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Strategies, Successes, and Gaps in Algebra Teaching: A Scoping Review

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Abstract. Algebra is a fundamental component of mathematics education that supports students' success in higher-level mathematical learning. However, many students struggle to understand algebraic concepts due to their abstract nature and the limited use of effective instructional strategies. This scoping review aims to (1) identify how algebra teaching activities are represented in the literature, (2) explore the main instructional themes and approaches discussed, and (3) examine existing research gaps that require further study. A total of 143 studies published between 2015 and 2025 were retrieved from the Scopus database, and after a rigorous screening process, six studies met the inclusion criteria for full analysis. The review identified five dominant instructional themes: contextual problem-based learning, visual and concrete representations, technology-enhanced and game-based learning, collaborative discussions, and reflective reasoning. These approaches were found to enhance students' engagement, conceptual understanding, and algebraic reasoning. Nevertheless, significant gaps remain in early algebra instruction, teacher professional development, and the integration of emerging technologies in classroom practice. The findings underscore the need for innovative, inclusive, and technology-integrated teaching strategies to strengthen students' algebraic thinking and improve the quality of mathematics education.

Keywords: Algebra Instruction; Teacher Strategies; Mathematics Education; Scoping Review; Conceptual Understanding

Abstrak. Aljabar merupakan komponen fundamental dalam pendidikan matematika yang berperan penting dalam mendukung keberhasilan siswa pada pembelajaran matematika tingkat lanjut. Namun, banyak siswa mengalami kesulitan dalam memahami konsep-konsep aljabar karena sifatnya yang abstrak dan terbatasnya penerapan strategi pembelajaran yang efektif. Tinjauan cakupan (*scoping review*) ini bertujuan untuk (1) mengidentifikasi bagaimana aktivitas pembelajaran aljabar direpresentasikan dalam literatur, (2) mengeksplorasi tema dan pendekatan pembelajaran utama yang dikaji, serta (3) menelaah kesenjangan penelitian yang masih perlu dikembangkan lebih lanjut. Sebanyak 143 artikel yang diterbitkan antara tahun 2015 hingga 2025 ditelusuri dari basis data Scopus, dan setelah proses penyaringan yang ketat, enam artikel memenuhi kriteria inklusi untuk dianalisis secara menyeluruh. Hasil tinjauan mengidentifikasi lima tema utama dalam pembelajaran aljabar, yaitu pembelajaran kontekstual berbasis masalah, representasi visual dan konkret, pembelajaran berbasis teknologi dan permainan, diskusi kolaboratif, serta penalaran reflektif. Pendekatan-pendekatan tersebut terbukti dapat meningkatkan keterlibatan siswa, pemahaman konseptual, dan kemampuan bernalar aljabar. Namun demikian, masih terdapat kesenjangan penelitian terkait pembelajaran aljabar di tingkat dasar, pengembangan profesional guru, serta integrasi teknologi baru dalam pembelajaran. Temuan ini menegaskan perlunya strategi pembelajaran yang inovatif, inklusif, dan terintegrasi dengan teknologi untuk memperkuat kemampuan berpikir aljabar siswa dan meningkatkan kualitas pendidikan matematika.

Kata kunci: Instruksi Aljabar; Strategi Guru; Pendidikan Matematika; Tinjauan Cakupan; Pemahaman Konseptual

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INTRODUCTION

Algebra, a branch of mathematics that studies symbols and the rules for manipulating them, not only serves as a foundation for solving diverse mathematical problems but also develops logical and analytical thinking, supports real-life applications, and provides the groundwork for advanced mathematics such as calculus and statistics (Sun et al., 2023; Kieran, 2018). As Wulandari et al. (2023) note, learning algebra strengthens reasoning skills essential for tackling complex problems, while its applications extend to financial planning, engineering, and scientific research (Fairuzi & Liesdiani, 2023).

Beyond these practical benefits, algebra plays a key role in fostering abstract thinking. It involves not only arithmetic operations but also pattern recognition, problem-solving, and engagement with more complex mathematical structures (Blanton et al., 2018). However, many learners encounter persistent difficulties. These challenges often arise from the abstract nature of the subject and the limited variety of teaching approaches. Traditional methods that fail to account for different learning styles—such as visual, kinesthetic, or collaborative preferences—can reduce both comprehension and motivation (Sibgatullin et al., 2018; Fitria et al., 2023; Mathaba et al., 2024). As Syarah et al. (2023) highlight, students frequently struggle with interpreting problem statements, identifying variables, coefficients, and constants, as well as performing algebraic operations. Such difficulties are often linked to teacher-centered instruction that lacks interactivity and real-world connections, underscoring the need for more effective strategies and engaging learning media (Sibgatullin et al., 2018; Fitria et al., 2023).

