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Analysis of Diagnostic Learning Obstacles of Junior High School Students on Straight-Line Equations: A Systematic Literature Review

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Abstract

The straight-line equations are an important part of learning mathematics, but many junior high school students still have difficulty understanding it. This study aims to identify the forms of learning obstacles, causal factors, error patterns, and learning implications on straight-line equations material through the Systematic Literature Review (SLR) approach. The research method uses the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Literature searches were conducted on Google Scholar, ERIC, DOAJ, and Garuda for articles published in the 2016–2026 period. Based on the selection process, four articles met the inclusion criteria. The synthesis results show that students experience three types of learning obstacles: ontogenical, epistemological, and didactical. Epistemological obstacles are the most dominant obstacles, indicated by difficulties in understanding gradients, determining straight-line equations, and connecting graph and algebraic representations. The main causal factors include limited mastery of prerequisite concepts, still procedural understanding, limited mathematical representation skills, and a learning orientation toward the use of formulas. These findings aid in understanding learning obstacles within the Brousseau framework and form the basis for developing learning that emphasizes concept understanding, mathematical representation, and student reasoning.

Keywords: learning obstacles, straight-line equations, SLR, Students' Errors, learning strategies.

1. Introduction

In the Indonesian education curriculum, the topic of straight-line equations is a basic competency that students must master, as it serves as a prerequisite for learning linear functions, linear equation systems, and advanced algebra concepts. In addition, mastery of mathematics is an important indicator in international assessments such as PISA (OECD, 2023). This math mastery includes mathematical literacy skills such as the ability to formulate, use, and interpret mathematical concepts in various contexts (OECD, 2023). These skills include understanding patterns, relationships between variables, representation of graphs and equations, functions, and straight-line equations.

Sasane (in Suarsana, 2025) said that learning straight-line equations should be easier for students to understand compared to other topics because the objects, namely points and lines, can be more easily represented visually, and the idea of lines is already known to students before learning. But many studies show that students' ability to master straight-line equations material is low. Research conducted by Leonard, Suhendri, Hasbullah, Mevianti, and Puteri (2022) said that straight-line equations material is the material that often causes difficulties for students**.** The same opinion was also expressed by Wirnadia, Pathuddin, Lefrida, and Alfisyahra (2024), who stated that students still have difficulties solving problems related to the straight-line equations. Furthermore, Islamiati and Sumiaty (2024) explained that the difficulties that students often face in solving problems related to straight-line equations are that students have difficulty in determining the gradient in the straight-line equations if one line is known to be perpendicular, students experience difficulties in determining the steps used in solving the problem, and difficulties in determining the formula to be used.

Theoretically and empirically, studies show that students' learning difficulties are often related to learning obstacles that arise during the learning process. A study by Hidayah and Maemonah (2022) found that students' learning difficulties stem from learning obstacles. More specifically, they explained some of the obstacles students face, including a lack of learning readiness, difficulties solving problems, and limited understanding of concepts. Panjaitan and Herman (2022) stated that learning obstacles occur due to students' inability to understand the material, resulting in errors in solving the problems or in the problems given. Other research also shows that, in addition to the obstacles above, there are obstacles caused by a lack of teacher preparation in teaching or by the incompatibility of students' needs with the textbooks used.

These learning obstacles can be significant impediments to students achieving the expected learning outcomes (CP), as they affect the occurrence of learning difficulties. According to Harel (in Bakar et al., 2019), "Learning obstacles are the barriers to the way of thinking and how to understand". This means that learning barriers are obstacles to thinking and understanding the learning material. Yuliana (in Farahdina, 2024) stated that obstacles are unexpected difficulties, meaning we do not know the exact cause; therefore, we need to identify the cause to find the right solution. According to Brousseau (in Farahdina, 2024), learning obstacles are classified as follows: (1) Ontogenical obstacle (ontogenic barrier) which is an obstacle related to students' cognitive development, (2) epistemological obstacle (epistemological obstacle) which is an obstacle related to conceptual limitations, (3) didactical obstacle (didactic barrier) is an obstacle caused by a less effective learning approach. Learning obstacles can lead to errors in understanding the concept of gradients, the shape of equations, and the relationship between equations and graphs. Therefore, a comprehensive study through the Systematic Literature Review (SLR) is needed.

