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# The Relationship between Quality of Understanding and Problem-Solving Ability in Mathematics Learning: A Systematic Literature Review

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**Abstract**

The quality of understanding and problem-solving abilities are essential components in mathematics learning. Understanding serves as a foundation for students to comprehend mathematical concepts, while the ability to solve problems allows students to use their knowledge in everyday contexts. The purpose of this study is to explore the relationship between students' quality of understanding and their problem-solving ability through a systematic literature review. The review focuses on how instrumental and relational understanding influence students' effectiveness in solving mathematical problems. The search process was conducted using Harzing's Publish or Perish software with Google Scholar and Scopus as the primary databases, limited to studies published between 2014 and 2025, resulting 30 relevant articles. The findings demonstrate a consistently positive relationship, where relational understanding contributes more strongly to effective and flexible problem-solving than instrumental understanding, especially in non-routine tasks. This review offers a clearer comparison of the relative roles of instrumental and relational understanding in supporting problem-solving, which has not been explicitly emphasized in earlier studies. Additionally, factors such as learning style, prior knowledge, reasoning skills, gender, emotional intelligence, and adversity quotient were identified as complementary influences that shape both understanding and problem-solving performance.



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## INTRODUCTION

The 21st Century skills are one of the main keys of the modern education system to prepare human resources to face global challenges. These skills consist of three categories, namely learning, literacy, and life skills. The Learning Skills category or often called the 4Cs consists of critical thinking, creativity, collaboration, and communication (Hummel, 2024). These 4C skills require students to engage in higher-order thinking processes (Sahril et al., 2022), which are closely related to

relational understanding and mathematical problem-solving. Critical thinking and creativity encourage students to reason about the relationships among concepts rather than merely memorize procedures, while collaboration and communication support the ability to discuss, justify, and reflect on mathematical ideas. Thus, 4C skills are not only relevant for students' success in learning in school, but also to help them become individuals capable of contributing effectively in a global society.

Skills possessed by every individual cannot be acquired instantly. These skills can be formed through a learning process. One of them is formed through mathematics learning. The quality of understanding is the basis of a concept and knowledge. This can be seen in the Bloom Taxonomy. Bloom's Revised Taxonomy identifies remembering and understanding as the core skills required at the first and second cognitive levels (Nafiati, 2021). This Bloom Taxonomy is a hierarchical structure where in order to achieve a higher goal, the lower level must be fulfilled first. In the context of mathematics learning, understanding is not merely the ability to recall concepts, but serves as a prerequisite for the next cognitive stages, namely applying, analyzing, and evaluating. These three stages represent core components of mathematical problem-solving, where students must not only apply procedures but also analyze situations and evaluate solutions. However, research by Kusnadi et al (2021) explained that the level of students' mathematical understanding in trigonometry is still not yet optimal. Moreover, Nurdiyana et al (2022) also explained that Junior high school students generally demonstrate a low level of mathematical understanding. Therefore, the quality of understanding in mathematics learning needs to be considered.

Another skill that students need to have is problem-solving ability. This problem-solving ability is a practical skill that is acquired when students solve problems (Polya, 2004). This ability is needed in daily life because It supports students in addressing the challenges presented to them. However, the problem-solving abilities of students within mathematics learning, both reviewed from the results of PISA and reviewed from the results of the Indonesian Education Report Card are still included in the low group. These results are in line with PISA 2022 Results (Volume I and II) - Country Notes: Indonesia which shows that in 2022 the average PISA score obtained is 366 which is still below the OECD average of 472 (OECD, 2022). Furthermore, based on Rapor Pendidikan Indonesia (2024), it can be seen in the medium category, but the percentage in 2022 is 41.14% and in 2023 it is 47.62%. The result is still below 50%. Therefore, this problem-solving ability also needs to be considered because considering this ability provides provisions for students in solving problems in daily life.

Based on the explanation above, it is evident that the quality of understanding and problem-solving ability is important for students. Enhancing students' understanding and problem-solving proficiency requires learning activities that are systematically designed, meaningful in application, and focused on developing higher-order cognitive processes. This is in line with the explanation Ulfa & Saifuddin (2018) which states that several important aspects need to be considered in determining strategies, models, and learning methods in the classroom, such as learning objectives, students' abilities and backgrounds, teachers' abilities and backgrounds, learning process conditions, and available facilities. By considering these aspects, an organized instructional approach can optimally facilitate the

development of strong understanding and problem-solving abilities in mathematics learning.