To address these challenges, researchers emphasize the importance of effective instructional strategies and supportive learning media. Appropriate tools can help teachers deliver material more clearly while also increasing learner engagement (Wulandari et al., 2023), For example, Algebra Cards (KAJAR) have proven effective in improving achievement; a study at SMPQ Al-Asrar reported that 90.95% of participants responded positively and 90% achieved strong learning outcomes (Fairuzi et al., 2024). Similarly, innovative approaches that integrate interactive and contextual elements have been shown to enhance both interest and understanding (Wulandari et al., 2023; Hidayat et al., 2023; Hamidah et al., 2025).

Several studies highlight diverse methods for teaching algebra, including technology-based instruction, the use of manipulatives, and discussion-oriented strategies (Blanton et al., 2018). Contextual learning, in particular, has been shown to connect abstract concepts to real-life experiences, making ideas more tangible and meaningful (Pertiwi et al., 2024). Within the Indonesian context, the *Realistic Mathematics Education* (PMRI) approach emphasizes contextual problems and everyday exploration to deepen conceptual understanding (Zulkardi, 2002; Gravemeijer & Doorman, 2022; Hamidah et al., 2024a).

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Despite these promising strategies, most research has concentrated on isolated methods within limited contexts, such as manipulatives or digital tools (Fyfe et al., 2019; Hwang et al., 2015). A comprehensive review is still lacking, particularly one that categorizes instructional activities across different settings and evaluates their broader effectiveness (Fyfe et al., 2019; Hamidah et al., 2024b). Therefore, this study undertakes a scoping review to map the range of instructional practices in algebra education, identify major themes in the literature, and highlight research gaps. The findings are expected to provide valuable insights for designing more effective teaching strategies and inspire educators to adopt diverse approaches that support meaningful learning in mathematics.

METHOD

According to Arksey and O'Malley (2005), a scoping review is an ideal method for determining the scope of a body of literature on a specific topic and for providing a clear indication of the volume of available studies. Additionally, Munn et al (2018) mphasize that a scoping review is particularly useful when clarification of concepts or theoretical frameworks is required, making it a valuable alternative to a systematic literature review. Unlike a systematic review, which focuses on evaluating the quality of evidence to answer narrowly defined questions, a scoping review allows for a broader mapping of literature, identification of key themes, and recognition of research gaps. This flexibility makes it especially appropriate for the present study, which seeks not only to synthesize effective instructional activities in algebra learning but also to highlight underexplored areas that warrant further investigation.

The scoping review method follows several systematic stages to ensure a comprehensive and transparent process. Based on the framework developed by Arksey and O'Malley (2005) and and later refined by Levac et al. (2010), the process consists of five stages: identifying the research question, identifying relevant studies, selecting studies, charting the data, and collating, summarizing, and reporting the results. These steps ensure that the review is conducted systematically while maintaining sufficient breadth to map existing literature and effectively identify research gaps.

Identifying the Research Question

This review is guided by three key research questions: how have different algebra teaching activities been addressed in the literature? What are the main themes and topics explored in the literature on algebra teaching activities? What research gaps in the current literature warrant further exploration in future studies? These questions serve as the foundation for identifying and analyzing the scope of relevant studies in the field.

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Identifying Relevant Studies

To collect relevant literature, the authors used the Publish or Perish application with the keywords "algebra" and "algebraic mathematics." The search was limited to articles published within the past ten years (2015–2025) from the Scopus database. Publish or Perish was selected due to its effectiveness in extracting data from multiple academic sources (Putra et al., 2023). This approach enabled the authors to compile 143 articles from Scopus that met the predefined search criteria. The careful and rigorous methodology in gathering literature ensured the relevance and quality of the selected studies.

