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ANALYSIS OF STUDENTS' ABILITY TO UNDERSTAND MATHEMATICAL CONCEPTS IN PROBABILITY MATERIAL

Ulya Sofiatunnisa[1*], Alpha Galih Adirakasiwi[2]

[1,2] Mathematics Education, Singaperbangsa University Karawang, Karawang, Indonesia
*Corresponding author. Address, Postal code, City, Country.

E-mail: 2110631050106@student.unsika.ac.id [1]
alpha.galih@fkip.unsika.ac.id [2]

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ABSTRACT
The concept of chance has an important role in everyday life, especially for vocational students who are able to master analytical and decision-making skills in the world of work, but students' low understanding of the concept of chance is a challenge that requires more attention in learning mathematics. This study aims to analyze students' understanding of mathematical concepts in opportunity material at the Vocational High School (SMK) level. The method used is descriptive qualitative, with data collection through written tests, interviews, and documentation. The research sample consisted of 28 students of class XI SMK using random sampling technique. The results showed that students' understanding of the concept of chance was still low, with an average mastery of only 20% of the total indicators tested. The indicators of restating concepts (4%) and classifying objects based on concepts (0%) have the lowest percentage, indicating that students still have difficulty in understanding the concept of chance in depth. The indicator of applying concepts in algorithms and mathematical representations (54%) had the best results, although there were still errors in choosing the right formula. Meanwhile, the indicator of connecting the concept of chance with other fields (21%) shows that students are not familiar with the application of chance outside of mathematics. The main factor causing this low understanding is the lack of understanding of the basic theory of probability and the tendency of students to memorize the formula.
Keywords: conceptual understanding; mathematics learning; probability material.

ABSTRAK
Konsep peluang sangat penting dalam kehidupan sehari-hari, khususnya bagi siswa SMK yang perlu menguasai keterampilan analitis dan pengambilan keputusan. Namun, pemahaman siswa terhadap konsep ini masih rendah, yang menjadi tantangan dalam pembelajaran matematika. Penelitian ini bertujuan untuk menganalisis pemahaman konsep matematis siswa dalam materi peluang di tingkat Sekolah Menengah Kejuruan (SMK). Metode yang digunakan adalah deskriptif kualitatif, dengan pengumpulan data melalui tes tertulis, wawancara, dan dokumentasi. Sampel penelitian terdiri dari 28 siswa kelas XI SMK dengan teknik random sampling. Hasil penelitian menunjukkan bahwa pemahaman konsep peluang siswa rata-rata hanya 20% dari indikator yang diuji. Indikator seperti menyatakan ulang konsep (4%) dan mengklasifikasikan objek (0%) memiliki persentase terendah, menunjukkan kesulitan siswa dalam memahami konsep secara mendalam. Meskipun indikator menerapkan konsep dalam algoritma dan representasi matematis (54%) menunjukkan hasil terbaik, masih terdapat kesalahan dalam pemilihan rumus. Indikator yang menghubungkan konsep peluang dengan bidang lain (21%) juga menunjukkan bahwa siswa belum terbiasa dengan penerapan peluang di luar matematika. Faktor utama penyebab rendahnya pemahaman ini adalah kurangnya pemahaman teori dasar peluang dan kecenderungan siswa untuk menghafal rumus tanpa memahami penerapannya. Oleh karena itu, diperlukan strategi pembelajaran yang lebih efektif, seperti pendekatan berbasis pemecahan masalah dan pembelajaran kontekstual, untuk meningkatkan pemahaman siswa dalam materi peluang.
Kata kunci: *materi peluang; pemahaman konsep; pembelajaran matematika.*