However, previous studies have generally examined instrumental and relational understanding or problem-solving ability separately, without systematically analyzing how both forms of understanding interact in the process of solving mathematical problems. Although many studies have measured levels of understanding, only a limited number have provided an integrated synthesis that explains how relational and instrumental understanding contribute differently to students' problem-solving performance. This gap indicates the need for a comprehensive review that clarifies the relationship between these two constructs within various learning contexts. Therefore, this study will conduct a systematic literature review to collect, analyze, and synthesize the results of previous research related to the relationship between the quality of understanding and problem-solving ability in mathematics learning. This review is expected to provide a clearer theoretical explanation and practical reference in formulating instructional strategies that respond to issues in mathematics learning.

## RESEARCH METHODS

In this research, the Systematic Literature Review (SLR) method is utilized to summarize and analyze findings from prior studies (Tukatman et al., 2023). Systematic reviews are a form of evidence synthesis in which researchers establish explicit eligibility criteria, collect all available studies that meet these criteria, and summarize the results (Brignardello-Petersen et al., 2025). By employing this approach, the present study ensures that the review process is structured, comprehensive, and objective in identifying the relationship between quality of understanding and problem-solving ability in mathematics learning. The steps of the research method carried out are as follows.

### Identify Research Questions

This study begins by defining the Research Questions (RQ), which function to direct the synthesis of previous findings and align them with the intended research goals. RQ are: (RQ1) What is quality of understanding?; (RQ2) What is problem-solving ability?; (RQ3) What is the relationship between quality of understanding and problem-solving ability in mathematics learning?; (RQ4) What are the factors that affect the quality of understanding and problem-solving ability?

### Determining the Location of the Database

The database location is the location of the search for research results that are in accordance with the research questions that have been prepared. This study utilized Harzing’s Publish or Perish software to access databases, specifically retrieving articles from Google Scholar and Scopus.

### Selection of Relevant Research Results

The location of the database has been determined. Furthermore, relevant research is sought using the keywords: instrumental understanding, relational understanding, and problem-solving ability in mathematics learning. The studies published in the period 2014 to 2025. Based on these criteria, a total of 33 relevant studies were

obtained. These thirty-three studies were subsequently examined in depth using the predetermined research questions to draw conclusions regarding the relationship between quality of understanding and problem-solving ability in mathematics learning. The article selection process is illustrated in Figure 1.

