focusing on numeracy learning remain limited. This suggests that the integration of multisensory approaches within early mathematics instruction, especially under a deep learning framework, still offers substantial opportunities for further exploration and development.

The findings of Noreen et al. (2025) indicate that multisensory approaches have significant potential to enhance primary students' mathematics achievement. Nevertheless, their study remains partial and does not explicitly link multisensory instruction with deep learning principles. Therefore, future research should focus on developing systematic instructional models that integrate multisensory strategies with

deep learning principles. Such models may ensure that early mathematics instruction is not only effective in improving cognitive outcomes but also meaningful, inclusive, and sustainable.

Overall, the expanded evidence presented in this review highlights multisensory learning as a promising pedagogical strategy for strengthening deep learning-oriented early mathematics instruction. By improving conceptual understanding, engagement, motivation, inclusivity, and assessment quality, multisensory approaches offer valuable contributions to the development of effective primary mathematics education. At the same time, the limited number of studies explicitly integrating multisensory learning with deep learning frameworks highlights the need for further research and innovation in this field.

CONCLUSION

Based on the findings of the literature review over the past ten years, it can be concluded that multisensory approaches play a significant role in supporting meaningful and deep learning-oriented early mathematics instruction. This approach enables students to develop conceptual understanding through the engagement of multiple sensory modalities, allowing abstract mathematical concepts to be understood in a more concrete and contextual manner.

This review indicates that multisensory approaches contribute not only to improving conceptual understanding but also to enhancing students' engagement, motivation, and the overall quality of learning experiences in primary education. The integration of visual, auditory, kinesthetic, and tactile elements provides opportunities for learners with diverse characteristics and learning preferences to participate actively in the learning process. Therefore, multisensory instruction aligns with the principles of inclusive and student-centered learning.

Within a deep learning framework, multisensory approaches have been shown to support learning that is meaningful, mindful, and joyful. Learning experiences that involve multiple senses help students not only understand mathematical procedures but also construct meaning and connections among concepts. This reinforces the position of multisensory approaches as a relevant pedagogical strategy for implementing deep learning in early mathematics learning.

However, the review also reveals that research explicitly integrating multisensory approaches within a deep learning framework in early mathematics learning remains relatively limited. Most studies continue to focus on literacy-related domains or examine the two approaches separately. Therefore, this review highlights the opportunity to further develop research and instructional models that more systematically integrate multisensory approaches and deep learning in the context of primary school numeracy.

Overall, this literature review provides a conceptual foundation indicating that multisensory approaches have the potential to serve as an effective strategy for supporting meaningful and sustainable early mathematics learning. These findings are expected to inform the development of instructional practices and future research focusing on the integration of multisensory approaches and deep learning in primary education.

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