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STUDENTS' CONCEPTUAL UNDERSTANDING OF SYSTEMS OF LINEAR EQUATIONS IN TWO VARIABLES: A DESCRIPTIVE QUANTITATIVE STUDY AT THE JUNIOR HIGH SCHOOL LEVEL

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ABSTRACT

This study aimed to analyze junior high school students' conceptual understanding of Systems of Linear Equations in Two Variables (SLETV) based on conceptual understanding indicators at SMP Fitra Abdi Palembang. Conceptual understanding is a fundamental ability in mathematics learning; however, many students experience difficulties in applying mathematical concepts to contextual problems. This study employed a descriptive quantitative method involving 31 ninth-grade students selected through random sampling. Data were collected using an essay test consisting of seven items aligned with conceptual understanding indicators. The results showed that students' overall conceptual understanding was categorized as high, with an average score of 60.50. Students demonstrated very high achievement in recognizing and restating concepts (92.47%) and presenting concepts in various representations (83.87%). However, the lowest achievement was found in applying concepts or algorithms to problem-solving (26.89%), indicating difficulties in connecting abstract concepts with real-life situations. These findings suggest that teachers should emphasize learning strategies that promote conceptual application, such as Problem-Based Learning or contextual approaches, to improve students' ability to apply mathematical concepts meaningfully. This study contributes to mathematics education by providing a detailed profile of students' conceptual understanding indicators that can serve as a reference for instructional improvement.

ABSTRAK

Penelitian ini bertujuan untuk menganalisis pemahaman konseptual siswa sekolah menengah pertama terhadap materi Sistem Persamaan Linear Dua Variabel (SPLDV) berdasarkan indikator pemahaman konsep di SMP Fitra Abdi Palembang. Pemahaman konseptual merupakan kemampuan fundamental dalam pembelajaran matematika; namun demikian, banyak siswa masih mengalami kesulitan dalam menerapkan konsep matematika pada permasalahan kontekstual. Penelitian ini

menggunakan metode deskriptif kuantitatif dengan melibatkan 31 siswa kelas IX yang dipilih melalui teknik pengambilan sampel acak. Pengumpulan data dilakukan menggunakan tes uraian yang terdiri atas tujuh butir soal yang disusun sesuai dengan indikator pemahaman konsep. Hasil penelitian menunjukkan bahwa pemahaman konseptual siswa secara keseluruhan berada pada kategori tinggi dengan nilai rata-rata sebesar 60,50. Siswa menunjukkan capaian yang sangat tinggi pada indikator mengenali dan menyatakan kembali konsep (92,47%) serta menyajikan konsep dalam berbagai bentuk representasi (83,87%). Namun, capaian terendah terdapat pada indikator menerapkan konsep atau algoritma dalam pemecahan masalah (26,89%), yang mengindikasikan adanya kesulitan siswa dalam mengaitkan konsep abstrak dengan situasi kehidupan nyata. Temuan ini menunjukkan bahwa guru perlu menekankan strategi pembelajaran yang mendorong penerapan konsep, seperti Problem-Based Learning atau pendekatan kontekstual, guna meningkatkan kemampuan siswa dalam menerapkan konsep matematika secara bermakna. Penelitian ini berkontribusi terhadap bidang pendidikan matematika dengan memberikan profil rinci indikator pemahaman konseptual siswa yang dapat dijadikan acuan dalam perbaikan pembelajaran.

Introduction

Mathematics involves abstract concepts; therefore, presenting these concepts in learning activities must consider students' characteristics as recipients. Novitasari et al. (2022) and Tanzimah et al. (2023) argue that mathematics plays a significant role in developing students' thinking and problem-solving skills, particularly in daily life and local environments where students directly interact with their surroundings.

Hidayat et al. (2020) explain that mathematical conceptual understanding is essential for solving problems in mathematics and other sciences, making it a vital necessity in the modern era. One mission of mathematics education is to guide students toward understanding the concepts required to solve the problems they face. Consequently, the ability to understand mathematical concepts is one of the most critical criteria for students in teaching and learning activities.

However, Mayasari & Habeahan (2021) reveal that students' conceptual understanding remains low, as evidenced by errors made when solving mathematical problems. Supporting this, Rohmah et al. (2024) state that several factors contribute to this low understanding, one of which is the continued use of conventional teaching methods by teachers.

In addition to teaching methods, conceptual understanding is demonstrated when students can define concepts, identify examples and non-examples, develop mathematical connections between ideas to build a comprehensive understanding, and apply mathematics in contexts outside the subject (Atmaja, 2021). According to Tarigan and Tasyah (2024), a lack of fundamental conceptual understanding makes it difficult to apply linear equations to real-life situations, hindering the teaching and learning process. Ardila et al. (2022) further note that conceptual understanding among junior high school students is still unsatisfactory. Conversely, Yulianah et al. (2020) state that students understand concepts if they can explain them and apply them to various problems, an ability Rahmawati et al. (2023) emphasize as essential.