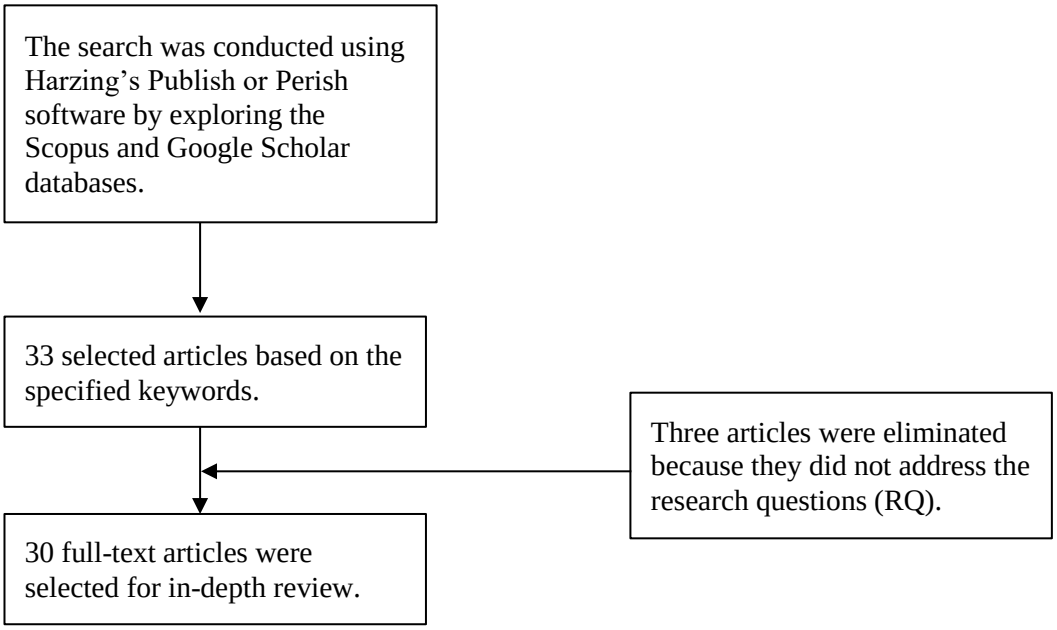


Figure 1. PRISMA Flowchart

Subsequently, these 30 articles were analyzed to answer the predetermined research questions. The data analysis in this SLR was carried out through thematic grouping based on four main focuses: (1) the definition of quality of understanding, (2) the definition of problem-solving, (3) the relationship between quality of understanding and problem-solving ability, and (4) the factors that influence students' quality of understanding and problem-solving ability.

## RESULTS AND DISCUSSION

Based on the predefined keywords, an initial total of 33 studies were identified. However, after applying relevance-based screening that considered the clarity of focus, methodological alignment, and the extent to which each study addressed the relationship between quality of understanding and problem-solving ability, three studies were excluded. Therefore, 30 full-text articles were retained for further analysis. This selection process was carried out to ensure that the reviewed studies provided sufficiently direct and meaningful insights related to the research questions. As a result, the synthesized findings reflect patterns that can be interpreted reliably within the context of mathematics learning. The list of included studies is presented in Table 1, along with their research focus and main findings.

Based on Table 1, it can be seen that most of the research methods used are qualitative descriptive methods. This is appropriate because what is being reviewed is the relationship between the quality of understanding and problem-solving ability. However, the research methods studied also include quantitative research methods, case studies, quasi-experiments, and systematic literature reviews. The

results of research with different research methods help answer the research questions that have been prepared.

Table 1. Detected research results

| Sources | Research Methods | Research Results |
|---|---|---|
| (Afriyani & Pramita, 2021) | Qualitative | Students with functional understanding (relational understanding) are able to carry out a more meaningful translation process. |
| (Alnar et al., 2024) | Qualitative | The findings show that FI and FD learning styles affect students' problem-solving. FD2 students tend to rush and make errors. Although all students solved the problems, their understanding remained at the instrumental level. |
| (Baiti et al., 2020) | Qualitative | The results show a clear relationship between the amount of feedback students receive and their level of understanding. Students who received high feedback met all indicators of instrumental understanding and four indicators of relational understanding. Those with moderate feedback achieved four instrumental and one relational indicator, while students with low feedback met only one instrumental indicator. |
| (Darsono et al., 2018) | Quantitative | The study revealed that students' problem-solving ability increased after the relational thinking-based learning module was implemented. |
| (Elvandari & Hanifah, 2022) | Qualitative | The results show two cognitive styles among students: reflective and impulsive. Reflective students, both male and female, demonstrate low instrumental understanding but high relational understanding. In contrast, impulsive students of both genders show low levels of both instrumental and relational understanding. |
| (Fajriah & Suji Santoso, 2014) | Quantitative | The results show that mathematical understanding plays an important role in supporting problem-solving ability. In general, students demonstrate a moderate level of problem-solving ability when assessed using Polya's problem-solving stages. However, further analysis indicates that students tend to demonstrate stronger instrumental understanding than relational understanding. |
| (Fathonah & Maftuh, 2016) | Qualitative | Learning style influences problem-solving. Divergent and accommodating students show formal understanding when identifying problems, relational in planning, and instrumental when implementing and reviewing solutions. |

Table 1. (*continued*)