Research on learning obstacles in various mathematics subject has been conducted in recent years, as these obstacles are among the factors that affect the success of mathematics learning. A systematic literature review conducted by Rosita et al. (2024) shows that the learning barriers commonly encountered in learning algebra include didactical, epistemological, and ontogenical barriers. In addition, students have difficulty understanding concepts, developing problem-solving strategies, and solving contextual problems. The findings show that learning obstacles are not only related to students' procedural abilities but also to their conceptual understanding and learning processes.

In line with this, Wang (2015) explained that the difficulty of learning algebra is influenced by several factors, namely algebra content, cognitive gap, teaching issues, learning matters, and transition knowledge. The findings show that the barriers to learning mathematics are not only due to weak mastery of concepts but are also influenced by students' cognitive development, the transition from arithmetic to algebra, and classroom learning practices. Although various studies have examined learning obstacles in mathematics and algebra, those that specifically synthesize learning obstacles in straight-line equations materials remain very limited. Most studies have focused solely on identifying students' mistakes, misconceptions, or learning difficulties, without linking them to Brousseau's classification of learning obstacles: ontogenical, epistemological, and didactical. In fact, analysis of these three types of obstacles can provide a deeper understanding of the causes of students' learning difficulties. The novelty of this research lies in the synthesis of research results on learning obstacles in straight-line equations material, based on Brousseau's classification: ontogenical, epistemological, and didactical. In addition, this study not only identifies the forms of obstacles students experience but also analyzes the causal factors, error patterns that arise, and learning implications for overcoming these obstacles.

Previous studies have generally focused on identifying students' errors, misconceptions, and learning difficulties in straight-line equations. However, limited attention has been given to synthesizing these findings within Brousseau's framework of learning obstacles. Consequently, the relationships among prerequisite knowledge, representational skills, instructional practices, and students' learning obstacles remain fragmented. Therefore, this review is needed to provide an integrated understanding of how ontogenetic, epistemological, and didactical obstacles emerge and interact in students' learning of straight-line equations.

In this study, diagnostic learning obstacles are understood as the process of identifying and analyzing the forms of learning barriers, their causal factors, the patterns of errors that arise, and the learning conditions that contribute to their emergence. Thus, the analysis focuses not only on the mistakes students make, but also on the reasons why they occur and how those obstacles can be overcome through proper learning. Based on this description, this study aims to: (1) identify the form of learning obstacles experienced by junior high school students in straight-line equations; (2) analyze the factors that cause the emergence of learning obstacles; and (3) formulate learning implications that can be used to minimize learning obstacles in straight-line equations material.

2. Method (SLR-PRISMA)

1. Research Design

This study uses the Systematic Literature Review (SLR) method with reference to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. This method was chosen because it enables researchers to identify, evaluate, and synthesize relevant research results systematically and transparently. The data source was obtained from scientific articles accessed through Google Scholar, ERIC, DOAJ, and Garuda. The article search process is assisted by the Publish or Perish application to make it easier to identify relevant articles. Keywords used in the search process include "learning obstacles in mathematics", "diagnostic learning obstacles", "straight-line equations", "student errors in straight-line equations", and "straight-line equations.