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Introduction

Probability is a mathematical concept used to predict the likelihood of an event occurring in everyday life (Rahmi, Iltavia, & Zarista 2021). This concept helps in various human activities, such as predicting outcomes, calculating risks, predicting data, and making decisions. A deep understanding of probability is important because it provides students with the ability to analyze and interpret various situations involving uncertainty. The ability to understand mathematical concepts is not merely about memorizing formulas, but more about how students apply them in various contexts (Nurhangesti & Seruni 2024). As stated by Lestari & Yudhanegara (2018), understanding mathematical concepts helps students translate mathematical ideas more globally and functionally. When students truly understand concepts, they can solve problems more easily because they have a strong foundation to face more complex challenges. This also helps students deepen their procedural mathematical knowledge (Hutagalung 2017). Understanding mathematical concepts is one of the goals and competencies that every student must achieve in mathematics (Nailopo, Fitriani, & Simarmata 2022).

However, in practice, many students struggle to understand mathematical concepts deeply. Some previous studies, such as those by Heppinia & Tiya (2015), Rismawati (2016), and Rismawati & Hutagaol (2018), state that one of the biggest obstacles in learning mathematics is students' low understanding of the concepts they are studying, with many students more accustomed to memorizing formulas rather than truly understanding their meaning. As a result, students often make errors when applying concepts or become confused when faced with problems that require further analysis. One such challenging topic is probability, as it requires not only calculation but also a deep understanding of the relationships between events. Probability is often used to predict the likelihood of an event, such as the success of a project or the risk of failure in business decisions. This understanding is also relevant in the vocational students' world of work, such as in fields like engineering, trade, and services.

The concept of probability is frequently encountered in everyday life. However, many students still have difficulty understanding how probability works. Students face challenges in solving probability problems due to their inadequate mastery of the basic probability concepts. Many students tend to memorize formulas without understanding the terminology used in probability material, and they lack an understanding of the probability concept, which involves certain mathematical operations. As a result, students struggle to solve problems related to probability (Damayana, Andinasari, & Lusiana 2019). A study conducted by Lumbantoruan & Male (2020) showed that conceptual errors in probability material often relate to students' understanding of independent events, where students often incorrectly assume that the probability of one event is unaffected by another event, even when the relationship between the events is clearly visible. This indicates that, although probability is an important part of mathematics, many students still do not fully understand its theoretical foundations. Therefore, it is crucial to analyze students' understanding of mathematical concepts related to probability to identify the difficulties they experience and create more effective teaching methods. Radiusman (2020) states that students with a strong understanding of

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mathematical concepts tend to find it easier to solve various types of problems, especially in probability material.

Several previous studies also highlight the low level of students' understanding in probability material. Setiani, Roza, & Maimumah (2022) found that students often have difficulty presenting the concept of probability correctly. While they may know the formulas, they struggle to explain or apply them in various forms of mathematical representations. Therefore, further efforts are needed to understand where the difficulties lie and how to help students overcome them. In line with the study by Putridayani & Chotimah (2020), students face difficulties in understanding mathematics, particularly probability material in story problems, as they often incorrectly apply the formulas, leading to errors in solving the problems. Another study by Handayani & Aini (2019) showed that the percentage of students' ability to understand probability concepts was 31.25%, which is considered low. Students are unable to determine the correct steps to solve probability concept problems. Based on previous research, it is essential to analyze students' conceptual understanding to assess their learning outcomes.

Most of the research on conceptual understanding in probability has been conducted on junior and senior high school students, such as the studies by Ate, Irianti, & Setiawan (2022), Manurung & Manurung (2024), while studies on vocational school students remain limited. Vocational students approach learning with a more practical skill-oriented perspective compared to academic theory. This makes the challenge of understanding probability concepts different, especially in applying concepts that require higher analytical and abstract thinking skills. Therefore, the aim of this research is to analyze the understanding of probability concepts among vocational students and identify the obstacles they face in understanding and applying this concept. By understanding the difficulties students face in more depth, it is hoped that more effective ways to help students understand probability better can be found.

Given the importance of understanding probability concepts and the challenges students face in learning them, a deeper analysis of how students understand this concept is very relevant. Through this research, it is hoped that new insights will be gained that not only help develop more effective teaching strategies but also contribute to the improvement of the quality of mathematics education, especially in probability material.