Study Selection

The study selection process involved establishing inclusion and exclusion criteria to filter the most relevant studies. The inclusion criteria were: (1) peer-reviewed journal articles published between 2015 and 2025; (2) written in English or Indonesian; (3) focusing on instructional activities or strategies for teaching algebra at the primary, secondary, or teacher education levels; (4) containing empirical or descriptive data related to teaching practices; and (5) available in full-text format. The exclusion criteria included: (1) opinion papers, editorials, or theoretical articles without empirical data; (2) studies focusing on mathematical topics other than algebra; (3) duplicate or inaccessible articles; and (4) publications before 2015. The selection process eliminated five duplicate articles, 28 closed-access articles, and 102 articles that did not align with the research questions. After this screening, eight articles remained for further review. The systematic approach to study selection ensured that only the most relevant and accessible research was included in the final analysis.

Charting the Data

Data charting played a crucial role in organizing and interpreting information by categorizing it based on key issues and themes. In line with previous scoping reviews, various types of information were extracted, including article titles, year of publication, author names, abstracts, study locations, country contexts, research objectives, empirical research designs (quantitative, qualitative, or mixed methods), methodologies used, data collection methods (such as surveys or interviews), types of data (primary or secondary), theoretical frameworks, study participants or population characteristics, key findings, and research limitations (O'Neill et al., 2023). The entire data extraction process was conducted by the primary author with support from co-authors to ensure accuracy and consistency.

This scoping review follows a structured and systematic approach to map the existing literature on algebra teaching activities, guided by the methodological frameworks of Arksey and O'Malley (2005), Levac et al. (2010), and the PRISMA Extension for Scoping Reviews (PRISMA-ScR) checklist (Tricco et al., 2018). By synthesizing findings from multiple studies, this research

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aims to provide valuable insights for educators and researchers while identifying areas that require further investigation. The study selection process is illustrated in Figure 1.

Collating, Summarizing, and Reporting Results

The fifth and final stage of this study presents the findings through descriptive frequency analysis and thematic analysis (Arksey & O'Malley, 2005). Descriptive frequency analysis serves to provide a numerical summary of key characteristics and the overall distribution of the retained studies (Levac et al., 2010). This analysis examines various aspects, including the year of publication, journal, country of origin of the first author and its context, research design, theoretical framework, terminology, definitions, and characteristics of the subjects studied. Following this, a thematic analysis is conducted. This approach is a valuable tool for identifying key areas of focus within a particular topic while also revealing gaps in the existing literature (Arksey & O'Malley, 2005).

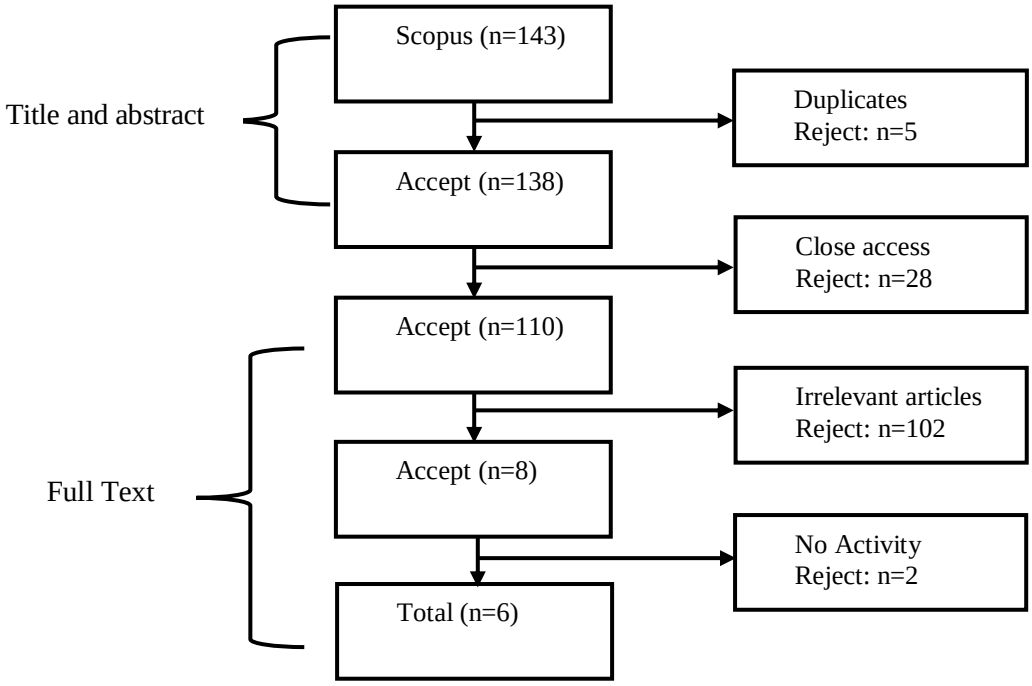

Figure 1. Study Selection Process.

