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Junior high school teachers' perceptions and practices of inductive learning for supporting students' critical thinking

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Abstract

Learning mathematics requires students to assess information, compare alternative solutions, and explain their reasoning. However, opportunities for students to engage actively in these processes depend on how mathematical learning is designed and enacted in the classroom. Guided inductive learning offers a relevant approach because it engages students in examining cases, identifying patterns, and constructing mathematical generalizations rather than receiving concepts solely through direct explanation. In this context, teachers' perceptions and classroom practices are important because they may shape the opportunities provided for students to engage in critical-thinking processes. Therefore, this study explored junior high school mathematics teachers' perceptions and practices of guided inductive learning in relation to students' critical-thinking processes. A qualitative phenomenological approach was employed with 12 junior high school mathematics teachers in Tasikmalaya, Indonesia, selected through purposive sampling. Data were collected through semi-structured interviews and classroom observations and analysed using Moustakas' phenomenological procedures. The findings revealed three interconnected themes: teachers' conceptions and enactment of guided inductive learning, scaffolding of students' critical-thinking processes, and pedagogical challenges and professional needs. Teachers described and enacted inductive learning as a structured process involving examples, pattern identification, generalization, guiding questions, collaborative discussion, justification, and adaptive scaffolding. However, limited instructional time, curriculum demands, and differences in students' readiness affected its classroom enactment. Teachers also expressed a need for structured learning procedures, practical resources, and professional development. Overall, the findings describe how teachers understood and enacted guided inductive learning and how critical-thinking processes were reflected in the observed classroom activities.

Keywords: Critical Thinking, Inductive Learning, Phenomenology

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INTRODUCTION

Students often have challenges in evaluating information, building mathematical arguments, making generalisations and explaining their solutions. This produces students who are very dependent on teacher-like approaches and less able to solve problems that need higher-level reasoning. Critical thinking skills are enhanced in an atmosphere that stimulates investigation, reflection and active student participation in learning (Aini et al., 2019; Darling-Hammond et al., 2020; Dwyer et al., 2014; Wahid, 2022). In addition, students tend to have better critical thinking skills if they are provided with ample opportunities to practice these skills in learning activities. Students who had done more critical thinking assignments gained more in critical thinking skills. The results of this study show that there is a need for instructional strategies that provide students with additional opportunities to analyze, evaluate, and make decisions independently (Roohr & Burkander, 2020; Sujatmika et al., 2024).

While such an expectation is certainly ideal, the reality in the classroom is often different. There is research that shows that the critical thinking skills of kids have not been effectively developed. Students typically have problems with analyzing material, constructing mathematical reasoning, generalizing, and explaining their solutions. Therefore, pupils tend to depend heavily on teacher-like methods and are less skilled in problem solving involving higher-level reasoning. An environment that encourages exploration, reflection, and active student participation in learning improves critical thinking skills (Darling-Hammond et al., 2020; Lau, 2011). Furthermore, students are more likely to develop critical thinking skills if they are provided with sufficient opportunity to practice these skills in learning activities. The frequency of students' engagement in tasks that require critical thinking skills was positively connected to the growth of students' critical thinking skills. Based on the findings of this study, instructional techniques should be designed to provide students with more opportunity to engage in analysis, assessment, and decision-making processes autonomously (Roohr & Burkander, 2020).

Inductive learning is an instructional method that is believed to have the potential to improve the development of critical thinking skills. In this method, students are situated as active learners who create knowledge by observing examples, identifying patterns, formulating conjectures, and drawing inferences. In inductive learning, students are encouraged to organize knowledge, uncover regularities, build concepts, and develop understanding based on the evidence obtained through the process of inquiry and reasoning. This approach is in keeping with the constructivist perspective of learners acting as organizers of information through meaningful learning experiences. Inductive learning helps students improve their ability to absorb information, organize data, and systematically create ideas using systematic cognitive processes (Husni et al., 2019; Sinha et al., 2019).

Inductive learning is often associated with the inductive thinking approach developed by Hilda Taba for educational environments such as the teaching of mathematics. This approach is one of the instructional strategies in information processing that seeks to help students process information, generate concepts, and develop thinking abilities through classification and generalization processes (Joyce et al., 2015; Taba, 1962; Wahyuni et al., 2025). Taba delineated education into three stages: creation of conceptions, analysis of evidence, and application of principles. At these stages, children learn to detect features, to group knowledge, to locate correlations, to draw generalizations, and to test discoveries with evidence. This technique provides opportunities for students to actively create information so that learning is not only procedural mastery but also higher-order thinking skills.

