Vol. 10, No. 1 (2026) 147-166 ISSN: 2597-4866
Indonesian Journal of Primary Education

Identifying mathematical problems in classroom action research proposals: a qualitative case study of pre-service primary teachers

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Received 28 April 2026; First Revised 18 May 2026; Accepted 28 May 2026
First Available Online 1 June 2026; Publication Date 1 June 2026

Abstract

The ability to accurately identify learning problems is a fundamental stage in conducting Classroom Action Research, particularly in elementary mathematics learning. However, pre-service primary teachers often focus on general classroom issues rather than students' specific mathematical difficulties. Although previous studies have examined professional noticing and reflective practice in teacher education, limited attention has been given to how pre-service primary teachers identify mathematical problems when formulating Classroom Action Research proposals. This study aimed to analyze the levels of mathematical problem identification reflected in pre-service primary teachers' proposals. A qualitative case study design was employed, involving 32 pre-service primary teachers enrolled in a Classroom Action Research course during the 2025/2026 academic year. Data were collected through proposal document analysis, semi-structured interviews, revised proposals, and classroom discussion documentation. The data were analyzed thematically through open coding, axial coding, and selective coding. The findings revealed four levels of mathematical problem identification: general learning problems, procedural problems, conceptual mathematical problems, and reflective-pedagogical problems. Most participants remained at the general and procedural levels, indicating that they tended to recognize visible classroom symptoms and procedural errors rather than diagnose underlying mathematical difficulties. This study contributes an empirical four-level framework that extends discussions on professional noticing, diagnostic competence, and pedagogical reasoning by showing how pre-service teachers progress from recognizing classroom symptoms to interpreting students' mathematical thinking and connecting it with instructional decision-making. The findings also provide implications for strengthening Classroom Action Research courses through diagnostic training and analysis of students' mathematical learning difficulties.

Keywords: *Identification of mathematical problems; Classroom Action Research; Professional noticing; Diagnostic competence, Pedagogical reasoning.*

INTRODUCTION

Mathematics learning in elementary school requires teachers not only to deliver instructional content effectively but also to understand the various learning difficulties students encounter. These difficulties may include conceptual misconceptions, representational errors, limited reasoning abilities, and students' inability to connect mathematical concepts with contextual situations (Ball et al., 2008). In mathematics learning, students' difficulties often emerge not only in procedural aspects but also in how they understand and represent mathematical concepts (Ball et al., 2008). Furthermore, teachers' ability to notice and interpret students' mathematical thinking processes plays an important role in understanding students' learning difficulties more deeply (Jacobs et al., 2010). Therefore, elementary school teachers need the ability to accurately identify mathematics learning problems so that the instructional actions designed truly correspond to students' needs (Hoth et al., 2022; Jazby et al., 2023). This ability constitutes an essential component of teachers' professional competence, particularly in the processes of reflection and instructional improvement.

In elementary mathematics education, not every classroom problem can be directly regarded as a mathematical learning problem. Issues such as low achievement, limited participation, or low learning motivation often represent observable symptoms rather than the underlying causes of students' difficulties. For Classroom Action Research to generate meaningful instructional improvements, teachers need to identify the mathematical roots of these problems, such as misconceptions about fractions, representational errors, procedural misunderstandings, difficulties in mathematical reasoning, or inadequate conceptual understanding. Classroom Action Research is commonly conducted through cyclical stages of planning, action implementation, observation, and reflection to improve classroom learning practices (Pertiwi et al., 2023). Without such analysis, instructional interventions may address surface-level classroom conditions while leaving students' mathematical difficulties unresolved. Therefore, the ability to distinguish between general learning problems and conceptually grounded mathematical problems is a critical competence for pre-service elementary school teachers.

Within the context of teacher education, the ability to identify mathematics learning problems should begin to be developed when pre-service teachers participate in Classroom Action Research courses (Cárdenas Claros et al., 2024; Nurlaelasari & Saputra, 2024). Classroom Action Research is a form of reflective inquiry conducted to improve the quality of instruction through continuous processes of problem identification, action planning, implementation, observation, and reflection (Nurlaelasari & Saputra, 2024; Simmons et al., 2021). Reflective practice in teacher education is important because it helps pre-service teachers understand instructional problems more deeply before determining improvement strategies (Ngololo & Kanandjebo, 2021). In addition, reflective practice enables pre-service teachers to develop professional noticing and pedagogical reasoning in understanding students' thinking processes during mathematics learning (Cribbs et al., 2024). Thus, the ability to identify problems is a fundamental stage in preparing Classroom Action Research proposals, as it determines the quality of the reflections and instructional actions designed by pre-service teachers.

However, in practice, pre-service elementary school teachers often experience difficulties in formulating mathematics learning problems in a specific and substantive manner (Burgos & Godino, 2021; Cárdenas Claros et al., 2024). Many Classroom Action Research proposals still formulate problems in terms of low achievement, limited student participation, or uninteresting instruction without examining whether these classroom symptoms originate from specific mathematical difficulties. Consequently, the proposed instructional actions often focus on changing learning media or teaching strategies rather than addressing misconceptions, conceptual misunderstandings, representational difficulties, or procedural errors experienced by students. This condition indicates that pre-service teachers still struggle to connect classroom phenomena with students' mathematical thinking processes (Larrain & Kaiser, 2022; Dröse & Prediger, 2023; Jacobs et al., 2010; Jamaludin et al., 2022). Studies on teacher noticing suggest that prospective teachers frequently concentrate on observable classroom events, whereas students' underlying mathematical reasoning often receives less attention (Jacobs et al., 2010). Moreover, studies on mathematics teacher education indicate that pre-service teachers are often more focused on instructional procedures and teaching strategies than on conceptual analyses of students' learning difficulties (Copur-Gencturk & Tolar, 2022). As a result, problem identification tends to remain administrative in nature and does not yet address the root causes of students' mathematical difficulties in depth. This issue suggests the need for a more specific framework to describe how pre-service primary teachers identify mathematical problems in Classroom Action Research proposals. Rather than merely examining whether pre-service teachers are able to formulate research problems, this study focuses on the levels of sophistication reflected in their mathematical problem identification.

