Learning Obstacles in High School Algebra Learning: A Literature Review

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Abstract
Algebra is one of the fundamental topics in mathematics education at the high school level, but various studies show that students still experience many difficulties in understanding and applying algebraic concepts. These difficulties have the potential to create learning obstacles that impact students' low learning achievement. This study aims to identify and describe the types of learning obstacles faced by high school students in learning algebra based on previous research results. The method used is a Systematic Literature Review (SLR) by reviewing seven relevant research articles published in national journals. The review process was carried out through the stages of formulating research questions, collecting and selecting articles, analyzing content, and synthesizing research findings. The results of the study show that student learning obstacles in algebra learning are classified into three main types, namely ontogenic obstacles, epistemological obstacles, and didactic obstacles. Ontogenetic obstacles are related to a weak understanding of basic concepts, procedural errors, and psychological factors of students. Epistemological obstacles arise in the form of students' difficulties in relating algebraic concepts, particularly in the mathematical modeling of contextual problems. Meanwhile, didactic obstacles are influenced by procedural learning designs that lack context and variety in learning strategies. The findings of this study are expected to serve as a reference for educators in designing more effective algebra learning to minimize student learning obstacles.

1. Introduction

Mathematics serves as a foundational discipline that underpins the advancement of other sciences and is consequently mandated as a subject at all educational levels, including junior and senior high schools (Ministry of Education and Culture, 2018a, 2018b). Among the core topics in school mathematics, algebra holds particular significance. Algebra is integral to numerous scientific fields and practical applications, such as network and communication systems, physical laws, population modeling, and statistical analysis (NCTM, 2000). Within mathematics, algebra functions as the language of science and provides access to more advanced mathematical concepts (Jupri et al., 2014; Usiskin, 1995). Furthermore, algebraic concepts are essential for solving real-world problems, establishing algebra as a fundamental competency that students are expected to acquire (Haryarti et al., 2016).

Despite its importance, student's understanding of algebra remains below expectations. Evidence from the Trends in International Mathematics and Science Study (TIMSS) demonstrates that Indonesian students have consistently scored below the international average in the algebra content domain (TIMSS, 2011). Research indicates that students commonly encounter difficulties translating verbal information from contextual problems into algebraic expressions and mathematical models (Jupri & Drijvers, 2016). Additional studies have found that students struggle with complex algebraic word problems and contextual situations (Rohimah, 2017). At the senior high school level, similar challenges have been observed, including difficulties in formulating mathematical models, selecting appropriate graphical representaions in linear programming, and accurately substituting variable values (Hasanah & Fuadiah, 2024). Collectively, these findings indicate that many students continue to experience challenges in comprehending and applying algebraic concepts.

Difficulties students encounter in learning algebra can be analyzed through the lens of learning obstacles. Suryadi (2019) defines learning obstacles as barriers that impede student's learning processes and may originate from ontogenic, epistemological, and didactical factors. Numerous studies in algebra-related topics. Rohimah (2017) identified difficulties in applying the concepts of linear equations and inequalities in one variable especially within contextual problems at both junior and senior high school in Ciwidey, Indonesia. Sadiah et al. (2024) observed that high school students encounter obstacles such as the inappropriate application of theoretical knowledge, difficulty selecting appropriate mathematical techniques, and challenges in understanding task requirements. Additionally, documented a range of learning obstacles across various

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algebra topics, demonstrating that learning barriers persist as a significant issue in algebra education (Fahrilianti, 2020; Fasya et al, 2024; Hasanah & Fuadiah, 2024; Panjaitan & Rosjanuardi, 2025).

While previous studies have identified learning obstacles within specific algebra topics, the literature remains fragmented and primarily addresses particular concepts or localized contexts. Currently, there is a lack of comprehensive research synthesizing findings on learning obstacles across multiple algebra topics at the senior high school level. Consequently, the patterns, characteristic, and predominat types of learning obstacles that students encounter in algebra are not yet fully understood. This gap underscores the necessity for a comprehensive review of existing studies to offer a more holistic understanding of student's learning obstacles in algebra.

Therefore, this study aims to investigate and identify the learning obstacles that senior high school students experience across various algebra topics through a review of the existing literature. By synthesizing prior research, this study seeks to provide a comprehensive understanding of the types and characteristic of learning obstacle in algebra. The findings are expected to contribute to future research on algebra learning and serve as a reference for designing more effective instructional strategies to address student's difficulties in learning algebra.