| Sources | Research Methods | Research Results |
|---|---|---|
| | | Asymmetrical students show formal understanding in identifying and planning but instrumental in later stages. Convergent students show formal understanding at the start and relational understanding in the following stages. |
| (Fitri & Prabawanto, 2021) | Qualitative | The results showed that students only had instrumental skills, without anyone showing relational skills. They cannot explain the relationship between squares and rectangles, and are only able to solve routine problems that have been taught beforehand. |
| (Giriansyah et al., 2023) | Qualitative | Visual learners can classify objects, connect concepts, and apply concepts algorithmically. Auditory learners are able to identify the essential conditions of a concept and use them in algorithmic procedures. Kinesthetic learners can classify objects and apply concepts algorithmically in problem solving. |
| (Goddu et al., 2025) | Qualitative | The results showed that toddlers aged 24-30 months and Preschoolers aged three were found to apply relational reasoning in tasks involving causal problem solving. |
| (Hidaiyah et al., 2023) | Qualitative | Students with high mathematical ability demonstrate relational understanding, as They show the ability to identify mathematical connections, implement them in problem solving, and explain the logic behind their steps. Students with moderate ability show instrumental understanding, as they can apply memorized procedures but cannot explain their reasoning. In contrast, learners with low levels of mathematical ability exhibit limited understanding because they are unable to meet both relational and instrumental understanding indicators. |
| (Ikrimah, 2017) | Qualitative | Reasoning level affects the type of understanding used in problem solving. Individuals with high reasoning use formal understanding to identify problems, relational understanding to plan solutions, and instrumental understanding to execute and review them. Those with moderate reasoning use formal understanding only to identify problems, and rely mainly on instrumental understanding in planning, executing, and reviewing solutions. Individuals with low reasoning use formal understanding to |

Table 1. (*continued*)

| Sources | Research Methods | Research Results |
|---|---|---|
| | | identify problems and instrumental understanding for all remaining stages. |
| (Indayani et al., 2015) | Qualitative | Emotional intelligence influences problem-solving. Individuals with high emotional intelligence show strong relational understanding and solve problems thoroughly. Those with moderate emotional intelligence can solve problems but are less precise. Individuals with low emotional intelligence can only handle routine problems and show limited relational understanding. |
| (Kurniasi, 2016) | Qualitative | Gender differences affect the type of mathematical understanding. Men tend to have an relational understanding. In contrast, women are more likely to have instrumental understanding. |
| (Linda et al., 2024) | Qualitative | Students who are able to solve problems well and go through the stages of solving problems completely show relational understanding. |
| (Mukarramah, 2018) | Qualitative | Learners' initial abilities influence the type of understanding used in problem solving. Students with high initial ability tend to show relational understanding and can apply it effectively. Those with intermediate ability also display relational understanding but in a more limited scope. Students with low initial ability demonstrate only instrumental understanding. |
| (Murdikah et al., 2021) | Qualitative | The study revealed that a majority of Mathematics teachers continue to rely on instrumental understanding. |
| (Najwa, 2019) | Qualitative | The findings indicate that students with strong problem-solving abilities are able to achieve relational understanding. |
| (Nurjanah et al., 2021) | Quasi Experiment | Research shows that the learning method using the Edmodo and Google Classroom platforms does not have a significant influence on students' relational understanding. However, A positive relationship exists between relational understanding and self-regulated learning ability, where students with good self-regulation ability tend to have higher relational understanding. |
| (Rachmawati et al., 2023) | Qualitative | The findings indicate that students with rational personality types display relational understanding and are able to fulfill all instrumental indicators as well as six relational indicators. |

Table 1. (*continued*)

| Sources | Research Methods | Research Results |
|---|---|---|
| (Rahmawati et al., 2022) | Qualitative | The results showed that 52% of students had instrumental understanding and 48% of students had relational understanding. |
| (Rizki & Haerudin, 2022) | Qualitative | The findings indicate that students with strong relational understanding are able to solve the given problems with ease. |
| (Rizki, 2013) | Quasi Experiment | The Index Card Match learning strategy can improve students' relational understanding. |
| (Rochsun et al., 2024) | Qualitative | It was found that relational understanding and cognitive style have a notable correlation with students' problem-solving ability. |
| (Safitri et al., 2018) | Qualitative | Research shows that students with AQ quitter and camper types only have instrumental understanding, so they cannot give a clear reason for the steps taken. In contrast, students with relational understanding are able to solve problems systematically by following Polya procedures. |
| (Sahin et al., 2015) | Case Studies | The results of this research showed that students were able to solve derivative material problems because students did not understand the procedures carried out. This shows that students have instrumental understanding. |
| (Santoso, 2019) | Qualitative | Students with high and moderate abilities are able to solve problems at the instrumental understanding level, whereas those with low ability struggle to identify the required concepts. For relational understanding questions, students with high abilities show a good mathematical understanding. However, students with moderate and low abilities have difficulties, especially in determining concepts and performing the calculations necessary to solve problems. |
| (Sudrajat, 2022) | SLR | Students who demonstrate high problem-solving ability in mathematics tend to have well-developed relational and instrumental understanding, while students who have mathematical problem-solving in the medium and low categories only have instrumental understanding. |
| (Yazidah et al., 2018) | Qualitative | This study found that students with a Field Independent learning style who possess relational understanding can successfully complete the assigned problems. |