Inductive learning is theoretically connected to the development of critical thinking since it implies the active examination of material and the construction of concepts instead of getting the concepts straight from the teacher. Inductive learning is when students start with specific cases, examples, or observations and then try to recognize patterns, evaluate information, make generalizations, and draw conclusions based on the facts at hand. These activities may offer students an opportunity to participate in cognitive processes that are related to critical thinking, such as analysis, interpretation, inference, and evaluation. In this setting, it is necessary to disentangle inductive learning from inductive reasoning. Inductive learning is the method of instruction in which the learning activities are arranged so that students can derive concepts from specific instances. Inductive thinking is the mental process in which patterns are identified, and generalizations are formed from particular information. Previous studies on inductive thinking said that inductive thinking contributed positively to students' critical thinking abilities through the actions of gathering information, interpreting data, analyzing findings, and forming conclusions based on the evidence (Husni et al., 2019).

Another distinction is to be made between inductive learning and discovery learning. Both approaches involve active student engagement and construction of knowledge. However, discovery-based learning tends to focus more on students' exploration and discovery of concepts, principles, or relationships using inquiry and problem-solving. In contrast, inductive learning can be distinguished by the process of moving from specific cases or observations to broader concepts or generalizations. A meta-analysis found that discovery-based learning had good benefits on students' critical thinking skills, mathematical reasoning, conceptual knowledge, and problem-solving ability (Khairunnisa & Juandi, 2022). This finding provides related evidence on active and student-centred learning, but it should not be construed as direct evidence of the effectiveness of inductive learning. In this study, we therefore focus explicitly on inductive learning and the perceptions and practices of junior high school mathematics teachers in the support of students' critical thinking.

Although previous research has demonstrated the potential contribution of inductive learning to students' learning outcomes, little attention has been paid to teachers' understanding and implementation of inductive learning in junior high school mathematics classrooms. Research in mathematics education has revealed that teachers' beliefs, understandings, and underlying concepts are related to their pedagogical decisions and instructional methods (Koolos et al., 2022; Yang et al., 2020). However, this relationship is not always obvious, as contextual constraints may also impact classroom methods. Epistemological ideas of middle school mathematics teachers affect their conceptualization and construction of learning environments (Karataş & Tığlı, 2021); curriculum and examination requirements can affect their instructional decisions. However, little attention has been paid to how these teacher-level characteristics precisely function in the implementation of inductive learning and how teachers offer opportunities for students to engage in processes related to critical thinking. The importance of this gap is that in inductive learning teachers need to make specific

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pedagogical decisions, such as choosing acceptable cases or examples, sequencing examples, posing challenge questions, giving scaffolding, and responding to students' emerging generalizations. In particular, these teacher-mediated judgments are important for transferring the concepts of inductive learning from an intended pedagogical approach to enacted classroom practice. They also affect how much opportunity kids are given to analyze information, understand evidence, develop inferences, draw conclusions, and justify their thinking. It is, thus, crucial to investigate teachers' opinions and reported practices to understand not just whether inductive learning is adopted, but also how it is interpreted, adapted, and enacted in actual mathematics classrooms. Therefore, this study fills this vacuum by exploring the beliefs and practices of junior high school mathematics teachers on inductive learning, the problems they face, and the pedagogical assistance they require to develop students' critical thinking.

Several studies have found that inductive learning can support students' critical thinking and mathematical abilities (Husni et al., 2019; Kholid & Syafif, 2025). More importantly, inductive learning is particularly relevant to critical thinking because its instructional structure requires students to construct knowledge and generalizations from specific examples or cases. Rather than receiving mathematical ideas directly from the teacher, students are guided to examine examples, compare and classify information, identify patterns, analyse evidence, formulate generalizations, and examine the validity of their conclusions. These activities provide students with opportunities to engage in cognitive processes central to critical thinking, including analysis, interpretation, inference, evaluation, and justification. Such processes are particularly relevant to addressing common difficulties in students' critical thinking, such as analysing information, interpreting evidence, drawing reasoned conclusions, and justifying their reasoning. Thus, inductive learning is not merely an instructional approach that may improve critical thinking outcomes; its instructional structure creates opportunities for students to practise cognitive processes underlying critical thinking in mathematical contexts. However, most previous studies have focused primarily on the effectiveness of inductive instructional approaches and their effects on students' learning outcomes. Consequently, although these studies provide evidence of the potential contribution of inductive learning to students' competencies, they provide limited insight into how teachers understand and enact inductive learning in their everyday classroom practice.

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This issue is important because the implementation of an instructional approach depends not only on its theoretical design but also on how teachers interpret, adapt, and enact it in actual classroom contexts.

Furthermore, the importance of critical thinking in junior high school mathematics learning is that students are required not only to obtain the correct answer, but also to analyze mathematical information, identify relationships and patterns, interpret representations, evaluate the validity of arguments, make reasoned conclusions, and justify their solutions. These procedures are vital for the development of pupils' problem-solving skills in non-routine mathematical problems and the use of mathematical principles in unexpected situations. Moreover, critical thinking development research has highlighted the vital role of instructors in providing learning environments where students are able to exercise analysis, discussion, reflection, and decision-making. The way that teachers see critical thinking can influence the way they teach and the opportunities they provide students for critical thinking (Anggraeny et al., 2022; Gunawardena & Wilson, 2021; Leibovitch et al., 2025; Marcos-vílchez et al., 2026; Zanden et al., 2020). But these works do not precisely examine teachers' grasp of critical thinking in the implementation of inductive learning in junior high school mathematics classrooms. Thus, the perceptions and practices of mathematics teachers in inductive learning, their interpretation of the tenets into classroom practices that provide opportunities for students to think critically, and how they deal with the problems that come in the way of its implementation are not well known. The importance of exploring these issues lies in the fact that the potential of inductive learning to support students' critical thinking depends not only on the theoretical design of inductive learning, but also on the way the teachers interpret, adapt, and enact the approach in the specific pedagogical and curricular context of junior high school mathematics education.