From Deborah Loewenberg Ball's perspective, teachers need the ability to understand how students learn mathematical concepts, including recognizing patterns of errors, misconceptions, and learning obstacles that emerge during mathematics instruction (Ball et al., 2008). This ability is essential because the quality of problem identification determines the appropriateness of the actions designed in Classroom Action Research. When learning problems are inaccurately identified, the resulting instructional actions often focus solely on changing teaching methods or learning media, without addressing the root causes of students' mathematical learning difficulties (Dröse & Prediger, 2023).

Furthermore, the ability to identify mathematical problems is closely related to teachers' professional noticing abilities. Professional noticing refers to teachers' ability to attend to, interpret, and respond to students' thinking processes during instruction (Dindyal et al., 2021; Jazby et al., 2023; Sherin et al., 2011). In mathematics learning, this ability is essential for understanding how students construct solution strategies, make errors, and develop conceptual understanding (Pertiwi et al., 2023; Dindyal et al., 2021; Santagata et al., 2021). Strong noticing abilities help pre-service teachers design instructional actions that are more relevant to students' needs (Jacobs et al., 2010; König et al., 2022). In this study, mathematical problem identification is understood as the ability of pre-service teachers to recognize, interpret, and formulate students' mathematics learning difficulties as researchable problems in Classroom Action Research proposals. This construct is examined through two complementary theoretical lenses: Mathematical Knowledge for Teaching and professional noticing. Mathematical Knowledge for Teaching provides a basis for examining whether pre-service teachers are able to recognize students' conceptual difficulties, procedural errors, and misconceptions, while professional noticing explains how they attend to and interpret students' mathematical thinking. Mathematical problem identification is also connected to diagnostic competence because pre-service teachers need to infer the possible causes of students' errors, misconceptions, or procedural difficulties. Furthermore, it involves pedagogical reasoning because the identified problems must be linked to appropriate instructional actions. Thus, mathematical problem identification serves as an integrative competence that connects mathematical knowledge, noticing, diagnosis, and pedagogical decision-making in the context of Classroom Action Research.

Previous studies on Classroom Action Research in teacher education have generally emphasized proposal preparation, reflective practice, and the implementation of instructional actions (Nugraini & Ramadhan, 2023; Cárdenas Claros et al., 2024; Calamlam & Calamlam, 2025). In mathematics teacher education, pre-service teachers are also often reported to focus more on instructional procedures and teaching strategies than on analyzing students' mathematical thinking processes (Yang et al., 2023; Copur-Gencturk & Tolar, 2022; Dröse & Prediger, 2023). These findings indicate that further attention is needed to how pre-service teachers construct mathematical problems as the basis for reflective inquiry in Classroom Action Research.

Although previous studies have examined professional noticing, reflective practice, and Classroom Action Research in teacher education, limited attention has been given to the specific process through which pre-service primary teachers identify mathematical problems before designing instructional interventions. Existing studies tend to emphasize teachers' ability to notice students' thinking during instruction, develop reflective practice, or prepare Classroom Action Research proposals in general. However, they rarely explain the developmental levels of mathematical problem identification reflected in pre-service teachers' proposals. This gap is important because the quality of problem identification determines whether the proposed instructional actions address general classroom symptoms or the underlying mathematical difficulties experienced by students. Therefore, this study addresses the gap by developing an empirical four-level framework of mathematical problem identification. The framework offers a specific conceptual lens for understanding how pre-service teachers progress from recognizing general classroom symptoms to diagnosing mathematical misconceptions and relating them to pedagogical decision-making.

Based on the foregoing discussion, this study aims to analyze the levels of mathematical problem identification demonstrated by pre-service primary teachers in mathematics Classroom Action Research proposals. Specifically, this study seeks to develop an empirical framework that describes how pre-service teachers progress from identifying general classroom problems to recognizing procedural errors, conceptual mathematical difficulties, and reflective-pedagogical problems. The findings are expected to provide an overview of the quality of problem identification conducted by pre-service teachers and to serve as a basis for developing more reflective and contextual Classroom Action Research instruction in elementary teacher education.

RESEARCH METHODS

This study employed a qualitative approach using a case study design. The selection of this design was based on the purpose of the study, namely, to obtain an in-depth understanding of pre-service elementary school teachers' abilities to identify mathematical problems in Classroom Action Research proposals. A qualitative approach enabled the researchers to analyze how pre-service teachers understood, interpreted, and constructed mathematics learning problems within the authentic context of preparing Classroom Action Research proposals. A case study approach was selected because it facilitates a detailed examination of a phenomenon within its natural setting, especially when contextual factors are closely intertwined with the phenomenon itself (Yin, 2018). In addition, case studies in educational research allow researchers to gain a more comprehensive understanding of participants' thinking processes, experiences, and interpretations related to the phenomenon under investigation (Creswell & Poth, 2016).

The participants consisted of 32 pre-service teachers enrolled in the Elementary School Teacher Education Program who were taking the Classroom Action Research course during the even semester of the 2025/2026 academic year. Participants were selected using purposive sampling because all of them had prepared mathematics Classroom Action Research proposals as part of their course assignments, which served as the primary source of data in this study. The participants represented prospective elementary school teachers who had completed school observation activities and were in the process of developing research-based instructional improvement plans. The primary data consisted of students' Classroom Action Research proposal documents, particularly the background and problem identification sections related to elementary mathematics learning.

To obtain deeper qualitative information, semi-structured interviews were conducted with eight participants who were selected purposively based on variations in the quality of mathematical problem identification found in their proposals. The selected participants represented the four levels of mathematical problem identification, with two participants from each level: general learning problems, procedural problems, conceptual mathematical problems, and reflective-pedagogical problems. This selection was intended to capture diverse forms of reasoning used by pre-service teachers when formulating mathematical learning problems and determining instructional actions in their Classroom Action Research proposals.