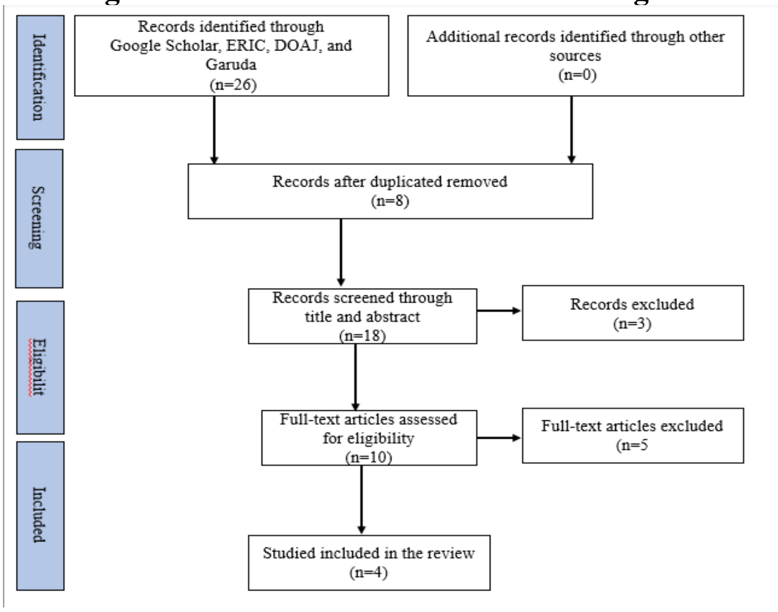
2. Inclusion and Exclusion Criteria

Table 1. Inclusion and Exclusion Criteria

Serial Number	Inclusion Criteria	Exclusion Criteria
1	Articles published in 2016–2026	Articles published before 2016
2	Discuss learning obstacles, learning difficulties, misconceptions, or student mistakes in straight line equation material	Not discussing the material of straight-line equations
3	Discuss the obstacles students experience in solving problems related to straight-line equations	Not addressing students' learning barriers
4	The research subjects are junior high school students or equivalent	The research subject is not a junior high school student or equivalent
5	Articles are available in full-text	Articles are not available in full-text
6	Articles from scientific journals or proceedings indexed by Scopus or SINTA 1–3	Articles are not indexed or are under SINTA 3
7	Articles written in Indonesian or English	Articles other than Indonesian and English

The research stage refers to the PRISMA guideline, which consists of four stages: identification, screening, eligibility, and inclusion (Moher et al., 2009). At the identification stage, articles are obtained through searches on Google Scholar, ERIC, DOAJ, and Garuda using predetermined keywords. From the initial search results, 26 articles were identified as potentially relevant to the research topic. At the screening stage, duplicate articles are removed and filtered based on title, abstract, and keyword criteria. Articles that do not align with the research's focus are eliminated at this stage. Furthermore, at the eligibility stage, articles that pass the screening stage are examined in depth through full-text review to ensure their suitability for inclusion or exclusion according to the set inclusion and exclusion criteria. The final stage is inclusion: the determination of the article used in the synthesis process. Based on all selection stages, 4 articles were identified that met all criteria and were used as the main sources in this study. The article selection process based on the PRISMA stages is presented in Figure 1.

Figure 1. SLR Article Selection Flow Diagram



3. Data Analysis Techniques

Before analysis, all articles that meet the inclusion criteria are evaluated using a quality assessment to ensure methodological quality and relevance to the research objectives. The assessment is based on four indicators: clarity of the research objectives, suitability of the research method, clarity of the research results, and relevance of the findings to learning obstacles in the material on straight-line equations. Only articles that meet all quality indicators are used in the synthesis process. The data were then analyzed using qualitative methods. Each finding related to learning obstacles is identified and grouped according to Brousseau's classification: ontogenical, epistemological, and didactical obstacles. Furthermore, a synthesis of the forms of learning barriers, the factors that cause the emergence of obstacles, the patterns of student errors, and the recommended learning implications in each study was conducted. The following table presents the results of the qualitative assessment.

Table 2. Quality Assessment Results

Article	QA1	QA2	QA3	QA4
Article 1	Yes	Yes	Yes	Yes
Article 2	Yes	Yes	Yes	Yes
Article 3	Yes	Yes	Yes	Yes
Article 4	Yes	Yes	Yes	Yes

Description:

- QA1 = Research objectives are clear
- QA2 = Clear research method
- QA3 = The results of the study are clear
- QA4 = Relevant to learning obstacles in the straight-line equations material

3. Results and Discussion

Characteristics of the Reviewed Study

Based on the article selection process using the PRISMA guidelines, four articles met all inclusion criteria and were included in the synthesis. The four articles were published between 2016 and 2026 and used a qualitative research approach to identify the learning obstacles of junior high school students in straight-line equations material. The instruments used are generally diagnostic tests, interviews, observations, and analyses of students' work. The focus of this research includes identifying the forms of obstacles students experience and their causal factors, the patterns of errors that arise, and the implications of learning that can be used to overcome learning obstacles in the material on straight-line equations. The characteristics of the four articles include the year of publication, the research design, the number of subjects, the research instruments, and the main findings, as presented in Table 1.