Unlike previous research that was mostly focused on measuring the efficiency of inductive learning in improving students' abilities, this study considers teachers as the key information source to understand how inductive learning is perceived and implemented in junior high school mathematics education. Therefore, this study aims to investigate the perspectives and actions of junior high school mathematics teachers regarding inductive learning in an effort to improve students' critical thinking skills. This research aims to describe teachers' perceptions of inductive learning, the application of teachers' instructional practices that may help students in learning mathematical concepts, the problems experienced by teachers during the implementation, and the pedagogical support needed to develop students' critical thinking in learning mathematics.

METHODS

Research Design

This study employed a qualitative research approach with a phenomenological design to explore the experiences of mathematics teachers in the application of inductive learning and their understanding of the significance of inductive learning in strengthening students' critical thinking skills. The phenomenological approach was chosen as this study focused on the lived experiences of the instructors and the meanings they made of the teaching practices they experienced firsthand in mathematics classroom environments (Creswell & Poth, 2018; Moustakas, 1994). The research was conducted at junior high schools in Tasikmalaya City, West Java, Indonesia. The phenomenological approach in educational research is considered relevant to uncovering teachers' experiences in navigating the dynamics of learning and changes in the social context of education (Creswell & Poth, 2018).

Research Participants

Participants were purposefully selected based on their activity in mathematics education and experience of teaching in the junior high school. Purposive sampling was used so that the researcher could select participants who had experiences related to the topic being investigated (Patton, 2015). The participants were picked by the purposive sampling technique, as phenomenological research demands that participants have direct experience of the phenomena under inquiry. The selection criteria were junior high school mathematics teachers in Tasikmalaya City who actively teach mathematics, have experience in learning activities in the form of examples, pattern identification, and mathematical generalization, and are willing and available to be interviewed and observed while in class. In the study, there were 12 teachers, comprising three males and nine females, with teaching experiences spanning from 2 to 30 years. Teaching experience varied and led to different descriptions of how inductive learning was perceived and implemented in mathematics classrooms. Before data collection, all participants were informed about the study objectives, procedures, voluntary nature of participation, and their rights. Informed consent was obtained from all participants before the interviews and classroom observations. To ensure confidentiality and anonymity, participants' identities were replaced with codes GP-01 to GP-12 throughout the data analysis and reporting.

Data Collection Instruments

Data were acquired from three sources: semi-structured interviews, class observations, and documentation. The different data sources were used to give a complete understanding of junior high school mathematics teachers' beliefs and practices of inductive learning and its function in helping students' critical thinking processes. The interview and classroom observation guides were designed based on the research objectives and the conceptual framework of inductive learning and critical thinking. The interview guide was designed to focus on teachers' perceptions, experiences, practices, obstacles, and pedagogical requirements; the observation guide was developed to focus on the implementation of inductive learning and opportunities for students to engage in critical-thinking processes. The interview and classroom observation guides were produced based on the research objectives and the conceptual framework of inductive learning and critical thinking. The interview guide was developed to explore teachers' opinions, experiences, practices, obstacles, and pedagogical requirements, and the observation guide was developed to explore the application of inductive learning and the participation of students in critical-thinking processes.

Two professionals in mathematics education and qualitative research assessed both instruments. Experts evaluated the relevance, clarity, and congruence of the items with the research goals and conceptual framework. On the basis of their feedback, vague, overlapping, and insufficiently targeted items were amended prior to the data collection. First, the 12 participating junior high school mathematics instructors were interviewed individually in a semi-structured manner via Zoom. Each interview lasted 30–60 minutes and was audio-recorded with the consent of the participants. Open-ended questions and follow-up inquiries were used to explore teachers' understanding and experiences of inductive learning, classroom practices, students' responses, problems, and techniques for encouraging critical thinking. Secondly, the data from the interviews were

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complemented by non-participant classroom observations. The observations focused on the use of inductive learning, including the use of examples, identification of patterns, questioning, scaffolding, generalization, classroom discussion, and opportunities for students to analyze information, interpret evidence, draw conclusions, and justify their reasoning. Observation notes were taken with the observation guide. Third, supporting data were gathered in the form of relevant teaching papers, such as lesson plans or teaching modules, student worksheets (LKPD), instructional materials, assessment assignments, and chosen students' work. These materials provided information on the planning and implementation of inductive learning and students' engagement in critical thinking processes. The three data sources were evaluated for consistency and differences in information across the sources. Interview data gave insight into teachers' opinions and experiences, observations gave evidence of classroom practices, and documentation gave supporting evidence of learning activities. Triangulation improved the trustworthiness of the findings (Creswell & Poth, 2018).