The research procedure is summarized in Figure 1. The study involved pre-service primary teachers who had conducted classroom observations and prepared mathematics Classroom Action Research proposals. The collected data were then analyzed thematically to identify levels of mathematical problem identification.

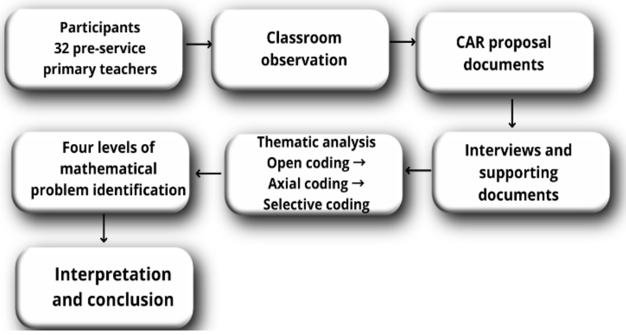

Figure 1 (Research Procedure)

As shown in Figure 1, the research process moved from classroom observation and proposal analysis to thematic coding and interpretation. This process resulted in four levels of mathematical problem identification among pre-service primary teachers.

Data were collected through document analysis and interviews. Document analysis was conducted to identify how pre-service teachers formulated mathematics learning problems, the sources of the problems raised, and the depth of their analysis of students' learning difficulties. Meanwhile, interviews were conducted to explore the participants' reasons for selecting particular Classroom Action Research problems, their understanding of students' mathematics learning difficulties, and their considerations in choosing instructional improvement strategies. The combination of document analysis and interviews was intended to obtain more comprehensive data and enhance the credibility of the study.

The primary instrument in this study was the researcher, while supporting instruments included proposal analysis guidelines and interview guidelines. Within qualitative inquiry, researchers play a central role in generating and interpreting data, allowing them to construct rich interpretations of participants' experiences and meanings (Creswell & Poth, 2016). The proposal analysis guidelines were developed based on indicators of mathematical problem identification abilities derived from Deborah Loewenberg Ball's concept of Mathematical Knowledge for Teaching and Miriam Sherin's concept of professional noticing. Mathematical Knowledge for Teaching emphasizes teachers' abilities to understand conceptual difficulties, misconceptions, and students' mathematical thinking processes (Ball et al., 2008), whereas professional noticing refers to teachers' abilities to attend to, interpret, and respond to students' mathematical thinking during instruction (Jacobs et al., 2010). Based on these frameworks, the analysis indicators included: (1) the ability to recognize students' mathematics learning difficulties, (2) the ability to distinguish between general pedagogical problems and mathematical problems, (3) the ability to explain the causes of mathematics learning difficulties, and (4) the alignment between the identified problems and the instructional actions designed in the Classroom Action Research proposal.

To ensure a systematic analysis of participants' abilities to identify mathematical problems, a coding framework was developed based on the concepts of Mathematical Knowledge for Teaching and professional noticing. These frameworks emphasize teachers' abilities to recognize students' mathematical difficulties, interpret the underlying causes of errors, and connect instructional decisions with students' learning needs. The coding framework was used as a guide during the analysis of proposal documents and interview data. Table 1 presents the indicators employed to classify participants' mathematical problem identification abilities.

Table 1
(Coding Categories and Indicators for Mathematical Problem Identification)

Coding Category	Indicator
General Learning Problems	Focuses on low achievement, motivation, participation, or classroom atmosphere without explaining specific mathematical difficulties
Procedural Problems	Identifies students' errors in applying formulas, algorithms, or solution procedures
Conceptual Mathematical Problems	Identifies misconceptions, conceptual misunderstandings, or difficulties in mathematical reasoning
Reflective-Pedagogical Problems	Relates students' difficulties to instructional design, teaching approaches, or learning experiences

These indicators served as the basis for the coding and categorization process. The analysis proceeded through three coding stages, namely open coding, axial coding, and selective coding, to identify patterns and generate themes from the data.

Data were analyzed thematically through three stages: data reduction, data display, and conclusion drawing. This analytical model was employed to help the researchers systematically organize, interpret, and identify meaningful patterns within qualitative data (Miles et al., 2014). During the data reduction stage, students' proposals were coded based on the characteristics of mathematical problem identification found in the Classroom Action Research proposals. The coding process was conducted through three stages. First, open coding was used to identify various forms of mathematical problem statements appearing in the proposals and interview transcripts. Second, axial coding was conducted to group similar codes based on common characteristics and patterns of problem identification. Third, selective coding was employed to develop broader themes that ultimately resulted in four categories of mathematical problem identification: general learning problems, procedural problems, conceptual mathematical problems, and reflective-pedagogical problems. The four categories were not predetermined prior to analysis but emerged inductively through the iterative coding and comparison of proposal documents and interview data. To strengthen the credibility and reliability of the coding process, the initial coding results were reviewed independently by members of the research team. Each researcher examined selected proposal excerpts and interview transcripts to determine whether the data were appropriately classified into the four categories. Differences in interpretation were discussed through peer debriefing until consensus was reached regarding the classification of participants' responses. In addition, the emerging categories were compared with the theoretical constructs of Mathematical Knowledge for Teaching and professional noticing to ensure conceptual alignment between the empirical data and the theoretical framework. Several representative excerpts from proposal documents and interviews were re-examined to confirm that each category accurately reflected the characteristics of participants' mathematical problem identification. Furthermore, the final categories were reviewed by two mathematics education experts to assess whether the category descriptions, indicators, and representative excerpts were theoretically relevant and empirically appropriate. Feedback from the experts was used to refine the wording of category labels and clarify the distinctions among the four levels of mathematical problem identification. Coding procedures were employed to organize qualitative information into meaningful categories, thereby facilitating the identification of recurring themes and relationships across the dataset (Saldaña, 2021). The data display stage was conducted using tables, proposal excerpts, and narrative descriptions to illustrate patterns in pre-service teachers' abilities to identify mathematical problems. The final stage involved drawing conclusions regarding the characteristics of participants' abilities and the factors influencing the quality of problem identification in Classroom Action Research proposals.