2. Method

This study employs a Systematic Literature Review (SLR) methodology. SLR is a structured approach for collecting, critically examining, integrating, and synthesizing research findings on a specific topic by following predetermined steps (Triandini et al., 2019; Tamur et al., 2023). The SLR process consists of five stages: (1) formulating research questions, (2) collecting articles relevant to the research topic, (3) classifying and evaluating the collected articles, (4) summarizing the articles, and (5) interpreting the findings from the reviewed literature (Nurfadilah et al., 2022). The review commenced with the identification of the research theme, specifically "learning barriers". The literature search was conducted on January 19, 2026, using Google Scholar via the Publish or Perish application. Google Scholar was chosen as the primary database because preliminary searches indicated that studies specifically addressing learning obstacles in mathematics education were relatively limited in major indexed databases, including Scopus. Furthermore, Google Scholar provides broader coverage of scholarly publications, including journal articles, conference proceedings, theses, and dissertations, which enables a more comprehensive identification of literature relevant to the research topic. The search used the keyword "learning obstacles" and was limited to the first 200 records retrieved via Publish or Perish. All records were exported and compiled into a database for subsequent screening. Duplicate records were identified and removed prior to screening to ensure each study was represented only once. The remaining articles were eligibility criteria advanced to the full-text assessment stage. In accordance with the PRISMA procedure, the selected studies were analyzed and synthesized to identify patterns and characteristics of learning obstacles reported in the literature. The article selection process, including the numbers of identified, screened, excluded, and included studies, is summarized in the PRISMA flow diagram.

2.1. Data Sources and Search Strategy

A Systematic Literature Review (SLR) was conducted to identify, examine, and synthesize studies addressing learning barriers. Data collection utilized the Google Scholar database through the Publish or Perish application. The search strategy applied the keyword "learning barriers" and was restricted to the 200 most relevant articles. Titles, abstracts, and keywords were screened for alignment with the research focus. Additionally, the bibliographies of selected articles were reviewed to identify further relevant sources not captured in the initial search.

2.2. Inclusion and Exclusion Criteria

Articles were included if they met the following criteria: (1) addressed learning barriers; (2) presented empirical research data; (3) were published in scientific journals; (4) were available in full-text; and (5) demonstrated relevance to the research focus. Exclusion criteria comprised: (1) articles not addressing learning barriers; (2) editorials, opinion pieces, or conceptual studies; (3) articles without full-text availability; and (4) publications lacking sufficient information for analysis. Each article meeting the inclusion criteria was evaluated for alignment with the research objectives, methodological clarity, and relevance of findings to learning barriers.

2.3. Study selection procedures

Only articles meeting these quality standards were included in the analysis. The review process adhered to the procedures described by Triandini et al. (2019) and Nurfadilah et al. (2022): (1) formulating the research question, (2) collecting relevant articles, (3) classifying and evaluating the articles, (4) summarizing study results, and (5) interpreting research findings. Following the search process using Publish or Perish, articles were selected according to the established inclusion and exclusion criteria. Eligible articles underwent in-depth analysis to identify types of learning barriers, their characteristics, and key findings relevant to the research

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topic. The synthesized analysis provides a comprehensive overview of the development of research on learning barriers.