Data Analysis

The data were analyzed using the transcendental phenomenological technique of Moustakas (1994) to explore the lived experiences of teachers applying inductive learning in supporting students' critical thinking. Data were analyzed to study teachers' lived experiences of inductive learning in relation to students' critical-thinking processes using Moustakas' (1994) transcendental phenomenological approach. The epoche was used to bracket previous assumptions about inductive learning and critical thinking to preserve the focus on the experiences of the participants. Interviews were transcribed verbatim, and transcripts were reviewed several times to provide an overall understanding of the data. The study started with horizontalization to find key statements regarding teachers' perceptions, experiences, and behaviors. Redundant, duplicative, or extraneous statements were deleted. Significant statements that represented the meaning of the statements were given initial codes. Similar codes were grouped to form meaning units and sub-themes, which were then arranged into three main overarching themes. For example, comments on the teacher's questions in a step-by-step manner were tagged as "guided questioning." In contrast, comments about examination of examples and identification of regularities were coded as "pattern identification." The coding process was recorded in tables connecting verbatim

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statements, codes, subthemes, and themes, thereby allowing a verifiable link from the raw data to the finished themes. The themes were then merged to give a common interpretation of the teachers' experiences.

Several tactics were used to enhance trustworthiness. Transcripts were reviewed multiple times against codes and emergent themes to ensure interpretations were anchored in participants' stories. Codes, meaning units and themes were reviewed and compared for consistency of interpretation. The audit trail records significant analytical judgments and adjustments made during the development of the subject. Data triangulation was achieved by comparing interview data with classroom observations and pertinent instructional documents, so as to establish convergence and divergence across sources. To facilitate transferability, detailed descriptions of participants, classroom situations, and findings were also supplied. These approaches enhanced the reliability, dependability, confirmability and transferability of the findings (Creswell & Poth, 2018).

RESULT AND DISCUSSION

Analysis of the interview and classroom observation data identified three overarching themes representing junior high school mathematics teachers' experiences of guided inductive learning in relation to students' critical thinking. The themes were developed through the identification of significant statements, coding, grouping of meaning units, and synthesis of recurring patterns across participants' experiences. The three themes were: (1) Teachers' Conceptions and Enactment of Guided Inductive Learning; (2) Scaffolding Students' Critical-Thinking Processes; and (3) Pedagogical Challenges and Professional Needs. Interview data provided information about teachers' perceptions, experiences, and reported practices, while classroom observations provided additional evidence of how guided inductive learning was enacted during mathematics instruction. The two data sources were compared to identify similarities and variations between teachers' reported understandings and observed classroom practices. The quotations presented under each theme were selected to represent recurring experiences among the participants.

Teachers' Conceptions and Enactment of Guided Inductive Learning

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The first theme describes how teachers understood critical thinking and guided inductive learning and how these understandings were reflected in their mathematics teaching practices. The findings showed that teachers generally viewed critical thinking as a process that requires students to understand mathematical problems, analyse available information, consider possible solutions, provide reasons for their answers, and draw conclusions based on evidence. Critical thinking was therefore perceived as extending beyond obtaining the correct answer to include the reasoning used to reach and justify a mathematical conclusion.

This understanding was expressed by several participants. For example, GP-01 described critical thinking as the ability to understand a problem, analyse relevant information, and explain the reasoning behind a selected solution.

GP-01 (3 years of teaching experience)

> "Critical thinking is the ability of students to understand a problem, analyse the information given, and explain why they choose a particular solution. Critical thinkers do not normally answer instantly but try to grasp the problem and defend their solutions."

Similarly, GP-11 emphasized the processes of analysing information, evaluating possible solutions, providing justification, and drawing evidence-based conclusions.

GP-11 (5 years of teaching experience)

> "Critical thinking means analysing information, evaluating alternative solutions, providing justification, and drawing conclusions supported by evidence."

Teachers' descriptions of guided inductive learning were closely related to these reasoning processes. Rather than presenting mathematical concepts or rules directly, teachers described learning as beginning with particular examples or cases from which students were guided to observe similarities, identify patterns, formulate conjectures, and develop generalizations. GP-02, for example, described inductive learning as helping students discover mathematical concepts through patterns.

GP-02 (2 years of teaching experience)

> "Inductive learning helps students discover concepts from patterns and encourages them to think independently."

GP-08 (8 years of teaching experience)

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> "Students examine the examples to identify characteristics, properties, or relationships that always occur. Then they make a rule and test if it is true and makes sense by trying it out on another example."

GP-09 (23 years of experience in teaching)

> "I think it is quite effective because students can understand from concrete things to abstract concepts."

GP-11 (5 years of teaching experience)

> "Students observe patterns, formulate conjectures, test them using different cases, discuss the findings with peers, and finally construct mathematical concepts together."