Research Methods

This research uses a descriptive qualitative method to analyze students' understanding of mathematical concepts in probability material. The qualitative research aims to describe phenomena, events, attitudes, social activities, perceptions, and individual or group thoughts in-depth (Arnidha 2017). his approach was chosen because it allows researchers to gain a deeper understanding of how students master the concepts being studied, including the obstacles they face when solving problems. The primary data in this study were obtained from the results of written tests, interviews with students, and supporting documentation for the analysis process.

In October 2024, the study was conducted involving students from class XI of a Vocational High School in Karawang District. The research sample was selected

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using the Simple Random Sampling technique, which gave each class an equal chance of being selected. From the seven available classes, class XI TM 1 was chosen as the sample, which consisted of 28 students.

The data collection process was carried out in several stages. The first stage involved giving a written test to the students, consisting of three essay questions designed to measure students' understanding of probability material. The test was developed based on the indicators of conceptual understanding from the research (Ummah 2023). After the test was given and collected, the second stage involved conducting interviews with several students selected based on the test results. These interviews were unstructured, allowing students to freely express their thoughts about the difficulties they faced when answering the questions. This stage also aimed to explore in more detail the main causes of students' difficulties in understanding and applying probability concepts. The third stage was documentation to help clarify the research results and provide visual evidence to support the data analysis.

The data analysis technique in this study refers to the Miles & Huberman model, which consists of three main steps: data reduction, data presentation, and drawing conclusions. Data reduction was carried out by sorting and filtering information from the test results and interviews that were most relevant to the research objectives. The students' answers were then categorized according to the indicators of conceptual understanding. After the data was reduced, data presentation was done by organizing the analysis results in the form of tables and descriptive narratives for easier understanding. The final step was drawing conclusions, where the researchers interpreted the results and identified the extent to which students understood the concept of probability and the obstacles they faced during the learning process.

The indicators of conceptual understanding used in this study refer to Kilpatrick (Yanti, Kusumawardani, Rohmah & Kulsum 2022) which includes four main aspects: 1) Restating the concepts that have been learned verbally, 2) Applying the concepts in the form of algorithms or other mathematical representations, 3) Classifying objects based on the concepts learned, and 4) Connecting various mathematical concepts, both internally and externally.

To assess the students' understanding level, the test results were analyzed based on score percentage criteria and formulas according to Andini (2017), which are presented in Table 1.

Table 1. Criteria for Students' Ability to Understand Mathematical Concepts

Percentage of Correct Answers	Understanding Category
0% - 20%	Very Poor
21% - 40%	Poor
41% - 60%	Fair
61% - 80%	Good
81% - 100%	Very Good

The percentage of student scores is calculated using the formula (1) as follows:

$$x = \frac{a}{b} \times 100\% \quad (1)$$

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Explanation:
x = percentage of correct answers from students (2)
a = number of points obtained by students from correct answers (3)
b = maximum score that can be achieved (4)

Results and Discussion

Based on the results of this research, it was conducted to analyze the mathematical conceptual understanding of students in SMK (Vocational High School) regarding probability material. The test given to students consisted of three essay questions covering four indicators of conceptual understanding according to Kilpatrick, which include four main aspects: 1) Restating the concepts that have been learned verbally, 2) Applying the concepts in the form of algorithms or other mathematical representations, 3) Classifying objects based on the concepts learned, and 4) Connecting various mathematical concepts, both internally and externally.

After the data from the three essay questions were collected and analyzed, it was found that students' understanding of the concept of probability was still categorized as low, with an average mastery of only 20% of all the indicators tested. The percentage of students' understanding of each indicator can be seen in Table 2.