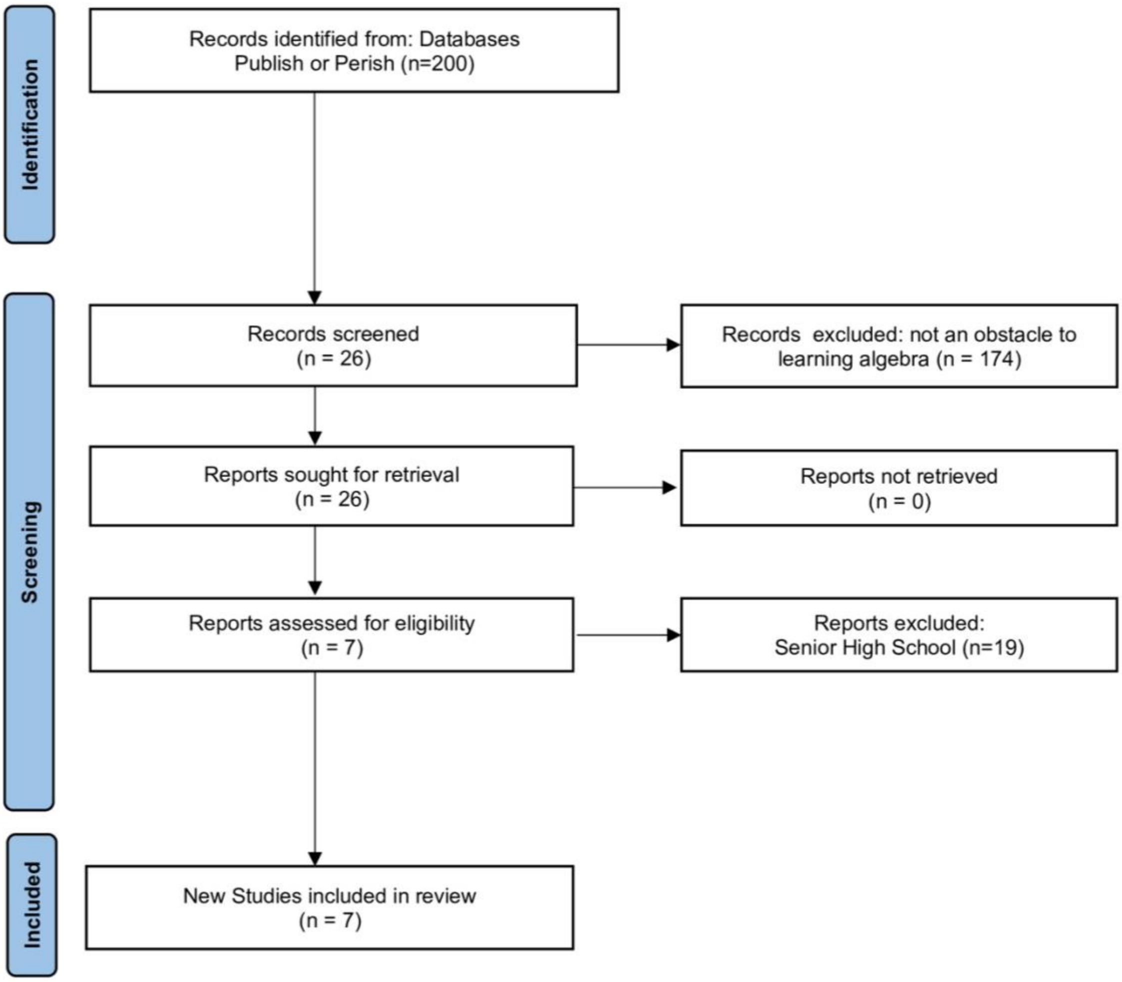

Figure 1. PRISMA diagram of the Stages of a Systematic Literature Review

2.4. Data Analysis Techniques

Thematic analysis was employed to analyze the data in this study. Articles meeting the inclusion and exclusion criteria were thoroughly reviewed to identify information pertaining to learning barriers. Extracted data from each article were organized according to research focus, research subjects, research methods, and key findings. Subsequently, the research results were systematically analyzed to identify patterns, similarities, and differences across articles. The findings were categorized into themes aligned with the research objectives. The analysis specifically addressed the types of learning barriers, their underlying factors, and their impact on the learning process. The analysis process was conduct. The analysis was conducted iteratively, with results from multiple studies compared and integrated to achieve a comprehensive synthesis of learning barriers. This synthesis informed the description of research developments, identification of remaining research gaps, and formulation of recommendations for future research.

3. Results and Discussion

3.1. Results

A review of the selected literature identified seven articles that address barriers to student learning in high school algebra. These articles investigate a range of algebraic topics, including linear programming, systems of linear inequalities with two variables, equations and absolute value inequalities with one variable, arithmetic operations in algebraic expressions, and systems of linear equations with three variables. The findings indicate that student learning barriers can be categorized into three primary types: ontogenic barriers, epistemological barriers, and didactic barriers. Following the selection process, seven articles were identified and subjected to in-depth analysis. Table 1 provides a summary of these studies.