To ensure the trustworthiness of the data, the study employed source triangulation and method triangulation. Source triangulation was conducted by comparing the results of proposal analysis with interview findings, while method triangulation was carried out through the combined use of document analysis and interviews. In addition, member checking was conducted with several participants to ensure that the researchers' interpretations accurately reflected the participants' intended meanings.

RESULTS AND DISCUSSION

This study aimed to analyze the ability of pre-service elementary school teachers to identify mathematical problems in mathematics Classroom Action Research proposals. The research data were obtained from the analysis of 32 Classroom Action Research proposals developed by pre-service elementary school teachers enrolled in the Classroom Action Research course during the even semester of the 2025/2026 academic year. Supporting data were collected through semi-structured interviews, revised proposal documents, classroom discussion documentation, and students' reflective notes during the proposal development process.

The research process began with participants conducting observations of mathematics instruction in elementary schools, followed by the preparation of Classroom Action Research proposals based on the problems identified during the observations. The proposals were then analyzed to examine how participants identified and constructed mathematical problems in the context of mathematics learning.

The analysis revealed that the participants' ability to identify mathematical problems varied considerably. Most participants still focused on general classroom issues, while only a small number were able to identify mathematical difficulties in a more conceptual and reflective manner. This condition indicates that pre-service teachers tend to pay greater attention to classroom behavior and activities than to understanding students' mathematical thinking processes in depth. These findings are consistent with studies on professional noticing, which suggest that pre-service teachers are generally at an early stage of interpreting students' thinking and tend to focus on surface-level aspects of instruction (van Es et al., 2017). Based on the coding results from proposal documents and interviews, the participants' abilities to identify mathematical problems were classified into four levels: (1) general learning problems, (2) procedural problems, (3) conceptual mathematical problems, and (4) reflective-pedagogical problems. This classification indicates the development of participants' pedagogical reasoning abilities in understanding the relationship between students' learning difficulties, mathematical concepts, and the instructional actions designed.

Table 2
(Distribution of Participants' Abilities in Identifying Mathematical Problems)

Level of Problem Identification	Number of Participants	Percentage
General learning problems	14	43.75%
Procedural problems	9	28.13%
Conceptual mathematical problems	6	18.75%
Reflective-pedagogical problems	3	9.37%

The distribution shown in Table 2 indicates that most pre-service teachers were still positioned at the early stages of mathematical problem identification. The dominance of general learning problems and procedural problems suggests that many participants were able to notice visible classroom symptoms or students' procedural errors, but had not yet developed sufficient diagnostic reasoning to interpret the conceptual causes underlying those difficulties. From the perspective of professional noticing development, this finding reflects an early noticing stage in which pre-service teachers tend to attend to observable classroom events, such as student participation, motivation, and achievement, before being able to interpret students' mathematical thinking in depth. Therefore, the distribution of participants across the four levels should not only be understood as a descriptive result, but also as an indication of the developmental trajectory of pre-service teachers' noticing and diagnostic competence.

To provide a clearer overview of the characteristics of each level, Table 3 summarizes the key indicators, representative examples, and interpretations of the four levels of mathematical problem identification that emerged from the analysis. The table illustrates the progression from general descriptions of classroom problems toward more sophisticated interpretations that connect students' mathematical difficulties with instructional design and pedagogical reasoning.

Table 3
(Characteristics of Mathematical Problem Identification Levels)

Level	Key Indicators	Example	Interpre-tation
General Learning Problems	Focus on achievement, motivation, participation, or classroom atmosphere	Students appeared less active during mathematics learning.	Problem identification remains at the level of observable classroom symptoms.
Procedural Problems	Focus on formula use, algorithms, or solution procedures	Students confuse the formulas for squares and rectangles.	Mathematical errors are recognized, but analysis remains procedural.
Conceptual Mathematical Problems	Identify misconceptions and conceptual misunderstandings	Students believe that 1/4 is greater than 1/2 because 4 is greater than 2.	Participants begin to interpret students' mathematical reasoning and misconceptions.
Reflective Pedagogical Problems	Relate students' difficulties to instructional design and teaching practices	Students were introduced to volume formulas before developing conceptual understanding.	Participants demonstrate pedagogical reasoning by linking learning difficulties to instructional decisions.

As shown in Table 3, the four levels reflect increasing sophistication in participants' abilities to identify mathematical problems. While participants at the general and procedural levels tended to focus on observable classroom conditions and procedural errors, those at the conceptual and reflective-pedagogical levels demonstrated deeper interpretations of students' mathematical thinking and the instructional factors influencing learning difficulties. The following sections describe each level in greater detail.

4.1 General Learning Problems (n=14)

The data indicate that most participants were still at the level of general learning problems. Participants at this level tended to identify problems based on surface-level classroom conditions, such as low learning achievement, lack of learning motivation, or limited student participation during mathematics instruction. One excerpt from a participant's proposal illustrates this condition:

"Based on the observation results, students appeared less active during mathematics learning, resulting in low student achievement."

This excerpt indicates that the participant is still focused on general classroom symptoms and has not yet explained the specific mathematical difficulties experienced by students. During the interviews, participants admitted that they found it easier to observe students' behavior than to understand the conceptual mathematical difficulties experienced by students. This can be seen in the following interview excerpt:

R: "When conducting classroom observations, what was the first thing you paid attention to when determining the problem for Classroom Action Research?"

S12: "I usually first observe whether the students are active or not during the lesson."

R: "Then how did you determine that there was a problem in mathematics learning?"

S12: "If the students are less active and their scores are low, it means the learning process is not interesting enough."

R: "Did you also observe the students' conceptual difficulties in mathematics?"

S12: "Not really. I focused more on the classroom condition first."