RESULT AND DISCUSSION

Following the PRISMA-ScR guidelines (Tricco et al., 2018) and Arksey and O'Malley's (2005) framework, the findings are organized into five thematic categories derived from the six included studies. The findings are presented based on a thematic synthesis of the six included studies, which focused on how algebra teaching activities are designed and implemented across various educational settings.

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The reviewed research articles are published across international and national journals, representing diverse contexts, participant groups, and research designs. Despite this diversity, several recurring instructional patterns emerged. These patterns reflect five dominant approaches in algebra instruction: contextual problem-based learning, visual and concrete representations, technology-enhanced and game-based learning, collaborative discussions, and reflective reasoning. A summary of the reviewed studies and their characteristics is presented in Table 1.

Table 1. Overview of Articles on Teaching School Algebra

Articles	Context	Activity	Rasionale	Subjects Involved	Research Design
Pincheira & Alsina, 2024a	MKT-Early Algebra Questionnaire (6-12 years old)	Student error analysis, the use of algebraic symbols, problem-solving with variables, and understanding the concept of change	Physical activity	10 elementary school teachers in Spain	Instrumental study
Hatisaru et al., 2024	Dice Farmer Two Numbers Book	Solving problems involving two 12-sided dice with specific conditions, determining the number of chickens and cows on a farm based on the total animals and legs, using simultaneous equations to find two numbers based on their sum and difference, calculating the number of books using a repeated division pattern.	Physical activity	Pre-service mathematics education students for secondary schools at Metropolitan University, Australia	case study approach
Pincheira and Alsina, 2024b	MKT-Early Algebra Questionnaire (6-12 years old)	Identifying mathematical relationships and patterns, pattern-based seriation, and describing qualitative and quantitative changes	Physical activity	60 early childhood education student teachers in Spain	mixed methods
Calor et al., 2020	Table and chair arrangement	students must create and modify algebraic formulas based on the number of tables and chairs in a given scenario	Physical objects	160 students aged 12 to 15	Quasi-experimental design
Masduki et al., 2019	Farmer	This study focuses on conceptual understanding, the use of patterns for making predictions, the application of mathematical reasoning, and the communication of mathematical ideas.	Physical activity	7th-Grade Mathematics Teachers	Case Study Method
Hwang et al., 2015	Average equations, age-related problems, chicken and rabbit problems, and flow rate calculations	Students learn algebra through interactive games with various levels and challenges	Concrete media	6th-grade elementary students	Experimental design with a quasi-experimental approach

Table 1 presents an overview of the six studies included in this review. The selected articles were published between 2015 and 2025 and represent research conducted in Spain, Australia, and Indonesia. Two studies employed qualitative case studies, two used quasi-experimental methods, one applied a mixed-method approach, and one was categorized as an instrumental study. Participants ranged from elementary and secondary school students to pre-service and in-service

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mathematics teachers, indicating a broad educational scope. Most activities involved concrete or physical experiences such as manipulatives, games, and problem-solving tasks grounded in real-life contexts. These descriptive findings suggest that recent algebra instruction emphasizes interactive, contextual, and hands-on learning approaches to enhance students' engagement and conceptual understanding.

Although these five themes are presented separately, they are interrelated in practice. Contextual and problem-based learning often incorporates visual representations, technological tools, and collaborative reflections. Together, these approaches illustrate how algebra instruction has evolved from procedural practice toward more interactive, technology-integrated, and conceptually oriented pedagogy. Based on this synthesis, the five major instructional themes are presented below, each discussed in terms of interpretation, connection with previous studies, and implications for teaching and curriculum design.

Theme 1: Contextual and Problem-Based Learning

Contextual problem-based learning helps students connect abstract algebraic concepts to real-life experiences. This aligns with constructivist and Realistic Mathematics Education (RME) perspectives, which emphasize that knowledge is actively constructed when learners engage in meaningful problem contexts (Gravemeijer & Doorman, 2022). For example, analyzing plant growth patterns can help students understand linear relationships and functions more authentically.

These findings are consistent with Star and Rittle-Johnson (2020) and Blanton et al. (2021), who reported that situating algebra in real-world contexts strengthens conceptual reasoning and knowledge transfer. Similarly, Pertiwi et al. (2024) noted that contextual learning makes abstract ideas more tangible and meaningful, enhancing students' motivation and persistence. In the Indonesian context, Elita et al. (2019) and Zulkardi & Kohar (2018) also emphasized that contextual problem-solving and PISA-like tasks promote mathematical literacy and reasoning.