Table 3. Results of the study of learning obstacles of the material on straight-line equations

Author	Year	Research Design	Subject	Instruments	Key Findings
Islamiati & Sumiaty	2024	Qualitative	Junior High School Students	Diagnostic tests, interviews	The results of the study showed that most students had not mastered the prerequisite material, especially in the material of the Cartesian coordinate system, this made students experience obstacles in determining the coordinate points on the graph, reading the relationship between the graph and the straight-line equations. In addition, students also had difficulty in determining the slope of the line (gradient) and experienced obstacles in managing the time of working on the problem so that the problems worked on were not well settled.
Rahayu, Fitriani, & Setiawan	2023	Qualitative	28 junior high school students	Written test	The results of the study showed that 16 out of 28 students who were sampled still experienced obstacles in solving the given questions, there were obstacles in the form of ontogenical, epistemological, and didactical obstacles
Cadastra & Amelia	2018	Qualitative	32 junior high school students	Diagnostic tests	The results obtained showed that of the 6 students who were not able to identify the straight-line equations, 18 students were not able to determine the straight-line equations of two known points, 16 students were not able to determine the position of two

					lines, and 7 students were not able to draw a straight-line equation. The authors in the study concluded that the obstacles experienced by students in solving these problems are due to the limitations of the concepts understood by students, thus students' epistemological obstacles.
Isnaeni et al.	2018	Qualitative	Junior High School Students	Written test	In this study, it was found that obstacles related to ontogenic and epistemological obstacles were found when students determined the coordinate points. From the results of this study, it was found that students were not able to understand the concept of straight-line equations and were also not able to make counter examples of the questions given.

Types of Learning Obstacles in Straight Line Equation Material

The results of the synthesis show that junior high school students experience three types of learning obstacles, as classified by Brousseau: ontogenical, epistemological, and didactical. Of the three types of obstacles, epistemological obstacles are the most prevalent across all the studies. Epistemological obstacles are evident in students' difficulties understanding the concept of gradients, determining line equations from the information provided, relating graph representations to algebraic forms, determining the positions of two lines, and drawing graphs based on known equations. This barrier indicates that students' knowledge is still limited to a specific context and cannot yet be applied to other situations. For example, students can determine a gradient when an equation is presented in the form ($y = mx + c$), but have difficulty when the equation is presented in the general form ($ax + by + c = 0$).

Ontogenical obstacles include weak mastery of prerequisite material, particularly the Cartesian coordinate system, basic algebraic operations, and gradient concepts. This obstacle makes it difficult for students to determine coordinate points, read graphs, and understand the relationships between points, gradients, and straight-line equations. These findings suggest that students' cognitive readiness has not fully supported the understanding of more complex concepts in straight-line equations material. Didactical obstacles were identified in research showing that the learning process remains oriented towards the use of formulas and procedures for solving routine problems. Students tend to successfully solve problems similar to the examples given by the teacher but have difficulty when the question form is modified or presented in a different context.

This condition indicates that learning has not fully encouraged students to develop a deep understanding of the concepts. Overall, the synthesis results show that learning obstacles in straight-line equations material are not only related to students' mathematical abilities but are also influenced by cognitive readiness and classroom learning characteristics.

The dominance of epistemological obstacles across the reviewed studies suggests that students' knowledge of straight-line equations remains highly context-dependent. Students tend to succeed when solving routine tasks using familiar formulas but encounter difficulties when representations or problem contexts change. This finding indicates that classroom learning may place greater emphasis on procedural fluency than on conceptual understanding and representational flexibility.

Error Patterns That Appear in Straight Line Equation Material

Based on the synthesis of four studies, several error patterns were found to appear consistently. First, students have difficulty determining a line's gradient when the information provided does not correspond to the shapes they are used to. This error indicates that the student's understanding is still procedural and has not yet reached conceptual understanding. Second, students have difficulty connecting various mathematical representations, such as verbal representations, graphs, and algebraic forms. This error occurs when students are asked to specify the coordinate points of the graph, determine the axis cut-off points, or connect the graph to the corresponding line equations.