Table 2. Interpretation of Students' Ability in Understanding Mathematical Concepts

No	Indicator	Mastering Indicators		
		Number of Students	Percentage	Understanding Category
1.	Verbally restate concepts that have been learned	1	4%	Very Poor
2.	Applying concepts in mathematical algorithms and representations	15	54%	Fair
3.	Classify objects based on concepts	0	0%	Very Poor
4.	Connecting various concepts (internal & external)	6	21%	Poor
	Overall average		20%	Very Poor

From the results in Table 2, it can be concluded that students' understanding of probability concepts among SMK students is still not optimal. Further discussion of each indicator and students' answers in solving problems related to probability material is as follows:

Indicator 1 in question 1a measures how well students are able to restate the probability concept in their own words. The research results show that only one student, or 4% of 28 students, was able to explain the concept correctly, while most students struggled to convey the definition of probability or explain the relationships between concepts. In Figure 1, we can see a student's answer that meets the first indicator. The first indicator.

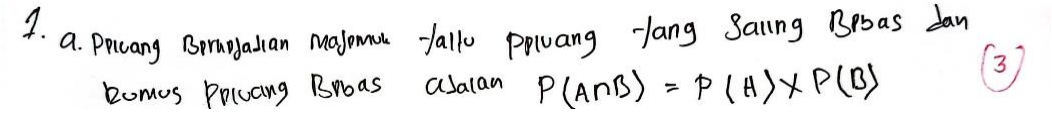

Figure 1. Correct student answer

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Figure 1, it can be seen that the student was able to restate the concept well. In their answer, the student could clearly explain the correct formula for calculating probability. This means that the probability of event A does not affect event B and vice versa, which is known as the probability of independent events. Thus, the student was able to restate the concept verbally and correctly identify and formulate the appropriate concept according to the problem.

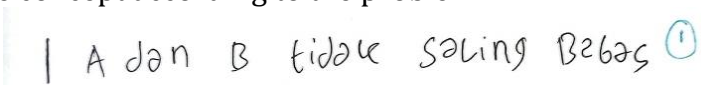

Figure 2. Students' incorrect answers

Figure 2 displays the answer from a student who stated, “A and B are not independent.” However, referring to the question given, this answer would be incorrect if both events A and B are independent. Even though the student tried to state the concept, it seems they did not fully understand it and expressed it incorrectly. Therefore, the first indicator of the ability to restate the concept verbally was not fully met.

Based on the interview, the student explained that events A and B are not independent because they believe that drawing marbles from two different boxes can affect each other. One of the main reasons for this difficulty is the lack of attention during the lesson. Many students tend to memorize formulas without understanding the theoretical foundation behind them, which leads to difficulties when they are asked to explain the concept in their own words. This finding aligns with the research by Ananda, Sanapiah, & Yulianti (2018) who state that conceptual errors often occur because students prioritize memorization over deep understanding. Astuti, Yusmin, dan Suratman (2015) also argue that the material taught to students should not just be considered something to memorize. More than that, with a good understanding, students can better comprehend the basic concepts of the subject.

Indicator 2 in question 1b tests the students' ability to apply the probability concept to solve calculation problems. In this part, the results were relatively better compared to the first indicator, with 54% of students able to solve the problem correctly. This indicates that the students' ability to apply the concept in algorithms and present it in various mathematical representations was fairly good. Further clarification of the students' ability regarding this indicator can be seen in Figure 3.