Teachers should integrate real-life problem scenarios (such as economic modeling, environmental data, or distance-time analysis) to help students see the relevance of algebra. Curriculum designers should embed contextualized activities that foster problem-solving and reasoning skills.

Theme 2: Visual and Concrete Representations

The use of visual and concrete representations plays a crucial role in bridging students' understanding of abstract algebraic ideas. Representations such as number lines, graphs, manipulatives, and algebra cards help visualize relationships between variables and strengthen

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structural understanding. This supports Dual Coding Theory (Paivio, 1991), which posits that combining verbal and visual information enhances learning.

Hatisaru et al. (2024) demonstrated that using diagrams and number lines helps students grasp inequalities intuitively. These findings align with Booth et al. (2021) and Carpenter et al. (2005), who showed that visual scaffolds and relational representations promote deeper conceptual comprehension in algebra. Similarly, Fairuzi & Liesdiani (2024) and Wulandari et al. (2023) reported that visual media and manipulatives such as KAJAR (Kartu Aljabar) increase students' engagement and achievement in Indonesian classrooms.

Teachers should incorporate visual models to represent algebraic relationships, while curriculum developers should promote the use of multiple representations. Professional development should also focus on equipping teachers with strategies for integrating visual and manipulative tools effectively.

Theme 3: Technology-Enhanced and Game-Based Learning

Technology-based and game-based learning environments enhance engagement and conceptual understanding in algebra. Interactive digital tools provide immediate feedback and allow students to explore at their own pace, aligning with Multimodal Learning Theory, which emphasizes learning through multiple sensory channels.

Hwang et al. (2015) found that game-based algebra instruction improved persistence and problem-solving skills. Similarly, Hamidah et al. (2025) reported that gamified formative assessments increased motivation and reinforced algebraic reasoning through interactive challenges. Other studies also highlight the potential of digital technologies such as augmented and virtual reality (Bertrand et al., 2024) and Android-based platforms (Hidayat et al., 2023) to improve visualization and engagement in mathematics learning.

Teachers should integrate digital learning platforms that support exploration and feedback-driven learning. Curriculum frameworks should encourage technology adoption in ways that enhance conceptual depth rather than merely replacing traditional exercises.

Theme 4: Collaborative Discussion and Reflective Reasoning

Collaborative and discussion-based learning fosters students' mathematical communication and reasoning skills. This aligns with Vygotsky's Sociocultural Theory, which views learning as a socially mediated process constructed through dialogue and shared reasoning.

Masduki et al. (2019) and Blanton et al. (2021) both found that structured discussions deepen conceptual understanding and build confidence in expressing mathematical arguments. Calor et al.

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(2020) similarly observed that shift-problem discussions in algebra encourage students to reason flexibly and refine their explanations. Fyfe et al. (2012) further noted that feedback during collaborative exploration enhances problem-solving persistence and conceptual retention.

Teachers should facilitate structured discussions where students compare strategies and justify solutions. Incorporating reflective journaling and peer feedback can further strengthen metacognitive awareness. Curriculum design should explicitly include collaborative and reflective learning activities.

Theme 5: Pattern Exploration and Generalization

Pattern exploration activities promote algebraic thinking by encouraging students to identify relationships and generalize rules. This supports the Early Algebra Framework, which views pattern recognition and generalization as foundations for formal algebra learning (Blanton et al., 2018).

Pincheira and Alsina (2024a, 2024b) demonstrated that exploring numerical and visual patterns helps students transition from arithmetic reasoning to algebraic generalization. These findings align with Carpenter et al. (2005) and Sun et al. (2023), who emphasized the role of patterning in developing functional reasoning. Likewise, Sibgatullin et al. (2022) and Mathaba et al. (2024) identified error analysis and pattern-based exploration as key pathways for strengthening algebraic thinking.

Teachers should include pattern-based exploration tasks (such as mosaics or tile designs) to develop generalization and variable thinking. Embedding these tasks in early curricula prepares students for higher-level algebraic reasoning and conceptual flexibility.

Synthesis and Research Gaps

The synthesis across these five themes reveals a consistent emphasis on conceptual understanding and learner engagement as central goals of algebra instruction. However, despite these advances, the reviewed literature also exposes several areas where empirical evidence remains limited.