Based on an interview with a mathematics teacher at SMP Fitra Abdi Palembang, conceptual understanding issues were identified. In the odd semester of the 2020/2021 academic year, the average student's ability was low because students tended to memorize formulas without knowing their origins. Consequently, they struggled with problems that differed slightly from examples and had difficulty applying concepts to word problems.

Previous research by Yulistia and Hidayati (2023) titled Analysis of Junior High School Students' Mathematical Conceptual Understanding Ability on Systems of Linear Equations in Two Variables (SLETV), concluded that students' understanding of SLETV is low, including its application in daily life. Similarly, Dermawanti & Marlina (2024) conducted a study titled "Analysis of Grade VIII Students' Mathematical Conceptual Understanding on Cubes and Prisms." This study aimed to identify students' abilities and provide teachers with information to design learning activities that improve understanding, specifically in identifying examples/non-examples and selecting appropriate procedures.

Although previous studies have examined students' conceptual understanding of Systems of Linear Equations in Two Variables (Yulistia & Hidayati, 2023; Umam & Zulkarnaen, 2022), most of these studies report students' understanding levels in general terms without providing a detailed analysis of each conceptual understanding indicator. Moreover, limited research has focused on the specific characteristics of students at SMP Fitra Abdi Palembang, where students tend to rely on memorization rather than conceptual application. Therefore, this study fills the research gap by presenting a comprehensive indicator-based analysis of students' conceptual understanding in SLETV within this specific school context.

Based on the explanation above, this study aims to analyze the conceptual understanding of Grade IX students at SMP Fitra Abdi Palembang on Systems of Linear Equations in Two Variables based on conceptual understanding indicators.

The results are expected to provide empirical insights for teachers in designing learning strategies that bridge the gap between conceptual knowledge and real-world application.

Method

This study uses a descriptive quantitative method. The subjects were 31 Grade IX students at SMP Fitra Abdi Palembang. The sample was selected using simple random sampling from Grade IX students, and Class IX1 was chosen to represent the population. The study was conducted during the odd semester of the 2024/2025 academic year, when the SLETV material was actively taught based on the applicable curriculum. Data were collected using a written test. Data analysis was conducted based on indicator achievement to assess students' mathematical conceptual understanding. The measured indicators include: (1) Recognizing and restating a concept, (2) Classifying objects based on mathematical concepts, (3) Identifying examples and non-examples of a concept, (4) Presenting concepts in various forms of mathematical representation, (5) Developing necessary or sufficient conditions for a concept, (6) Using, utilizing, and selecting specific procedures or operations, and (7) Applying concepts or algorithms to problem-solving.

The test instrument consisted of seven essay questions on SLETV. Before the study, the instrument was piloted on 20 students outside the research sample who had previously studied the material. The pilot results showed that all seven items were valid, with a reliability of 0.74, adequate and good discriminatory power, and varying difficulty levels (easy, moderate, and difficult). The calculation results are presented in the Tabel 1.

Secara keseluruhan dari hasil perhitungan dapat dilihat dari tabel dibawah ini:

Table 1
Instrument Pilot Test Results

Item No	Validity		Reliability	Discriminating Power		Difficulty Level		Result
	r_{Stat}	$R_{critical}$		DP	Criteria	DL	Criteria	
1	0,489933	0,444	0,74 (Reliable)	0,26	Fair	0,76	Easy	Accepted
2	0,629807			0,33	Fair	0,8	Easy	Accepted
3	0,647966			0,26	Fair	0,86	Easy	Accepted
4	0,951706			0,60	Good	0,43	Moderate	Accepted
5	0,764957			0,25	Fair	0,38	Moderate	Accepted
6	0,616336			0,28	Fair	0,52	Moderate	Accepted
7	0,756565			0,23	Fair	0,15	Difficult	Accepted

Based on the table above, it can be concluded that all seven tested items are suitable for the research. These items have met the criteria for validity, reliability, discriminating power, and difficulty level (Cysarah et al., 2021).

Table 2
Categorization of Mathematical Conceptual Understanding Percentage

Achievement Percentage (%)	Category
80 < PK≤100	Very High
60 < PK ≤ 80	High
40 < PK ≤ 60	Moderate
20 < PK ≤ 40	Low
0 < PK ≤ 20	Very Low

Data analysis in this study determines the percentage of students' mathematical conceptual understanding in each category using the following formula:

$$P = F/N * 100\%$$

Results and Discussion

This study was conducted with 31 Grade IX students at SMP Fitra Abdi Palembang. The instrument used was a validated essay test consisting of seven questions regarding Systems of Linear Equations in Two Variables (SLETV). Based on the research method, students' mathematical conceptual understanding is divided into five levels: very high, high, moderate, low, and very low. The overall data can be seen in the Table 3.