These findings indicate that the participants still perceived Classroom Action Research primarily as an effort to improve the classroom atmosphere rather than as a process of reflective inquiry aimed at understanding students' mathematical learning difficulties. This condition was reflected in the participants' problem identification, which emphasized low achievement and limited student participation without explaining the specific mathematical difficulties experienced by students.

> Berdasarkan hasil observasi dan wawancara yang telah dilakukan di kelas III SD Kreatif Harapan Bangsa, ditemukan bahwa keaktifan siswa dalam proses pembelajaran matematika masih rendah. Hal tersebut terlihat dari masih adanya siswa yang malu untuk bertanya dan menyampaikan jawaban.

> Rendahnya keaktifan dan kepercayaan diri siswa juga berdampak terhadap proses dan hasil belajar matematika. Siswa yang pasif cenderung kurang berpartisipasi dalam pembelajaran sehingga pemahaman terhadap materi menjadi kurang optimal.

Figure 2
(Example of A Participant's Problem Identification That Still Focuses on General Classroom Symptoms)

In addition, observations during proposal presentations revealed that several participants immediately proposed the use of interactive learning media without being able to explain the specific mathematical concepts that needed improvement (Pertiwi et al., 2023). This condition indicates a solution-oriented tendency, in which participants focused more on selecting instructional solutions than on diagnosing the root causes of students' mathematical difficulties. From Deborah Loewenberg Ball's perspective, teachers' competence involves not only mastery of mathematical content, but also the ability to understand how mathematical concepts are learned by students (Ball et al., 2008).

Conceptually, the tendency to formulate problems at the general learning level may be understood as a characteristic of pre-service teachers' early professional development. At this stage, pre-service teachers often rely on what is immediately visible in the classroom, such as students' passivity, low scores, or lack of motivation. These aspects are easier to observe than students' underlying mathematical reasoning. This finding suggests that classroom observation alone does not automatically lead pre-service teachers to identify mathematics-specific learning problems. Without structured support to analyze students' work, errors, and misconceptions, pre-service teachers may interpret learning problems as general pedagogical issues rather than as difficulties rooted in mathematical concepts.

4.2 Procedural Problems (n=9)

At the procedural problem level, participants began to identify students' mathematical errors more specifically; however, their analysis remained limited to problem-solving procedures. One example was found in the topic of the perimeter of plane figures. Students experienced difficulties in applying perimeter formulas because they frequently confused the formulas for squares and rectangles.

R: "In your opinion, what is the students' main difficulty in the topic of the perimeter of plane figures?"

S7: "Students often confuse the formulas for squares and rectangles."

R: "Why do you think students make such mistakes?"

S7: "I think it is because they have not memorized the formulas well and still lack practice."

R: "Is it possible that students do not yet understand the concept of perimeter itself?"

S7: "That may also be true, but I see the problem more in their incorrect use of formulas."

This interview excerpt indicates that the participant had begun to recognize students' mathematical errors, but these errors were still understood primarily as procedural mistakes in applying formulas and completing solution steps. The participant had not fully analyzed the possibility of underlying conceptual difficulties causing the students' errors. This condition suggests that participants still viewed mathematics learning mainly as a procedural activity, leading them to emphasize practice exercises and reinforcement of formula application rather than the development of students' conceptual understanding of mathematics.

These findings indicate that participants continued to perceive mathematics learning primarily as a procedural activity. Such a perspective led them to focus more on repetitive practice and procedural reinforcement than on understanding the mathematical concepts underlying the use of formulas.

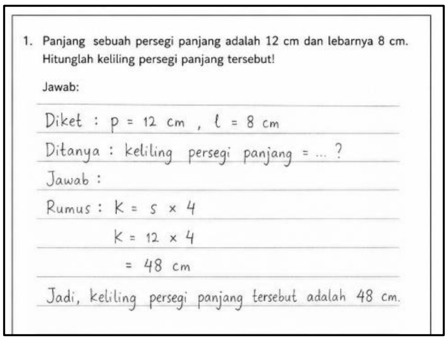

Figure 3
(Example of a Participant's Analysis of Students' Procedural Errors)

This procedural orientation indicates a transitional stage in pre-service teachers' mathematical problem identification. Compared with the general learning problem level, participants at this level had begun to notice mathematics-related errors. However, their interpretation remained limited to the incorrect use of formulas, algorithms, or solution steps. From the perspective of diagnostic competence, this suggests that participants were able to identify the presence of mathematical errors but had not yet fully inferred the conceptual sources of those errors. In other words, their diagnostic reasoning had developed beyond general classroom observation, but had not yet reached the level of interpreting students' conceptual understanding. This finding highlights the need for teacher education programs to provide explicit opportunities for pre-service teachers to distinguish between procedural mistakes and conceptual misconceptions.

4.3 Conceptual Mathematical Problems (n=6)

In contrast to the previous two levels, participants at the conceptual mathematical level began to identify students' misconceptions more deeply. They not only described students' errors, but also explained the nature of the conceptual misunderstandings involved. One example was found in the topic of fractions:

"Students believe that 1/4 is greater than 1/2 because the number 4 is greater than 2."

The following interview excerpt illustrates this condition:

R: "Why did you conclude that students experienced difficulties in the topic of fractions?"

S21: "Because some students said that 1/4 is greater than 1/2."

R: "In your opinion, why did the students think that way?"

S21: "They saw that 4 is greater than 2, so they assumed that 1/4 has a greater value."

R: "What does that indicate about the students' conceptual understanding?"

S21: "It means that students do not yet understand the relationship between a part and a whole. They do not understand that the larger the denominator, the smaller the part represented."

This interview excerpt indicates that the participant had begun to interpret students' mathematical reasoning rather than merely focusing on whether answers were correct or incorrect. The participant was able to recognize that the students' errors were caused by misconceptions regarding fractions as parts of a whole. This ability reflects the development of professional noticing, namely the ability to attend to and interpret students' mathematical thinking processes during instruction. Previous studies have shown that professional noticing helps pre-service teachers understand students' reasoning strategies and misconceptions more deeply in mathematics learning (van Es et al., 2017). Furthermore, noticing abilities enable pre-service teachers to move beyond merely observing classroom behavior toward interpreting students' mathematical reasoning in a more reflective manner (Estapa & Amador, 2016).