Overall, these five themes show that effective algebra instruction connects abstract ideas with real-world contexts, employs multiple representations, leverages technology, and encourages collaboration and reflection. Together, these approaches create a dynamic learning environment that supports conceptual understanding, critical thinking, and problem-solving.

Nevertheless, several research gaps remain. Few studies have examined effective approaches for introducing algebra in elementary education, despite strong arguments for early exposure to algebraic reasoning (Sun et al., 2023). Additionally, there is limited research on integrating

emerging technologies such as artificial intelligence (AI) and augmented reality (AR) to enhance algebra visualization (Bertrand et al., 2024). More investigation is also needed into teachers' readiness and professional development for implementing technology-based and discussion-oriented instruction (Masduki et al., 2019; Munn et al., 2018). Cross-cultural comparative studies remain scarce, leaving unexplored how local curricula and cultural contexts influence algebra learning (Zulkardi & Kohar, 2018; Putra et al., 2023).

Future research should focus on developing inclusive, innovative, and evidence-based instructional models that integrate contextual, technological, and reflective dimensions of learning. By addressing these gaps, algebra education can advance toward more adaptive and meaningful pedagogical approaches that prepare students for both academic and real-world problem-solving (Zulkardi, 2002).

CONCLUSION

This scoping review aimed to address three main research questions: (1) how algebra teaching activities are represented in recent educational research, (2) what dominant themes and instructional approaches emerge from the literature, and (3) what research gaps remain to be explored. The synthesis of six selected studies revealed five recurring approaches to teaching algebra: contextual problem-based learning, visual and concrete representations, technology-enhanced and game-based learning, collaborative discussion, and reflective reasoning. These approaches were found to enhance students' engagement, conceptual understanding, and algebraic reasoning across different educational settings.

From a pedagogical perspective, the findings highlight the importance of designing classroom activities that connect algebra to real-life contexts, incorporate multiple representations, and utilize interactive technologies to sustain engagement and deepen understanding. Teachers should also promote structured discussions and reflection to foster students' metacognitive skills. Professional development programs need to prepare teachers to implement these strategies effectively, particularly in integrating technology and facilitating collaborative learning.

Theoretically, this review reinforces the relevance of constructivist and sociocultural learning perspectives, as well as the Early Algebra Framework, in explaining how students develop algebraic thinking. The findings contribute to refining theoretical models that describe the transition from arithmetic to algebraic reasoning and the role of contextual and visual scaffolds in supporting abstraction.

In terms of research implications, several gaps remain. Further studies are needed to explore effective strategies for introducing algebra in early education, evaluate the use of emerging technologies such as artificial intelligence (AI) and augmented reality (AR), and examine teachers'

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readiness for technology-enhanced instruction. Cross-cultural comparative research is also necessary to understand how local curricula and cultural contexts shape the teaching and learning of algebra.

This review is limited by the small number and scope of the included studies, which restricts the generalizability of the findings. Future research should include a broader range of sources and longitudinal designs to capture the sustained effects of instructional innovations. Overall, the review provides a comprehensive understanding of how diverse instructional approaches can support algebra learning and offers a foundation for developing more adaptive, evidence-based, and inclusive frameworks for algebra education.

REFERENCES

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

Bertrand, M. G., Sezer, H. B., & Namukasa, I. K. (2024). Exploring AR and VR tools in mathematics education through culturally responsive pedagogies. *Digital Experiences in Mathematics Education, 10*(3), 462–486. https://doi.org/10.1007/s40751-024-00152-x

Blanton, M., Brizuela, B. M., Stephens, A., Knuth, E., Isler, I., Gardiner, A. M., Stroud, R., Fonger, N. L., & Stylianou, D. (2018). Implementing a framework for early algebra. In C. Kieran (Ed.), *Teaching and learning algebraic thinking with 5- to 12-year-olds* (pp. 27–49). Springer. https://doi.org/10.1007/978-3-319-68351-5_2

Booth, J. L., Newton, K. J., Tsang, J. M., & Barbieri, C. (2021). Algebraic thinking and misconceptions: A review. *Educational Psychology Review, 33*(2), 275–295. https://doi.org/10.1111/cdev.13568

Calor, S. M., Dekker, R., van Drie, J. P., Zijlstra, B. J. H., & Volman, M. L. L. (2020). Correction to: "Let us discuss math"; Effects of shift-problem lessons on mathematical discussions and level raising in early algebra. *Mathematics Education Research Journal, 32*(4), 765–767. https://doi.org/10.1007/s13394-019-00283-0