Taken together, these accounts show that teachers conceptualized guided inductive learning as a progressive process in which students move from specific or concrete examples toward pattern identification, conjecture or rule formulation, verification, and mathematical generalization. The accounts of GP-08 and GP-11 further show that concept construction involved examining relationships and testing emerging ideas rather than merely recognizing patterns. These findings are summarized in Table 1.

Table 1. Coding, Subthemes, and Theme of Teachers' Conceptions and Enactment of Guided Inductive Learning

Verbatim Quote	Coding	Subthemes	Themes
"Critical thinking is the ability of students to understand a problem, analyse the information given, and explain why they choose a particular solution."	Understanding, analysing, and justifying solutions	Conceptions of critical thinking	Teachers' Conceptions and Enactment of Guided Inductive Learning
"Critical thinking means analysing information, evaluating alternative solutions, providing justification, and drawing conclusions supported by evidence."	Analysis, evaluation, justification, and evidence-based conclusions	Conceptions of critical thinking	
"Inductive learning helps students discover concepts from patterns and encourages them to think independently."	Constructing concepts through patterns	Conceptions of guided inductive learning	
"Students observe patterns, formulate conjectures, test them using different cases, discuss the findings with peers, and finally construct mathematical concepts together."	Observation, conjecture, verification, and concept construction	Conceptions of guided inductive learning	

The results showed that teachers conceptualized critical thinking as a reasoning process that included understanding mathematical issues, analyzing information,

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contemplating viable solutions, justifying and reaching conclusions based on evidence. Hence, for teachers, critical thinking was not just about coming up with the right answer, but also the reasoning and explanation to arrive at a mathematical conclusion. This is in line with views that position analysis, evaluation, inference and justification at the core of critical thinking and mathematical reasoning (Facione, 1989; Meyer et al., 2020). Specifically, stresses the need to analyze mathematical thinking, uncover misconceptions, defend pedagogical decisions and use probing tactics to probe learners' reasoning (Mishiwo, 2025).

Teachers have described guided inductive learning as the process of constructing mathematical concepts from specific examples. Students will examine and evaluate cases and detect linkages and patterns, formulate conjectures and then apply these findings to generate more abstract mathematical theories. This idea is consistent with previous studies that point out that inductive reasoning starts from particular cases, the recognition of regularities and their relationship with mathematical structures, which leads to the possibility that learners develop more general mathematical knowledge (Sosa-moguel & Aparicio-landa, 2021). Thus, the teachers' descriptions suggest that guided inductive learning is more than merely analyzing situations, but includes grasping the relationships between the cases and leveraging the relationships between the cases to build larger mathematical ideas.

Classroom observations were broadly consistent with the interview data. Teachers frequently started learning activities with specific examples, issues or contexts before they introduced formal mathematical principles. Students were then asked to compare examples, look for similarities and differences, spot trends, and conclude. Teachers also focused students' attention on essential mathematical links by asking leading questions. How independent the students were, however, varied from classroom to classroom. Some students could recognize patterns and prove their conclusions with numerous cases, while others needed more direction from the teacher, especially in the identification of patterns and generalization phase. The need for such help is also evident in a study on mathematical pattern solving, where scaffolding was utilized to support students' thought process when they encountered difficulties (Firnanda & Susiswo, 2024).

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These results show that the inductive learning witnessed was not only a case of unguided discovery. Teachers still had a role in choosing and sequencing examples, asking probing questions, promoting discussion, providing support, and helping students explore their emerging findings. This result is consistent with research on the relevance of instructional assistance in student-centred inquiry activities (Asyhar, 2023; Lazonder & Harmsen, 2016). This also accords with studies on inquiry-oriented mathematics instruction that indicate that systematic exploration can help pupils to establish mathematical relationships and conceptual understanding (Bouhjar et al., 2021). Although inquiry-oriented learning is not equivalent to guided inductive learning, these findings provide useful evidence for integrating students' active discovery with proper teacher assistance.

Thus, the connection between guided inductive learning and critical thinking can be interpreted in terms of the reasoning tasks incorporated in the learning process. Students are required to look at relevant information when comparing examples, analyze mathematical relationships when identifying patterns, infer from available evidence when formulating generalizations and evaluate and justify when analyzing and explaining conclusions. These processes correspond to major dimensions of critical thinking (Facione, 1989) and are also represented in mathematics education research that investigates interpretation, analysis, evaluation, inference, and explanation in mathematical problem solving (Mulyanto et al., 2023; Noraini & Putri, 2025). Also congruent with Mishiwo (2025) focus on mathematical learning that goes beyond rote routines by offering opportunity for learners' reasoning to be reviewed, questioned, and justified.

Overall, the interview and observation findings indicate that teachers generally understood and enacted guided inductive learning as a structured movement from specific examples toward patterns and mathematical generalizations, with teacher guidance remaining important throughout the process. However, the extent of implementation and students' independence varied across classrooms. These findings do not establish that guided inductive learning improved students' critical-thinking skills. Rather, they indicate that the observed instructional practices provided opportunities for students to engage in processes associated with critical thinking, including analysing

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information, identifying relationships, drawing reasoned conclusions, and justifying their mathematical reasoning.