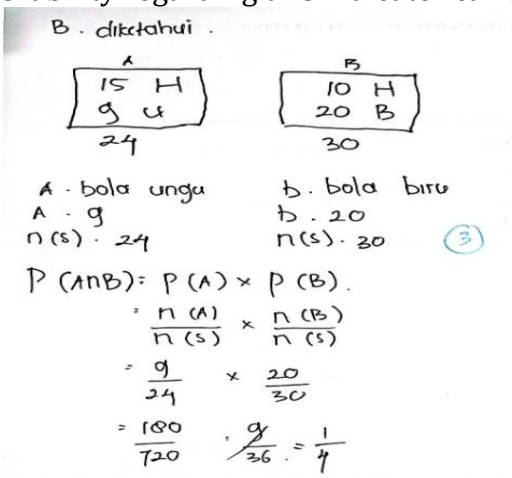

Figure 3. Correct student answer

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In the questions, students are expected to be able to apply concepts algorithmically, presenting concepts in various forms of mathematical representation. In Figure 3, it can be seen that one in 15 students managed to answer the question correctly. This shows that students are able to apply the concept of opportunity appropriately, starting from identifying relevant events, calculating the chances of each event, to correctly applying the formula for the possibility of multiple independent events. The student also managed to present the concepts clearly, using the corresponding mathematical fractions and formulas. However, Figure 4 shows the students' answers indicating errors in the application of the formula to calculate odds on multiple events.

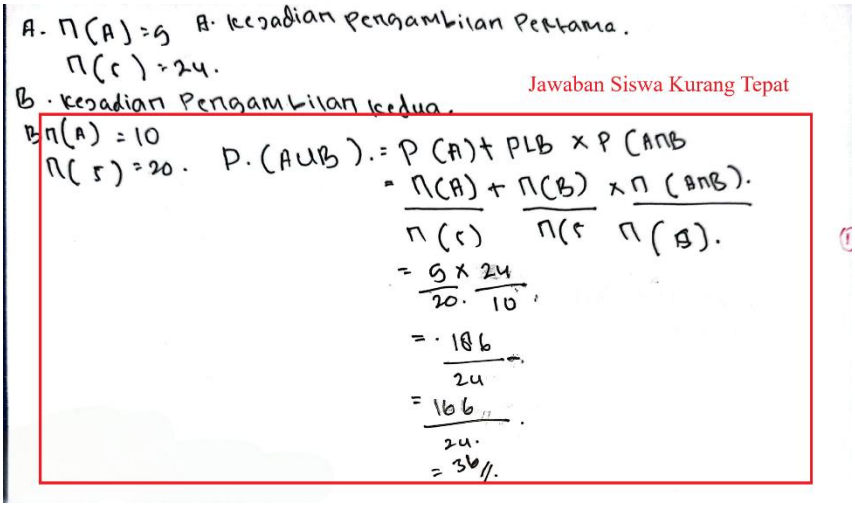

Figure 4. Students' incorrect answers

In Figure 4, although the student was able to identify the relevant events correctly, they made a mistake by applying the wrong formula for independent events. The student mistakenly used the formula for dependent events, which led to an incorrect calculation. This error reflects a conceptual barrier, as the student could not determine the appropriate formula to use for the problem.

The interview revealed that the confusion arose from the student struggling to determine the correct formula for the type of event presented in the question. This finding is in line with the research by Ramdan & Anwar (2019), which states that students often face difficulties in applying the correct formula when confronted with word problems requiring a deeper understanding.

Indicator 3 in question 2 tests the students' ability to classify objects or events based on the probability concept. Unfortunately, the research results showed that no student (0%) was able to fully answer this question. The main error that occurred was that students did not understand how to classify an event based on the probability concept. Some students only guessed the answers without providing clear reasoning for the classification. This shows that students are not yet accustomed to thinking critically when connecting theory with the problems given. This can be seen from the answers presented by students in Figure 5.

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2. Dua buah dadu dilempar secara bersama sama. Tentukan pernyataan berikut benar atau salah dengan memberikan tanda centang (pada kolom yang sesuai, beserta alasannya!