Carpenter, T. P., Levi, L., Franke, M. L., & Zeringue, J. K. (2005). Algebra in elementary school: Developing relational thinking. *ZDM – International Journal on Mathematics Education, 37*(1), 53–59. https://doi.org/10.1007/BF02655897

Elita, G. S., Habibi, M., Putra, A., & Ulandari, N. (2019). Pengaruh pembelajaran problem based learning dengan pendekatan metakognisi terhadap kemampuan pemecahan masalah matematis. *Mosharafa: Jurnal Pendidikan Matematika, 8*(3), 447–458. https://doi.org/10.31980/mosharafa.v8i3.517

Fairuzi, M. F., & Liesdiani, M. (2024). Analisis belajar siswa dalam menerapkan media KAJAR (Kartu Aljabar) untuk meningkatkan prestasi belajar siswa di SMPQ Al-Asrar. *Jurnal Pendidikan Matematika, 8*(2), 2108–2117. https://doi.org/10.31004/cendekia.v8i3.3297

Fitria, A., Subanji, Susiswo, & Susanto, H. (2023). Cognitive map: Diagnosing and exploring students' misconceptions in algebra. *Mathematics Teaching-Research Journal, 15*(5), 49–75. EJ1412238.pdf

Fyfe, E. R., Rittle-Johnson, B., & DeCaro, M. S. (2012). The effects of feedback during exploratory mathematics problem solving: Prior knowledge matters. *Journal of Educational Psychology, 104*(4), 1094–1108. https://doi.org/10.1037/a0028389

Gravemeijer, K., & Doorman, M. (2022). Context problems in realistic mathematics education: A calculus course as an example. *Educational Studies in Mathematics, 109*(2), 223–242. ESM-artikel.pdf

Hamidah, I., Zulkardi, Z., Putri, R. I. I., Susanti, E., & Nusantara, D. S. (2024a). Hypothetical learning trajectory design in reflection learning using the context of the Cirebon Red Mosque. *Jurnal Pendidikan Matematika (JUPITEK), 7*(1), 1–10. https://doi.org/10.30598/jupitekvol7iss1pp1-10

Hamidah, I., Zulkardi, Ilma, R., Putri, I., & Pramuditya, S. A. (2024b). How is the implementation of realistic

mathematics education on mathematical literacy skills? A systematic literature review. *Jurnal Pendidikan Matematika, 13*(3), 741–756. https://doi.org/10.31980/mosharafa.v13i3.2089

Hamidah, I., Zulkardi, Putri, R. I. I., & Pramuditya, S. A. (2025). Developing a mathematical literacy learning environment for students through educational game assistance. *Mathematics Education Journal, 19*(1), 141–162. https://doi.org/10.22342/jpm.v19i1.pp141-162

Hatisaru, V., Stacey, K., & Star, J. R. (2024). Mathematical connections in preservice secondary mathematics teachers' solution strategies to algebra problems. *Avances de Investigación en Educación Matemática, 25*, 33–55. https://doi.org/10.35763/aiem25.6354

Hidayat, W., Rohaeti, E. E., Hamidah, I., & Putri, R. I. I. (2023). How can android-based trigonometry learning improve the math learning process? *Frontiers in Education, 7*, 1–13. https://doi.org/10.3389/feduc.2022.1101161

Hwang, G. H., Lee, C. Y., & Kuo, T. H. (2015). The development of a game-based formative assessment mathematical algebra tutorial app. In *Proceedings of the 23rd International Conference on Computers in Education* (pp. 729–738). https://icce2023.apsce.net

Kieran, C. (2018). The early learning of algebra: A structural perspective. In C. Kieran (Ed.), *Research issues in the learning and teaching of algebra: The research agenda for mathematics education* (Vol. 4, pp. 33–56). Routledge. https://doi.org/10.4324/9781315044378-4

Levac, D., Colquhoun, H., & O'Brien, K. K. (2010). Scoping studies: Advancing the methodology. *Implementation Science, 5*(1), 69. https://doi.org/10.1186/1748-5908-5-69

Masduki, M., Suwarsono, S., & Budiarto, M. T. (2019). Teacher's strategies to promote student's mathematical competencies in algebra: A case study. *Journal of Physics: Conference Series, 1265*(1), 012016. https://doi.org/10.1088/1742-6596/1265/1/012016