Interestingly, participants at the conceptual level generally had direct experience observing mathematics instruction in elementary schools. These experiences appeared to make them more sensitive to students' reasoning strategies and misconceptions compared to participants who focused solely on the technical preparation of Classroom Action Research proposals.

In addition, the revised proposals indicated that discussion and reflection processes helped participants improve the quality of their identification of mathematical problems. In the initial proposals, participants tended to describe only general classroom problems; however, after engaging in reflective discussions, they began to explain the forms of misconceptions or conceptual difficulties experienced by students more specifically, as seen in figure 4 below.

Berdasarkan hasil observasi dan wawancara yang telah dilakukan di kelas III SD Kreatif Harapan Bangsa, ditemukan bahwa keaktifan siswa dalam proses pembelajaran matematika masih rendah. Hal tersebut terlihat dari masih adanya siswa yang malu untuk bertanya, ragu menyampaikan jawaban, serta cenderung pasif ketika diminta menjelaskan alasan dari jawaban yang diberikan. Setelah dilakukan analisis lebih lanjut, ditemukan bahwa rendahnya keaktifan siswa berkaitan dengan adanya kesulitan konsep yang dialami siswa pada materi pecahan. Beberapa siswa mengalami miskonsepsi dalam membandingkan nilai pecahan sederhana, seperti menganggap bahwa 1/4 lebih besar dari 1/2 karena angka 4 lebih besar dari 2. Hasil wawancara menunjukkan bahwa siswa masih memahami pecahan berdasarkan besar angka penyebut, bukan berdasarkan makna bagian dari keseluruhan. Kondisi tersebut menyebabkan siswa kurang percaya diri untuk menyampaikan pendapat atau menjelaskan proses berpikirnya dalam pembelajaran matematika. Dengan demikian, rendahnya keaktifan siswa tidak hanya disebabkan oleh faktor keberanian atau motivasi belajar, tetapi juga berkaitan dengan belum kuatnya pemahaman konsep matematika yang dimiliki siswa.

Figure 4
(Changes in Participants' Problem Identification from The General Level to The Conceptual Level After The Processes of Reflection And Discussion)

The emergence of conceptual mathematical problem identification indicates a more advanced stage of professional noticing. At this level, pre-service teachers no longer focus only on whether students' answers are correct or incorrect, but begin to interpret the reasoning behind students' responses. This shift is important because identifying misconceptions requires pre-service teachers to connect students' errors with mathematical meanings, representations, and conceptual relationships. Thus, the conceptual level reflects the development of diagnostic competence, as participants begin to explain why students experience particular mathematical difficulties. The movement from procedural to conceptual problem identification also shows that pre-service teachers' noticing can be strengthened through reflective discussions, analysis of student responses, and opportunities to examine the mathematical meaning behind students' errors.

4.4 Reflective-Pedagogical Problems (n=3)

Meanwhile, the highest level was found in the reflective-pedagogical category. Participants at this level were not only able to identify students' misconceptions, but also began to relate students' difficulties to the instructional design implemented by the teacher.

"Students' difficulties in understanding the volume of solid figures may be caused by previous instruction that directly introduced formulas without providing concrete experiences in observing volume units."

The following interview excerpt illustrates this condition:

R: "In your opinion, why do students still experience difficulties in understanding the volume of solid figures?"

S28: "Because during instruction, students were directly given formulas without first understanding the concept."

R: "What impact does that have on students' understanding?"

S28: "Students end up only memorizing the formulas without understanding the meaning of volume itself."

R: "So, in your opinion, the problem does not come solely from the students?"

S28: "Yes. The way the teacher presents the material also has an influence. If students are directly given formulas, they only memorize the forms without understanding their meaning."

This interview excerpt indicates that the participant had begun to reflect on the relationship between teachers' instructional strategies and students' conceptual understanding of mathematics. The participant no longer viewed learning difficulties solely as students' weaknesses, but also recognized that instructional design and the ways teachers present mathematical concepts can influence the quality of students' understanding. This ability reflects the development of reflective-pedagogical reasoning in identifying mathematics learning problems.

These findings indicate that participants were beginning to understand the importance of instructional designs that align with the learning characteristics of elementary school students in mathematics. Participants at this level also demonstrated a clearer connection between the identified problems and the instructional actions proposed in their Classroom Action Research proposals. The instructional actions selected were not limited to the use of engaging media, but were directed toward helping students construct conceptual understanding more meaningfully (Fitriani & Leton, 2024; Jamaludin et al., 2022). This finding is consistent with studies showing that effective mathematics instruction should be designed to support conceptual understanding rather than merely procedural mastery or formula memorization (Dindyal et al., 2021; van Es et al., 2017). Furthermore, concept-oriented instruction enables students to build connections among mathematical concepts and understand the meaning behind the procedures used in problem solving (Jamaludin et al., 2022; Molina, 2014). Therefore, the instructional actions proposed by the participants were aimed at helping students develop a more meaningful conceptual understanding.

The reflective-pedagogical level represents the most sophisticated form of mathematical problem identification found in this study. At this level, pre-service teachers were able to connect students' mathematical difficulties with instructional design and teaching decisions. This indicates the integration of professional noticing, diagnostic competence, and pedagogical reasoning. Participants at this level did not merely identify students' misconceptions, but also considered how previous instruction, learning experiences, or the sequence of concept introduction might have contributed to those misconceptions. Therefore, reflective-pedagogical problem identification reflects a shift from viewing learning difficulties as students' weaknesses toward understanding them as the result of interactions among students' thinking, mathematical content, and instructional design.

Overall, the findings indicate that pre-service teachers' mathematical problem identification is not merely a technical ability to formulate research problems, but a form of professional reasoning that involves mathematical knowledge, noticing, diagnosis, and pedagogical judgement. The dominance of general and procedural levels suggests that many participants were still developing the ability to move beyond observable classroom symptoms and procedural errors toward deeper interpretation of students' mathematical thinking.