Scaffolding Students' Critical Thinking through Guided Inductive Learning

The second topic revealed teachers' use of scaffolding to support students' reasoning via guided inductive learning. The key tactics reported were guiding questions, collaborative discussion, justification of solutions, and progressive withdrawal of teacher help. Instead of giving direct mathematical rules, teachers asked questions that led pupils to observe examples, recognize trends, and formulate generalizations.

GP-01 (3 years of teaching experience)

> "I go through questions with students step-by-step. For example, I show them many objects, and I ask them how those objects are related to the mathematical topic that we are going to study."

GP-11 (5 years of teaching experience)

> "I begin with observation questions such as, 'What do you notice? Then I get into analytical inquiries like 'What are the parallels and differences? And then to issues about generalization, like: 'If this pattern persists, what would happen?' "

GP-02 (2 years of teaching experience)

> "Students work together to look at the samples, come up with possible patterns and then explain their thinking to the class."

The teachers also urged the students to justify and analyze mathematical solutions.

GP-08 (8 years of teaching experience)

> "Students communicate their discoveries with each other, and their classmates review or challenge their reasoning."

These experiences imply that scaffolding was used to support students in moving from the observation and identification of patterns to explanation, evaluation and generalization, as summarized in Table 2.

Table 2. Coding, Subthemes, and Theme of Scaffolding Students' Critical-Thinking Processes

Verbatim Quote	Coding	Subthemes	Themes
"I take students through questions in a step-by-step fashion..."	Step-by-step questioning	Guided questioning	Scaffolding Students' Critical-Thinking Processes through Guided Inductive Learning
"What do you see? Can you spot any common patterns?..."	Observation and pattern-directed questioning	Guided questioning	
"I begin with observation questions... analytical questions... and finally generalisation questions..."	Progressive questioning from observation to generalization	Guided questioning	
"Students work together to evaluate the samples... and present their reasoning..."	Collaborative analysis and explanation	Collaborative discussion	

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Verbatim Quote	Coding	Subthemes	Themes
"Students share their findings... and their peers critique or challenge their thinking."	Explanation and peer evaluation	Justification and evaluation	

As shown in Table 2, the classroom observations generally supported the interview findings. The professors assisted students in finding relevant material, comparing situations, identifying correlations and patterns, and drawing conclusions by asking leading questions. Students also developed new ideas and shared their thinking with their classmates. However, the teacher support was not consistent room-to-room. Some students may continue the process of reasoning with few recommendations (e.g., follow-up questions, examples). In contrast, others require more (e.g. more follow-up questions, examples) in the stage of finding patterns and generalizations.

The results showed that scaffolding was involved in the inductive reasoning process and not a general teaching aid. The teachers did not immediately communicate the rules and the conclusions of the maths. However, the questions they asked had students look at individual conditions, compare cases, uncover correlations and trends and generalize. The mathematics teachers saw inductive reasoning as a process of analyzing individual instances, looking for regularities, moving toward more general mathematical connections (Sosa-moguel & Aparicio-landa, 2021). Hence, the present study demonstrated that instructor questioning improved student engagement in an inductive process, but not sufficiently to replace student thinking.

The wording of the questions was highly essential. Ask questions like, "What do you see?" "How are these things alike and different?" "Suppose the pattern continues?" The students moved from observing and comparing to patterning and generalizing. The cognitive burden of questions posed by mathematics teachers can vary, and questions that allow students to analyze, explain, assess and compare mathematical ideas might generate opportunities for more meaningful mathematical thinking (Dejarnette et al., 2020). These questions were part of the inductive process in this study, taking students from particular cases to more general mathematical results.

Another scaffold was collaborative discussion and justification. Students explained their thinking to peers about emergent patterns and conclusions. In these activities, the students had an opportunity to investigate facts, compare the interpretations and evaluate the plausibility of changing discoveries in mathematics. In

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this view, Gunawan et al. (2025) define scaffolding for critical thinking as an ongoing process of instructional support that aims at progressively enabling learners to engage in higher-order thinking abilities. In the present study, this support was included in inductive activities as students went from case investigation to articulation and evaluation of their emergent generalizations.

The amount of instructor help also changed, suggesting the scaffolding was flexible, not rigid. Those who were able to see patterns and connections with little prompting needed less prompting, but those who struggled more required more questions or examples. So the inductive strategy got the teacher's support for the students' answers. However, the students' responsibility to discover correlations and to develop mathematical generalizations remained.

Interviews and observations usually reveal that the scaffolding in inductive learning was mainly through incremental inquiry, collaborative debate, reasoning and flexible teacher support. This type of guidance enabled children to proceed beyond the study of individual cases to the recognition of patterns, the explanation of linkages, the evaluation of new concepts and the formulation of mathematical generalizations. There is no evidence that scaffolding or inductive learning improves students' critical thinking skills. Instead, they show how the investigated teaching styles fostered students' engagement in the reasoning processes of critical thinking in the inductive creation of mathematical ideas.