Mathaba, P. N., Bayaga, A., Tîrnovan, D., & Bossé, M. J. (2024). Error analysis in algebra learning: Exploring misconceptions and cognitive levels. *Journal on Mathematics Education, 15*(2), 575–592. https://doi.org/10.22342/jme.v15i2.pp575-592

Munn, Z., Peters, M. D. J., Stern, C., Tufanaru, C., McArthur, A., & Aromataris, E. (2018). Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC Medical Research Methodology, 18*(1), 143. https://doi.org/10.1186/s12874-018-0611-x

O'Neill, F., Dickson, G., Ströbel, T., & Thompson, A. J. (2023). Elite athlete activism, advocacy, and protest: A scoping review. *European Sport Management Quarterly, 25*(1), 145–173. https://doi.org/10.1080/16184742.2023.2287471

Pertiwi, N. P., Saputro, S., Yamtinah, S., & Kamari, A. (2024). Enhancing critical thinking skills through STEM problem-based contextual learning: An integrated e-module education website with virtual experiments. *Journal of Baltic Science Education, 23*(4), 739–766. https://doi.org/10.33225/jbse/24.23.739

Pincheira, N., & Alsina, Á. (2024a). Assessing knowledge to teach early algebra from the mathematical knowledge for teaching (MKT) perspective: A support tool for primary school teachers. *Journal on Mathematics Education, 15*(2), 639–660. http://doi.org/10.22342/jme.v15i2.pp639-660

Pincheira, N., & Alsina, Á. (2024b). Mathematical knowledge of early algebra exhibited by pre-service early childhood education teachers. *International Journal of Science and Mathematics Education, 23*(2), 461–487. https://doi.org/10.1007/s10763-024-10478-y

Putra, A., Zulkardi, Z., Putri, R. I. I., & Nusantara, D. S. (2023). Scoping literature review: What activities can help students discover permutations? *Edumatika: Jurnal Riset Pendidikan Matematika, 6*(2), 105–117. https://doi.org/10.32939/ejrpm.v6i2.3167

Rittle-Johnson, B., Fyfe, E. R., & Loehr, A. M. (2022). Conceptual and procedural knowledge: Their roles in learning algebra. *Review of Educational Research, 92*(1), 1–24. https://doi.org/10.1111/bjep.12124

Sibgatullin, I. R., Korzhuev, A. V., Khairullina, E. R., Sadykova, A. R., Baturina, R. V., & Chauzova, V. (2022). A systematic review on algebraic thinking in education. *Eurasia Journal of Mathematics, Science and Technology Education, 18*(1), em2061. https://doi.org/10.29333/ejmste/11486

EDUMATIKA: *Jurnal Riset Pendidikan Matematika* *e-ISSN 2620-8911*
Volume 8, Issue 1, May 2025 *p-ISSN 2620-8903*

Sun, S., Sun, D., & Xu, T. (2023). The developmental progression of early algebraic thinking of elementary school students. *Journal of Intelligence, 11*(12), 240. https://doi.org/10.3390/jintelligence11120222

Syarah, F., Harahap, Y. N., & Putri, J. H. (2023). Kesulitan siswa dalam mempelajari materi aljabar. *Journal on Education, 5*(4), 16067–16070. https://doi.org/10.31004/joe.v5i4.2656

Tricco, A. C., Lillie, E., Zarin, W., O'Brien, K. K., Colquhoun, H., Levac, D., … Straus, S. E. (2018). PRISMA extension for scoping reviews (PRISMA-ScR): Checklist and explanation. *Annals of Internal Medicine*. American College of Physicians. https://doi.org/10.7326/M18-0850

Wulandari, A. P., Salsabila, A. A., Cahyani, K., Nurazizah, T. S., & Ulfiah, Z. (2023). Pentingnya media pembelajaran dalam proses belajar mengajar. *Journal on Education, 5*(2), 3928–3936. https://doi.org/10.31004/joe.v5i2.1074

Zulkardi. (2002). *Developing a learning environment on realistic mathematics education for Indonesian student teachers* [Doctoral dissertation, University of Twente]. PrintPartners Ipskamp. https://repository.unsri.ac.id/6353/

Zulkardi, Z., & Kohar, A. W. (2018). Designing PISA-like mathematics tasks in Indonesia: Experiences and challenges. *Journal of Physics: Conference Series, 947*(1), 012015. https://doi.org/10.1088/1742-6596/947/1/012015