Table 1. (*continued*)

| Sources | Research Methods | Research Results |
|---|---|---|
| (Zaini et al., 2023) | Quantitative | Relational understanding has a positive relationship with students' self-efficacy. Students with higher levels of self-efficacy tend to exhibit higher levels of relational understanding. |

**RQ1: What is Quality of Understanding?**

Quality of understanding is how good or bad a student's ability is to integrate their knowledge and apply it in various mathematical situations with a deep understanding of how and why a concept or procedure works. Skemp (1987, p.153), distinguishes this into instrumental understanding and relational understanding. Both instrumental and relational understanding provide an overview related to the quality of understanding that students have. Skemp explains that instrumental understanding is not considered understanding at all. It is described as "rules without reason" without realizing that for many students and their teachers, ownership of the rules, and the ability to use them, is what they mean by "understanding".

Research conducted by Alnar et al (2024) and Sahin et al (2015) states that instrumental understanding refers to students' use of procedural steps to solve problems, even when they do not grasp the conceptual meaning behind them. This understanding is often mechanical in nature and limited to the application that the teacher has already taught. In contrast, Relational understanding is defined as the capacity of students to comprehend the interrelationships between concepts and use this knowledge in diverse problem-solving contexts. Students with this understanding produce a more meaningful process than instrumental understanding (Afriyani & Pramita, 2021). Relational understanding helps students not only solve problems but also understand their meaning (Sudrajat, 2022; Yazidah et al., 2018).

Across studies, relational understanding is consistently associated with deeper cognitive engagement and meaningful reasoning, while instrumental understanding is linked to surface-level knowledge and limited application. Thus, the quality of understanding reflects not merely what students know, but how knowledge is structured, connected, and used in mathematical thinking.

**RQ2: What is Problem-Solving Ability?**

Problem-solving ability involves a sequence of processes: understanding the problem, making a plan, carrying out the plan, and looking back the problem solving that has been prepared (Polya, 2004, pp.4-6). These four problem-solving procedures are in accordance with those listed in the research conducted by Fathonah & Maftuh (2016) and Ikrimah (2017). However, the synthesis of findings across the reviewed research reveals that the effectiveness of each stage is strongly influenced by the quality of understanding students possess. This pattern suggests that problem-solving ability is not merely a procedural skill but is deeply rooted in the structure and depth of students' mathematical understanding. Therefore, relational understanding functions as a cognitive foundation that supports flexible and adaptive problem-solving, while instrumental understanding primarily supports procedural execution (Najwa, 2019; Rizki & Haerudin, 2022; Sahin et al., 2015; Santoso, 2019; Yazidah et al., 2018).

**RQ 3: What is the Relationship between Quality of Understanding and Problem-Solving Ability in Mathematics Learning?**

The quality of understanding has a notable impact on how well students can solve problems. Instrumental understanding allows students to solve routine problems by following procedures, but is less supportive in dealing with new problems that require flexibility in thinking. In contrast, relational understanding gives students the ability to understand the relationships between concepts, making it more effective in addressing non-routine problems and tasks that demand higher-order reasoning. This is in line with the research that has been carried out by Afriyani and Pramita (2021), Fajriah and Suji Santoso (2014), and Hidaiyah et al (2023).

Moreover, relational understanding (better understanding) directly supports higher-order cognitive processes in Bloom's Revised Taxonomy (Hidayati & Shodikin, 2025). Students who understand how and why concepts are interconnected are better prepared to apply procedures appropriately, analyze problem structures, evaluate solution strategies, and even create new solution pathways. Therefore, relational understanding forms the cognitive foundation necessary for effective mathematical problem-solving. Meanwhile, students who rely primarily on instrumental understanding often depend on memorized steps, limiting their ability to generalize and transfer knowledge when facing new problem types (Alnar et al., 2024; Sudrajat, 2022). Thus, a high level of relational understanding is strongly associated with stronger and more flexible problem-solving ability.