Table 3
Criteria for Mathematical Conceptual Understanding

No	Percentage Range	Category	Number of students	Percentage
1	$80 < P \leq 100$	Very High	3	9.67 %
2	$60 < P \leq 80$	High	10	32.25%
3	$40 < P \leq 60$	Moderate	7	22.58%
4	$20 < P \leq 40$	Low	7	22.58%
5	$0 < P \leq 20$	Very Low	4	12.90 %
	Total		31	100%

Table 3 shows that among Grade IX students, 3 students (9.67%) achieved a very high level of understanding, 10 students (32.25%) reached a high level, 7 students (22.58%) were in the moderate category, 7 students (22.58%) were in the low category, and 4 students (12.90%) fell into the very low category.

Furthermore, student performance was analyzed based on the seven indicators of mathematical conceptual understanding. The result can be seen in Table 4.

Table 4
Results of Mathematical Conceptual Understanding Test

Indicators of Mathematical Conceptual Understanding	Percentage (%)	Category
Recognizing and restating a concept	92.47	Very High
Classifying objects based on mathematical concepts	55.20	Moderate
Identifying examples and non-examples of a concept	79.57	High
Presenting concepts in various forms of mathematical representation	83.87	Very High
Developing necessary or sufficient conditions for a concept	41.94	Moderate
Using, utilizing, and selecting specific procedures or operations	43.55	Moderate
Applying concepts or algorithms to problem-solving	26.89	Low
Mean score	60.50	High

The table above indicates that the average score for mathematical conceptual understanding across the seven indicators is 60.50, which is categorized as high. This aligns with research by (Krisnadi et al., 2020), who also reported a score of 69.56 in the high category. Student responses for solving SLETV problems are presented below by category, following the descriptive approach used by (Umam & Zulkarnaen, 2022).

Based on the data analysis, the profile of students' mathematical conceptual understanding reveals varying dynamics across each indicator. Overall, the average student ability reached 60.50 (High Category). However, there is a significant gap between theoretical knowledge (recognition/memorization) and applied skills (problem-solving).

In the indicator of recognizing and restating a concept, students achieved the highest percentage of 92.47 (Very High). This indicates that, fundamentally, students have an excellent grasp of the initial definitions of SLETV material. This finding is supported by research from (Khairani et al., 2021), which emphasizes that the ability to restate concepts is a primary foundation in mathematical understanding. Similarly, the indicators for presenting concepts in various representations (83.87) and identifying examples/non-examples (79.57) fell into

the high category. This aligns with studies by (Hayati & Marlina, 2021) and (Gustiadi et al., 2021), showing that students at this level are capable of communicating mathematical ideas in writing and accurately distinguishing concepts.

However, significant challenges emerged in indicators requiring deeper reasoning. In classifying objects (55.20), developing necessary/sufficient conditions (41.94), and selecting procedures (43.55), students only reached the Moderate category. Although (Lestari et al., 2024) states that students are capable of grouping information, this study reveals that many students struggle when they must determine the most efficient procedure to solve a problem. This is further reinforced by (Nurvitasari et al., 2024), who noted that students are often able to create mathematical models but fail to select the appropriate solution method.

The lowest achievement was observed in the indicator of applying concepts or algorithms to problem-solving (26.89%). This result indicates that students experience significant difficulties in transferring abstract SLETV concepts into contextual problem situations. One possible reason is that students are more accustomed to procedural exercises rather than contextual or non-routine problems. As noted by Indah and Hidayati (2021), students often fail to apply concepts correctly because they do not fully understand the underlying conditions of a problem. This is also confirmed by (Krisnadi et al., 2020) who found that students in the low category tend to be imprecise and rushed when reading word problems, leading to a failure in accurately applying problem-solving algorithms. This finding suggests that instructional practices should place greater emphasis on contextual reasoning and problem interpretation rather than formula memorization.

In synthesis, this research shows that while students excel in lower-order cognitive aspects (remembering and understanding), they still require intensive guidance in higher-order cognitive aspects (analyzing and applying). It is expected that teachers will not only focus on providing formulas but also emphasize logical reasoning and contextual practice to bridge this gap in understanding.

Conclusion

Based on the data analysis and discussion, students' conceptual understanding of Systems of Linear Equations in Two Variables at SMP Fitra Abdi Palembang is generally categorized as high. However, a significant gap exists between students' ability to recall concepts and their ability to apply concepts to contextual problems. This study contributes to mathematics education by providing a detailed indicator-based profile of students' conceptual understanding,

highlighting specific weaknesses that require pedagogical attention. Mathematics teachers are encouraged to implement learning models such as Problem-Based Learning (PBL) or Contextual Teaching and Learning (CTL) to help Students Bridge the gap between memorizing formulas and applying concepts in real-life problem situations. Future research is recommended to employ experimental or qualitative approaches to further explore effective instructional strategies for improving students' conceptual application skills.

Declarations

Author contribution. KA: resources, conceptualization, visualization, writing–original draft; NA: project administration, collecting and analyzing data; All authors agreed with the results and conclusions.

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