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A synthesis of seven reviewed studies indicates that student learning barriers in high school algebra can be categorized into three primary types: ontogenic, epistemological, and didactic barriers. Epistemological barriers are the most prevalent, as evidenced by students' challenges in constructing mathematical models from contextual problems, integrating various algebraic concepts, and transferring learned concepts to novel situations. Ontogenic barriers manifest as limited understanding of foundational concepts, procedural errors in algebraic operations, and psychological factors such as low motivation and interest. Didactic barriers are associated with instructional designs that emphasize procedures, lack contextualization, and offer limited diversity in learning strategies and exercises. Collectively, these findings suggest that algebra learning barriers are shaped by both students' internal characteristics and their educational experiences, including the quality of instructional design. Consequently, instructional development should prioritize strengthening conceptual understanding, fostering connections among mathematical concepts, and incorporating meaningful contexts to reduce student learning barriers.

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Table 1. Summary of Included Studies

No	Author & Year	Journal	Key Findings
1	Indah Widia Fahrilianti (2020)	JuMlahku : Jurnal Matematika Ilmiah	The research identified several learning obstacles encountered during the analysis of trial results on linear programming material: 1) students were unable to determine variable examples, 2) students were unable to construct mathematical models, 3) students lacked understanding of intersection points in linear programming problems, 4) students were unable to complete the solution area, and 5) students were unfamiliar with the stages involved in solving linear programming applications or story problems.
2	Zakiyatul Hasanah, Destiniar, Nyiayu Fahriza Faudiah (2024)	LAPLACE: Jurnal Pendidikan Matematika	Analysis of textbooks, lesson plans, teacher interviews, and diagnostic tests identified several learning obstacles: 1) 82.3% of students were unable to construct a mathematical model for a two-variable linear inequality system; 2) 88.2% could not determine the solution set or corner point of such a system; 3) 94.1% were unable to graph the solution set region; and 4) 29.4% did not respond to questions related to determining the optimum value of the objective function.
3	M. Azhari Panjaitan, Rizky Rosjanuardi (2025)	AKSIOMA: Jurnal Program Studi Pendidikan Matematika	The research identified three categories of learning barriers encountered by students: epistemological, ontogenic, and didactic. Epistemological barriers arose from incomplete conceptual understanding and unfamiliarity with applying one mathematical concept to another. Ontogenic barriers were attributed to insufficient understanding of equations and inequalities involving the absolute value of a single variable. Didactic barriers emerged during instructional processes implemented by teachers.
4	Lia Halimatus Sadiah, Suhendra, Tatang Herman (2024)	AKSIOMA: Jurnal Program Studi Pendidikan Matematika	The praxeological analysis conducted in this study identified three primary learning barriers: ontogenic, didactic, and epistemological. The theoretical justification for the techniques employed indicates that students demonstrate limited diversity in knowledge, learning experiences, and cognitive approaches, which may contribute to ontogenic barriers. Additionally, the use of inappropriate technology in supporting techniques can be detrimental and may lead to didactic barriers. Finally, students' inability to effectively utilize perceptual, memorial, and conceptual abilities when addressing novel problems suggests that, according to praxeological analysis, they encounter epistemological barriers due to restricted contextual understanding.
5	Siti Maryam Rohimah (2017)	JPPM	The study identified three primary types of learning obstacles encountered by students regarding linear equations and inequalities in one variable: ontogenic, epistemological, and didactical obstacles. Ontogenic obstacles arose when students learned algebraic forms directly from abstract examples, without introductory explanations that clarified the origins of the concepts. Epistemological obstacles were evident as most students could solve simple problems involving linear equations (PLSV) and linear inequalities (PtLSV) in one variable but struggled to apply these concepts to more complex or contextualized problems, particularly story problems. Didactical obstacles were associated with instructional practices, including teachers' procedural approaches to solving PLSV, the use of the "equal" sign when teaching PtLSV, the routine of drawing number lines on real numbers, and the lack of variety in practice questions.
6	Robby Ismail Fasya, Didi Suryadi, Nurjanah	Prismatika: Jurnal Pendidikan dan Riset Matematika	The results of the study indicate that students encountered five distinct types of learning barriers: instrumental ontogenic barriers, conceptual ontogenic barriers, psychological ontogenic barriers, epistemological barriers, and didactic barriers. Conceptual ontogenic barriers are evident when students interpret variables as representations of already known quantities. Instrumental ontogenic barriers are observed when students continue to make errors during calculations. Psychological ontogenic barriers manifest as obstacles to students' learning interests and motivation. Epistemological barriers arise when students struggle with story-based problems, as they are typically accustomed to problems presented solely as equations. Didactic barriers are reflected in students' statements that algebraic arithmetic operations were not taught at the Islamic boarding school, despite the importance of this material in algebra and its expected inclusion at the junior high school level or equivalent.
7	Yumna Hidayah, Eyus Sudihartinih, Encum Sumiaty (2021)	Jurnal Pendidikan Matematika RAFA	The results of this study identified four types of learning obstacles: difficulties in translating story problems into mathematical models, insufficient mastery of algebraic applications within story problems, challenges in converting story problems into geometric models, and uncertainty or confusion regarding the procedures required to solve the provided problem instrument.