One possible explanation for the predominance of general and procedural problem identification is the way Classroom Action Research is commonly introduced in teacher education programs. In many cases, Classroom Action Research is perceived primarily as an academic requirement for preparing research proposals rather than as a process of investigating students' mathematical thinking and learning difficulties. As a result, pre-service teachers tend to focus on observable classroom symptoms, such as low achievement, limited participation, or classroom engagement, because these problems are easier to identify and formulate within a proposal.

From the perspective of pre-service teacher development, this dominance may indicate that many participants were still developing the ability to move from descriptive observation to interpretive analysis. Beginning pre-service teachers often find it easier to describe classroom conditions than to infer the mathematical reasoning behind students' responses. As a result, low achievement, lack of motivation, or student passivity are frequently interpreted as the main problems, while the conceptual roots of students' mathematical difficulties remain underexplored. This condition suggests that mathematical problem identification requires a developmental process in which pre-service teachers gradually learn to attend to students' mathematical thinking, interpret the causes of errors, and connect those interpretations with instructional decisions.

Another possible explanation relates to the nature of instructional preparation typically experienced by pre-service teachers. Throughout teacher education, students are often encouraged to select instructional models, teaching methods, or learning media as solutions to classroom problems. While these experiences are valuable, they may unintentionally lead pre-service teachers to focus on choosing instructional interventions before thoroughly analyzing the mathematical causes of students' difficulties. Consequently, participants were more likely to propose learning models or media innovations than to investigate misconceptions, representational difficulties, procedural misunderstandings, or conceptual obstacles experienced by students (Fitriani & Leton, 2024; Pertiwi et al., 2023). This tendency may explain why only a small proportion of participants reached the conceptual and reflective-pedagogical levels of mathematical problem identification.

The dominance of general and procedural forms of problem identification indicates that many participants were still developing the capacity to diagnose and interpret students' mathematical reasoning in a comprehensive manner. Rather than examining the conceptual foundations of students' errors, participants tended to focus on visible classroom conditions or procedural mistakes. This finding indicates that identifying mathematical learning problems requires more than classroom observation skills; it also requires the ability to analyze students' reasoning, recognize misconceptions, and connect observed difficulties to underlying mathematical concepts. Therefore, the progression from general to reflective-pedagogical problem identification can be understood as a developmental process in which pre-service teachers gradually learn to view mathematics learning through the lens of students' thinking rather than through observable classroom behaviors alone.

The findings also have important implications for elementary teacher education programs, particularly Classroom Action Research courses. If pre-service teachers are expected to formulate research problems that accurately reflect students' mathematical learning needs, they need systematic opportunities to analyze authentic student work, identify misconceptions, distinguish between general classroom problems and mathematical learning difficulties, and justify the relationship between identified problems and proposed instructional actions. Engaging pre-service teachers in the analysis of authentic student responses, classroom cases, and recorded instructional episodes may provide valuable opportunities to strengthen both noticing skills and pedagogical judgement. Through these experiences, Classroom Action Research can function not only as a proposal-writing exercise but also as a medium for developing diagnostic competence in mathematics education.

The findings of this study reinforce the importance of developing mathematical problem identification as an integrative competence within Classroom Action Research courses. From the perspective of Professional Noticing, the dominance of general and procedural levels indicates that many pre-service teachers were still at an early stage of attending to and interpreting students' mathematical thinking. They were able to observe visible classroom symptoms and identify procedural errors, but had not yet fully developed the ability to interpret the conceptual meaning behind students' responses. This interpretation is in line with previous studies showing that practice-based experiences, such as analyzing students' thinking and observing classroom instruction, can help pre-service teachers develop deeper noticing abilities toward students' mathematical reasoning (Güner et al., 2025; König et al., 2022; van Es et al., 2017). From the perspective of Mathematical Knowledge for Teaching, this condition suggests that pre-service teachers still need to strengthen their ability to recognize students' misconceptions, conceptual difficulties, and mathematical reasoning as the basis for formulating mathematics-specific research problems. In addition, reflective activities and analyses of instructional practices play an important role in developing pre-service mathematics teachers' pedagogical reasoning, particularly in understanding the relationship between instructional strategies and students' conceptual understanding (Santagata et al., 2021; Santagata & Yeh, 2016). Therefore, the four-level framework proposed in this study provides a conceptual tool for understanding the progression of pre-service teachers' mathematical problem identification, from noticing general classroom symptoms to diagnosing conceptual difficulties and linking them with pedagogical reasoning. Through these processes, pre-service teachers not only learn how to prepare Classroom Action Research proposals administratively, but also learn how to understand the root causes of students' mathematical learning difficulties and design instructional actions that correspond to students' mathematical needs.

4.5 Developmental Progression of Mathematical Problem Identification

The four levels identified in this study can be interpreted as a developmental progression of pre-service teachers' mathematical problem identification. At the general learning problem level, pre-service teachers mainly attend to visible classroom symptoms, such as low achievement, lack of participation, or low motivation. At the procedural problem level, they begin to notice mathematics-related errors, but their interpretation remains limited to incorrect formula use or procedural steps. At the conceptual mathematical problem level, pre-service teachers begin to interpret students' reasoning and identify misconceptions underlying the errors. Finally, at the reflective-pedagogical level, they are able to connect students' mathematical difficulties with instructional design and pedagogical decision-making.

This progression indicates a shift from surface-level noticing toward interpretive and pedagogically informed diagnostic reasoning. The movement from one level to another requires more than classroom observation; it requires opportunities to analyze students' written work, discuss misconceptions, reflect on instructional decisions, and connect students' errors with mathematical concepts. Therefore, the four-level framework does not merely classify pre-service teachers' responses, but also describes how their professional noticing and diagnostic competence may develop within the context of Classroom Action Research.