Pedagogical Challenges and Professional Needs for Implementing Guided Inductive Learning

The third subject outlines the difficulties teachers had in applying inductive learning, and the pedagogical support they deemed required. The most often mentioned problems were limited teaching time, curricular requirements, variations in students' background knowledge and willingness to learn, and student engagement. These factors affected the teachers' capacity to have pupils look at examples, look for patterns, talk about relationships, and develop mathematical generalizations.

The most commonly stated difficulty was lack of instructional time. Teachers saw that inductive exercises required students to spend time exploring examples, discussing connections, noticing patterns, and drawing conclusions before formal mathematical ideas were presented.

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GP-01 (teaching experience of 3 years)

> "The biggest challenge is time in the classroom. "Students still need systematic assistance to avoid misconceptions during concept construction.

GP-09 (23 years teaching experience)

> "Challenges are the diversity of talents of the learners, the restricted time and that not all the kids are fully engaged during the learning."

GP-11 (5 years of teaching experience)

> "Inductive learning cannot always be applied consistently because of time limits, the different abilities of the students, the tendency to learn passively, and the curriculum requirements."

The varying readiness of pupils was particularly crucial because kids did not advance from instances to patterns and generalizations at the same pace. A few examples were enough to make the linkages apparent to some students, whereas other students needed more questions, examples, or explanations. This condition required teachers to vary the quantity of help supplied during the inductive process.

Teachers also pointed to the necessity for more formal instructional support alongside these problems. Participants reported that structured instructional methods, student workbooks, concrete examples of inductive tasks, and professional development could assist them in structuring learning from specific examples to mathematical generalizations.

GP-01 (3 years teaching experience)

> "We want more examples of worksheets and practical implementation in the classroom and training on strategies to develop students' critical thinking."

GP-02 (2 years teaching experience)

> "Teachers could be more systematic in applying this approach with a more structured instructional model and professional training in inductive learning."

The educational requirements and obstacles highlighted by teachers were closely related according to these testimonies. The limited time meant that instructional processes had to be manageable, variances in students' preparation required adaptable teacher support, and the intricacy of structuring inductive exercises called for structured resources and professional learning. These findings are summarized in Table 3.

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Table 3. Coding, Subthemes, and Themes of Pedagogical Challenges and Professional Needs

Verbatim Quote	Coding	Subthemes	Themes
"The biggest challenge is time in the class..."	Limited instructional time	Instructional constraints	Pedagogical Challenges and Professional Needs in Implementing Inductive Learning
"The challenges include the diversity of the pupils' abilities, limited time..."	Student heterogeneity and time constraints	Classroom challenges	
"The time limits, the differing abilities of students... and curriculum requirements..."	Multiple implementation constraints	Instructional and curriculum constraints	
"We need more examples of worksheets and practical implementation..."	Need for practical learning resources	Pedagogical support needs	
"A more structured instructional model and professional training..."	Need for structured guidance and training	Professional development needs	

As shown in Table 3, classroom observations largely confirmed the results of the interviews. Differences were noted in students' engagement and self-directedness in activities such as comparing instances, identifying patterns and forming conclusions. Some students were able to continue these exercises following initial instructor supervision, whereas others needed further questions or demonstrations. In other classrooms, the time required to lead students through these processes also constrained the chances for lengthy debate and exploration of emergent results.

These results indicate a close relationship between time limitations and aspects of the inductive learning process. The journey from concrete examples to abstract mathematical generalities needs opportunities to look at cases, to compare data, to see patterns, to make conclusions, not only to be told mathematical rules. Inductive reasoning is the process of transitioning from specific situations and identified regularities to more general mathematical relationships (Sosa-moguel & Aparicio-landa, 2021). This method helps to explain in the present study why teachers perceived limited instructional time and curriculum demands as key restraints in the use of inductive learning.

Another pedagogical problem was the different levels of students' preparedness. The findings from the interviews and observations demonstrated that students did not recognize trends and make generalizations independently to the same extent. Thus, teacher support has to be responsive to students' responses. This conclusion is associated with the developmental nature of inductive reasoning outlined, who discovered that inductive reasoning develops in a progressive way and incorporates learners' ability to identify regularities and generalize relationships from available information (Vo & Csapo, 2020). The diversity found in the present study thus helps to explain why teachers noted the need for adaptable ways to support students during inductive activities.

Participants' desire for structured learning materials also points to issues. Worksheets and instructional materials may include examples, comparison activities, guiding questions, and chances to construct and explore generalizations. Importantly, such materials should not supply mathematical rules in advance, but organize the knowledge and tasks by means of which students develop them. This is congruent with the model of inductive reasoning (Joyce et al., 2015) where learners are actively organizing information, finding linkages, and developing conceptual knowledge, hence, the teachers' demand for worksheets and structured procedures might be viewed as a demand to make the inductive process more manageable without substituting students' reasoning.