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3.2. Discussion

The results of the study demonstrate that learning barriers in algebra continue to be a significant challenge for high school students. These obstacles arise not only from students' limited abilities but are also shaped by their learning experiences and the instructional design employed. This observation is consistent with the classification of learning obstacles proposed by Brousseau (2002) and Suryadi (2019), which include ontogenic, epistemological, and didactic barriers. Epistemological obstacles are identified as the most prevalent type. These obstacles consistently manifested as student's difficulties in connecting mathematical concepts, translating contextual situations into mathematical models, interpreting algebraic representations, and applying previously learned concepts to unfamiliar problems. The recurrence of these challenges across multiple algebra topics indicates that student's knowledge is frequently context-bound and procedural, rather than flexible and conceptually integrated. Although many students could, execute routine procedures, they often struggled to adapt their knowledge to novel situations or to establish relationships among algebraic. Epistemological obstacles are primarily attributed to the abstract natire of the algebraic difficulties students from arithmetic thinking to algebraic reasoning. Kieran (1992) observes that students often struggle to interpret variables, generalize numerical relationships, and comprehend symbolic representations. As a result, algebraic knowledge is frequently learned as a network of interconnected concepts. Instructional practices that prioritize algorithmic manipulation and correct answers over conceptual understanding and reasoning further reinforce this issue. Concequently, students may excel at routine exercises but are unable to construct mathematical models, interpret representations, or transfer their knowledge to unfamiliar contexts. This finding further corroborates Kaput's (2008) assertion that algebra instruction should prioritize the development of algebraic reasoning and the interconnections among mathematical representations to enhance students' conceptual understanding.

Ontogenic obstacles represent a significant factor influencing student's learning. These obstacles result from insufficient mastery of foundational concepts, procedural errors in mathematical operations, and psychological factors such as low motivation and limited interest in learning. Inadequate understanding of basic concepts often leads to difficulties when students encounter more complex problems or tasks that require integrating multiple concepts. Meanwhile, didactical obstacles demonstrate that instructional methods also contribute to the development of learning difficulties. Instruction that emphasizes procedures without connecting concepts to real-world contexts, and that offers limited variety in strategies and exercises, reduces opportunities for students to develop robust conceptual understanding. Additionally, the use of inappropriate learning strategies and restricted learning experiences can intensify these barriers.

The findings have significant implications for the design of algebra instruction at the secondary school level. Given the prevalence of epistemological obstacles, instructional designs should emphasized developing conceptual understanding and algebraic reasoning rather than focusing solely on procedural fluency. Learning activities should facilitate student's ability to connect multiple representations, such as verbal, symbolic, graphical, and contextual forms, and to articulate the reasoning underlying their solutions. Furthermore, contextual and modeling-based tasks should be integrated regularly to help students recognize the applicability of algebraic concepts across diverse situations. Teachers should anticipate potential learning obstacles by identifying prerequisite knowledge, designing learning trajectories that systematically build conceptual connections, and implementing instructional interventions that directly address student's misconceptions. These approaches may reduce obstacles to learning and foster deeper, more meaningful learning of algebra.