The third error pattern is that students have difficulty building mathematical models from contextual problems. Many students are unable to identify known and asked information, determine solution strategies, or translate the information in the problem into mathematical form. As a result, students often make procedural and conceptual mistakes while solving problems. Fourth, students have difficulty applying the concepts they have learned to new situations. This finding can be seen when students can solve routine problems but fail to solve problems with a different structure, even though the concepts used are the same. This condition shows the limitation of knowledge transfer, a main characteristic of epistemological obstacles.

Factors Causing Learning Obstacles

The results of the synthesis show that the learning obstacles in the straight-line equations material are caused by several main factors. The first factor is the low mastery of prerequisite concepts, especially the Cartesian coordinate system and basic algebraic operations. Weaknesses in these basic concepts directly affect students' ability to understand gradient and straight-line equations. The second factor is students' tendency to memorize procedures without understanding the underlying concept. Students are used to using formulas mechanically, so they have difficulty explaining the mathematical rationale for the steps used or when faced with problems that differ from the examples given.

The third factor is low representation skills and mathematical literacy. Students have difficulty connecting verbal representations, graphs, and mathematical symbols, thus hindering the problem-solving process. The fourth factor is the characteristics of learning that are still teacher-centered and oriented towards solving routine problems. Learning that places too much emphasis on the use of formulas can leave students less well trained in reasoning, exploring various solution strategies, and developing conceptual understanding.

This finding aligns with Wang (2015), who stated that the difficulty of learning algebra is influenced by mathematical content factors, cognitive gaps, learning processes, and the transition from arithmetic to algebra. The results of the synthesis also support the findings of Rosita et al. (2024), who show that epistemological, ontogenical, and didactical obstacles are the most common obstacles in mathematics learning.

Learning Implications

Based on the synthesis results, learning straight-line equations should focus on strengthening understanding of concepts rather than just using formulas. Teachers need to ensure that students have mastered prerequisite concepts such as the Cartesian coordinate system and algebraic operations before learning straight-line equations. In addition, learning needs to involve various mathematical representations, such as graphs, tables, diagrams, and algebraic forms, so that students can understand the relationships among them. The provision of non-routine questions, problem-based learning, and mathematical discussion activities also needs to be improved to train students' reasoning skills and knowledge transfer. Thus, efforts to overcome learning obstacles in straight-line equations materials focus not only on improving students' procedural skills but also on developing conceptual understanding, representational skills, and overall problem-solving skills.

Conclusion

Based on the synthesis of four articles that met the inclusion criteria, it was found that junior high school students experienced three types of learning obstacles in the straight-line equations' topic: ontogenical, epistemological, and didactical. Among the three types of obstacles, epistemological obstacles are the most dominant, as demonstrated by students' difficulties in understanding gradient concepts, determining straight-line equations, connecting graph representations to algebra, and applying concepts to situations different from the examples studied. In addition, it was found that learning barriers were also influenced by low mastery of prerequisite concepts, understanding that was still procedural, limited mathematical representation skills, and learning practices that still focused on the use of formulas and solving routine problems.

Theoretically, this study contributes by synthesizing learning obstacles in the material on straight-line equations based on Brousseau's classification: ontogenical, epistemological, and didactical. The results of this study expand on previous studies that generally identified only student errors or misconceptions by providing a more comprehensive understanding of the forms of barriers, the causal factors, and the relationship between the characteristics of learning barriers and the mathematics learning process.

In practice, the results of this study can serve as a reference for mathematics teachers in designing more effective learning experiences to minimize learning obstacles. Learning straight-line equations should focus on strengthening prerequisite concepts, using various mathematical representations, applying problem-based learning, providing non-routine questions, and developing students' mathematical reasoning and reflection skills. Thus, students are not only able to use procedures and formulas, but also understand the meaning of concepts in depth.

This study has limitations because it identified only a small number of articles that met all inclusion criteria. Therefore, further research is recommended to examine learning obstacles in straight-line equations materials on a broader scale, across various learning contexts and educational levels, and to develop and test learning designs or didactic interventions specifically aimed at overcoming ontogenical, epistemological, and didactical obstacles in mathematics learning.

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