Participants' requests for their professional development were likewise strongly associated with the pedagogical requirements of inductive learning. Teachers must choose suitable examples, arrange them in a coherent manner, frame questions that focus attention on relevant patterns, notice students' challenges, and determine when further guidance is necessary. Leibovitch et al. (2025) demonstrated how professional development may be used to develop teachers' views and understanding of critical-thinking education, and that converting critical-thinking concepts to classroom practice needs attention to teachers' pedagogical understanding. In the present context, professional development could therefore address the operationalization of inductive education, for example, the design of sequences of examples, the formulation of guiding questions, the anticipation of students' challenges in reasoning, and the adaptation of support during the creation of a concept.

The data suggest that the instructional obstacles and professional demands identified by participants were related. Time constraints and curriculum requirements were related to the need for feasible inductive learning procedures, differences in students' readiness were related to the need for flexible support, and the challenge of helping students move from particular examples to mathematical generalizations was

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related to the need for structured materials and practice-oriented professional development. These criteria help explain how inductive learning might be facilitated in real mathematics classrooms, rather than showing that the strategy is beneficial in developing students' critical-thinking skills.

Overall, the interview and observation data suggest that the use of guided inductive learning involves a trade-off between students' opportunities to study examples, recognize trends, and construct generalizations and classroom limits. Time limitations and the curriculum require a systematic learning process. Variations in students' preparedness call for flexible teacher support. These characteristics also help explain why teachers need practical learning resources and professional development to facilitate classroom implementation. However, the study was limited to 12 mathematics teachers in one educational context and did not explicitly test increases in students' critical-thinking skills. Future research should include more diverse settings and student-level data to investigate further students' engagement in inductive and critical thinking processes.

Essence of Teachers' Lived Experiences

The essence of the teachers' lived experiences indicated that the implementation of inductive learning was a continual balancing act between the students' active reasoning and the teacher's suitable direction. By using questioning, discussion, reasoning, and adaptive support, teachers moved students from investigating and comparing individual examples to detecting patterns, explaining relationships, and creating mathematical generalizations. The interview and classroom observation results also indicated that the level of guidance varied according to the students' readiness and problems, as well as the limited instructional time and curriculum requirements affecting the enactment of these activities. These experiences prompted teachers to articulate a need for more structured teaching processes, adaptive learning materials and practical professional development. Overall, the teachers viewed inductive learning not just as the presentation of examples before the introduction of mathematical principles, but as an adaptable instructional process that offered students opportunities to analyze information, identify linkages, justify concepts and create reasoned conclusions.

Implications, Limitations, and Recommendations

The findings have a number of consequences for the teaching of mathematics. Inductive learning may be assisted by structured instructional methods, flexible learning materials, guided questions, and instructor support responsive to students' varying levels of preparedness. Professional development can also allow teachers to generate sequences of examples, anticipate students' difficulties in thinking, and provide appropriate support during the formation of concepts. However, this study was conducted with 12 junior high school mathematics teachers in a particular educational context, which restricts the transferability of the findings. Furthermore, although classroom observations offered evidence of students' engagement in reasoning tasks, the study did not directly test changes in students' critical-thinking skills. It is suggested that future studies explore inductive learning in more diverse school settings and include student-level data and direct measurements of critical thinking. Further research could also create and test organized teaching models and learning resources to address the pedagogical issues reported by teachers in this study.

CONCLUSION

This study explored junior high school mathematics teachers' perceptions and practices of guided inductive learning in relation to students' critical-thinking processes. The findings revealed three interconnected themes. First, teachers understood and enacted guided inductive learning as a structured process in which students examined examples, identified patterns and relationships, formulated generalizations, and examined their conclusions with teacher guidance. Second, teachers supported students' reasoning through guiding questions, collaborative discussion, justification, and adaptive scaffolding, indicating that teacher facilitation remained essential throughout the inductive process rather than leaving students to discover mathematical concepts independently. Third, the enactment of guided inductive learning was constrained by limited instructional time, curriculum demands, differences in students' readiness, and the availability of appropriate learning resources. Teachers therefore expressed a need for more structured learning procedures, practical instructional materials, and professional development to support its classroom implementation. Taken together, these findings show that guided inductive learning was perceived and practiced not merely as learning from examples, but as a teacher-supported process that engaged students in examining information, identifying relationships, constructing and justifying generalizations, and evaluating conclusions. These reasoning activities reflect processes associated with critical thinking, although this study did not directly measure changes in students' critical-thinking ability. The findings provide an empirical basis for designing more systematic pedagogical support for guided inductive learning in junior high school mathematics classrooms.

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AUTHOR CONTRIBUTIONS

The following are the contributions made by each author in this research:

First Author: Conceptualization, writing - original draft, editing, and visualization;

Second Author: Validation and supervision;

Third Author: Validation and supervision;

Fourth Author: Review, formal analysis, and methodology;

Fifth Author: Review, formal analysis, and methodology.

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