3.3. Implications

The theoretical implications of this study are twofold. First, it contributes to the literature on learning obstacles in mathematics by systematically synthesizing the challenges encountered by high school students in algebra. The findings provide a comprehensive overview of ontogenic, epistemological, and didactic obstacles across various algebra learning contexts. Second, the results affirm the significance of the learning obstacle theory proposed by Brousseau (2002) and expanded by Suryadi (2019) in explaining students' learning difficulties. The study indicates that learning obstacles are influenced not only by students' limited knowledge but also by their learning experiences and the instructional design implemented. Additionally, these findings highlight that analyzing learning obstacles can inform the development of didactic designs to address students' difficulties in algebra (Brousseau, 2002; Suryadi, 2010; Suryadi, 2019).

The findings of this study suggest that teachers should prioritize the development of students' conceptual understanding over the mere mastery of problem-solving procedures. Students' challenges in constructing mathematical models, integrating various algebraic concepts, and solving contextual problems underscore the necessity for instructional approaches that foster a deep comprehension of mathematical concepts (Jupri et al., 2014; Rohimah, 2017). Additionally, teachers should utilize diagnostic assessments to identify learning barriers and design targeted interventions that address students' specific needs (Hasanah & Fuadiah, 2024). Curriculum developers and education practitioners are encouraged to incorporate contextual learning strategies, diverse mathematical representations, and meaningful problem-solving activities to facilitate connections among mathematical concepts (NCTM, 2000). Moreover, the development of didactic designs that specifically address ontogenetic, epistemological, and didactic barriers represents a significant direction for future research and

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educational innovation (Sadiah et al., 2024; Panjaitan & Rosjanuardi, 2025). Furthermore, Stacey and MacGregor (1999) found that students frequently encounter difficulties when translating verbal problems into symbolic representations and identifying suitable solution strategies. Consequently, the results of this study provide a foundation for improving the quality of algebra instruction and reducing learning obstacles for high school students.

3.4. Limitations

Several limitations should be considered when interpreting these results. First, the literature search was limited to the Google Scholar database using the Publish or Perish application, which may have excluded relevant articles indexed elsewhere. Second, only articles meeting the established selection criteria were included, with most originating from educational contexts in Indonesia. As a result, the synthesis does not comprehensively represent learning barriers in algebra across diverse educational settings. Third, the study identified and classified learning barriers based solely on previous research findings, without direct empirical verification. Consequently, the results depend on the methodological rigor and reporting quality of the reviewed articles. Additionally, the limited number of eligible articles restricts the breadth of findings, which do not encompass all algebra topics taught at the high school level.

This study provides a comprehensive overview of the ontogenic, epistemological, and didactic barriers encountered by students in learning algebra. Future research should expand literature search sources by including international databases such as Scopus and Web of Science, examine a broader range of algebra topics, and integrate findings from literature reviews with empirical research to achieve a deeper understanding of the characteristics and causes of student learning barriers. Additionally, subsequent studies may focus on developing and implementing didactic designs specifically aimed at addressing the ontogenic, epistemological, and didactic barriers identified in previous research.

4. Conclusion

The literature review indicates that high school students continue to encounter multiple barriers when learning algebra. These barriers can be categorized into three main types: ontogenic, epistemological, and didactic. Ontogenic barriers involve insufficient mastery of fundamental algebraic concepts, procedural mistakes, and psychological factors such as low motivation. Epistemological barriers are the most prevalent, as evidenced by students' challenges in constructing mathematical models from contextual problems, integrating various algebraic concepts, and applying acquired knowledge to new situations. Didactic barriers arise from instructional designs that are predominantly procedural, lack contextual relevance, and offer limited diversity in teaching strategies and practice exercises. The findings suggest that barriers to learning algebra are influenced not only by students' abilities but also by their learning experiences and the instructional processes used in classrooms. Consequently, educators should design instruction that emphasizes conceptual understanding, the integration of concepts, and the use of meaningful contexts to reduce these barriers. Beyond characterizing the nature of learning barriers in algebra, this research provides a foundation for developing didactic designs and guiding future studies aimed at addressing and overcoming students' learning barriers in mathematics.

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The authors declared no potential conflicts of interest with respect to the research, authorship, and/ or publication of this article.

Data Availability

The datasets generated during and/ or analyzed during the current study are available from the corresponding author on reasonable request.

Declaration on AI Use

The authors confirm that neither artificial intelligence (AI) nor AI-assisted tools were utilized in the preparation of this manuscript.

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