4.6 Theoretical Interpretation of the Four-Level Framework

The four-level framework developed in this study provides a theoretical interpretation of how pre-service primary teachers' mathematical problem identification develops within Classroom Action Research contexts. At the general learning problem level, pre-service teachers mainly attend to visible classroom conditions, such as low achievement, lack of motivation, or limited participation. This indicates an early form of noticing in which attention is directed toward surface-level classroom events rather than students' mathematical thinking. At the procedural problem level, pre-service teachers begin to recognize mathematical errors, but their interpretation remains focused on formula use, algorithms, and solution steps. This level reflects partial diagnostic competence because students' errors are identified, yet the underlying conceptual causes are not fully examined.

At the conceptual mathematical problem level, pre-service teachers demonstrate a more advanced form of professional noticing by interpreting students' reasoning and identifying misconceptions. At this stage, problem identification moves beyond recognizing incorrect answers toward understanding why students think in particular ways. Finally, at the reflective-pedagogical level, pre-service teachers connect students' mathematical difficulties with instructional design and teaching practices. This level reflects the integration of diagnostic competence and pedagogical reasoning because pre-service teachers not only identify students' learning difficulties but also consider how instructional decisions may contribute to or address those difficulties.

Therefore, the proposed framework extends existing discussions on professional noticing by showing that noticing does not only occur during classroom interaction, but can also be traced in the way pre-service teachers formulate research problems in Classroom Action Research proposals. The framework also contributes to the literature on diagnostic competence by illustrating different depths of diagnosis, ranging from general symptoms to conceptual and pedagogical explanations. In addition, it strengthens the role of pedagogical reasoning in Classroom Action Research by emphasizing that instructional actions should be designed based on an analysis of students' mathematical thinking rather than merely on the selection of attractive learning media or teaching models.

The theoretical contribution of this framework lies in its ability to connect three domains that are often discussed separately in teacher education: professional noticing, diagnostic competence, and pedagogical reasoning. Existing discussions of professional noticing commonly emphasize teachers' ability to attend to and interpret students' thinking during classroom interaction. The present framework extends this discussion by showing that noticing can also be examined through written Classroom Action Research proposals, particularly in how pre-service teachers formulate mathematical learning problems. In addition, the framework complements studies on diagnostic competence by distinguishing different depths of problem identification, ranging from the recognition of general classroom symptoms to the interpretation of conceptual misconceptions and instructional causes. Thus, the four-level framework provides a conceptual tool for analyzing how pre-service teachers' noticing, diagnosis, and pedagogical reasoning are reflected in the process of constructing researchable mathematical problems.

4.7 Practical Implications for Classroom Action Research Courses

The findings suggest that Classroom Action Research courses in elementary teacher education should provide more structured opportunities for pre-service teachers to practice mathematics-specific problem identification. First, lecturers may integrate activities involving the analysis of authentic students' written work to help pre-service teachers distinguish between procedural errors and conceptual misconceptions. Second, pre-service teachers should be guided to compare general classroom problems, such as low motivation or low achievement, with mathematics-specific problems, such as misunderstanding place value, fraction magnitude, measurement concepts, or geometric properties. Third, diagnostic reflection tasks can be incorporated into proposal development, requiring students to explain the possible causes of learners' mathematical difficulties before selecting instructional interventions.

In addition, Classroom Action Research courses should require pre-service teachers to justify the alignment between the identified mathematical problems, the proposed instructional actions, and the expected learning improvements. Such activities may prevent pre-service teachers from directly choosing learning media or instructional models without first analyzing students' mathematical needs. Through these diagnostic training activities, Classroom Action Research can function not only as a proposal-writing assignment but also as a learning space for developing professional noticing, diagnostic competence, and pedagogical reasoning in mathematics education.

4.8 Limitations of the Study

This study has several limitations. First, the participants were drawn from a single teacher education institution, which may limit the transferability of the findings to other contexts. Second, the analysis relied primarily on Classroom Action Research proposals and interviews rather than direct observation of participants' classroom practices. Third, although the study provides an in-depth understanding of pre-service teachers' abilities to identify mathematical problems, the qualitative case study design does not aim to generate statistically generalizable conclusions. Future studies involving multiple institutions may provide a broader understanding of the development of diagnostic competence among pre-service teachers.

CONCLUSION

This study revealed that pre-service elementary school teachers' ability to identify mathematical problems in Classroom Action Research proposals varied across four levels: general learning problems, procedural problems, conceptual mathematical problems, and reflective-pedagogical problems. Most participants remained at the general and procedural levels, indicating that they tended to recognize visible classroom symptoms and procedural errors rather than diagnose students' underlying conceptual difficulties.

The main contribution of this study is the development of an empirical four-level framework that conceptualizes mathematical problem identification as part of pre-service teachers' diagnostic competence, professional noticing, and pedagogical reasoning. The framework shows a developmental progression from attending to general classroom conditions, recognizing procedural errors, interpreting students' mathematical misconceptions, and connecting those difficulties with instructional design. Thus, mathematical problem identification should not be viewed merely as a technical step in writing Classroom Action Research proposals, but as a form of professional reasoning in mathematics teacher education.

This four-level framework can be used as a conceptual tool for evaluating and developing pre-service teachers' ability to identify mathematical learning problems in teacher education programs. It may help lecturers assess the quality of problem identification in Classroom Action Research proposals and design diagnostic learning activities that guide pre-service teachers to analyze authentic student work, identify misconceptions, distinguish between general classroom problems and mathematics-specific difficulties, and align proposed instructional actions with students' mathematical needs.

This study was limited to participants from a single teacher education institution and relied primarily on proposal documents and interviews. Future research may examine the application of this framework across different teacher education contexts and investigate the effectiveness of instructional interventions designed to strengthen pre-service teachers' diagnostic competence, professional noticing, and pedagogical reasoning in mathematics Classroom Action Research courses.

THANK-YOU NOTE
The authors would like to express their sincere gratitude to IKIP Siliwangi for providing the 2025 competitive research grant, which greatly supported the successful implementation of this study through to publication.

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