**RQ 4: What are the Factors that Affect the Quality of Understanding and Problem-Solving Ability?**

Based on Table 1, it can be seen that there are several other factors that affect the quality of understanding and problem-solving ability. These factors are learning style, feedback level, cognitive style, gender, students initial abilities, reasoning level, mathematical ability, emotional intelligence, adversity quotient, and index card match learning. However, not all of these factors operate simultaneously in shaping both abilities. Therefore, a conceptual framework was developed to illustrate how specific student-related factors contribute to the development of understanding quality and subsequently influence problem-solving ability. Therefore, Figure 2 outlines the factors affecting the quality of understanding and problem-solving ability in mathematics learning.

Based on Figure 2, the synthesis of the reviewed studies indicates that learning style, feedback level, cognitive style, gender, students' initial abilities, reasoning level, mathematical ability, emotional intelligence, adversity quotient, and the use of the index card match learning strategy contribute to shaping the quality of understanding. Meanwhile, learning style, gender, students' initial abilities, reasoning level, emotional intelligence, and adversity quotient are reported to influence students' problem-solving ability. Thus, the factors that are consistently shown across studies to influence both the quality of understanding and problem-solving ability are learning style, gender, students' initial abilities, reasoning level, emotional intelligence, and adversity quotient.

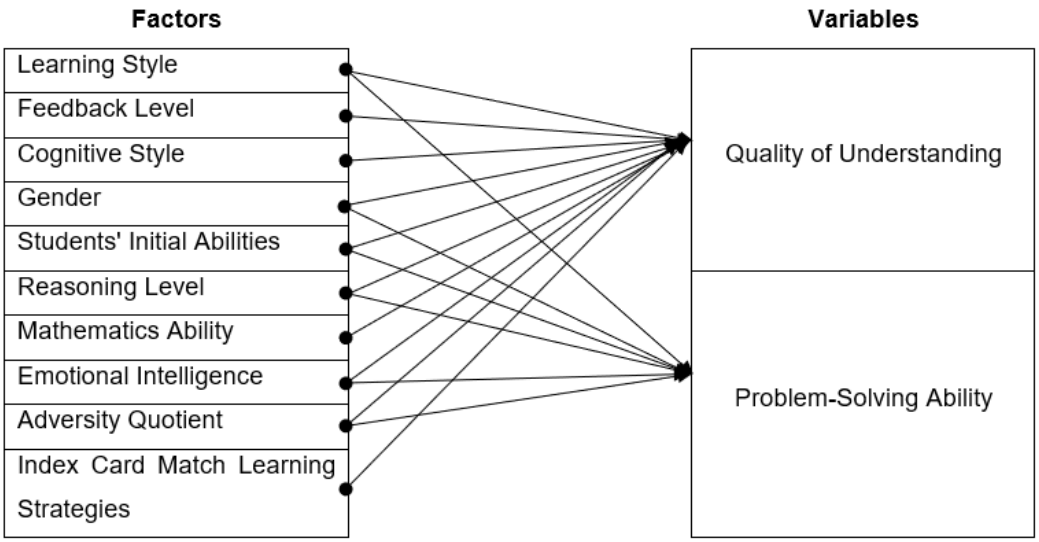


Figure 2. Factors Affecting the Quality of Understanding and Problem-Solving Ability in Mathematics Learning

## CONCLUSION

From the findings, it is evident that the quality of understanding involves students' capacity to connect and utilize mathematical concepts in various situations, supported by a deep awareness of the rationale behind each concept or procedure. This understanding consists of instrumental understanding, which emphasizes procedural knowledge, and relational understanding, which emphasizes conceptual reasoning. Problem-solving ability is defined as an individual's capacity to solve mathematical problems through steps that include understanding the problem, planning a solution, implementing the plan, and evaluating the outcome. The review shows a consistent pattern in which students with deeper and more connected understanding tend to demonstrate more flexible and effective problem-solving performance, while students who rely mainly on procedural knowledge often experience difficulty when encountering non-routine tasks. This suggests that instructional approaches should not only teach procedures but also emphasize conceptual reasoning, multiple representations, and opportunities for students to explain their thinking. Additionally, several factors influence both the quality of understanding and problem-solving ability, including learning style, gender, prior knowledge, reasoning ability, emotional intelligence, and adversity quotient. However, this SLR is limited by its reliance on descriptive synthesis and selected database sources, so the results should be interpreted as interpretive trends rather than causal claims.

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