Pernyataan	Benar	Salah
a. Peluang munculnya jumlah mata dadu lebih dari 5 adalah $\frac{13}{18}$		✓
b. Peluang munculnya jumlah mata dadu 4 atau 9 adalah $\frac{9}{36}$	✓	
c. Banyaknya titik sampel adalah 12	✓	
d. Peluang munculnya mata dadu pertama ganjil adalah $\frac{18}{36}$	✓	

Figure 5. Students' incorrect answers

Figure 5 shows a student's response where they simply put a checkmark without providing a rationale for classifying the probability event. According to the interview, many students admitted that they had not received sufficient practice on problems focused on classification concepts. Most of the lessons they received were centered on theoretical introduction and calculation exercises. Therefore, when faced with conceptual questions, students experienced difficulties. This finding aligns with the research by Hadar (Laman 2019), which states that conceptual misunderstanding often arises due to a lack of practice focused on deep conceptual understanding.

Indicator 4 in question 3 measures how well students can connect the probability concept with other mathematical concepts or other fields. The results showed that 21% of students were able to answer the question correctly, while the rest still faced difficulties. The students' correct answer meeting this indicator is shown in Figure 6.

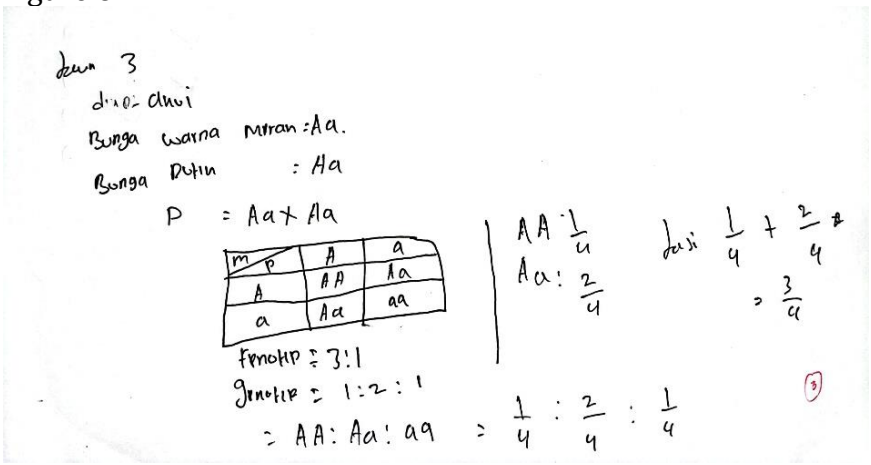

Figure 6. Correct student answer

Figure 6 illustrates a student who demonstrated a fair understanding of both genetics and the application of probability in mathematics. The problem in this indicator tested the students' understanding of probability in the context of genetics, where the students had to use a Punnett square to determine the probability of a trait appearing in a genetic cross. The correct answer shows that the student was able to logically connect the probability concept with biology. However, most students made errors in writing the genotype in the Punnett square, which led to inaccurate answers. On the other hand, Figure 7 displays a student's incorrect

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response, where they mistakenly wrote the genotypes in the Punnett square and miscalculated the probability.

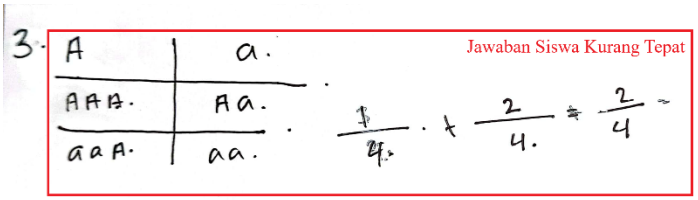

Figure 7. Students' incorrect answers

In Figure 7, some gene combinations were written incorrectly, and the calculation did not account for all possible combinations properly. The probability of dominant phenotypes (AA and Aa) should be 3/4, while recessive (aa) should be 1/4. This error indicates that students still need more practice in understanding how the Punnett square works and the application of probability concepts in genetics.

From the interviews, students stated that they struggled to connect probability with other subjects because they had never been taught real-life applications like this before. Students were more accustomed to working on probability problems related to dice, cards, or marbles. So when this concept was connected with other fields, students became confused. This finding supports the research by Hannah, Stewart, & Thomas (Radiusman 2020), who states that teachers need to make connections between mathematical concepts and real-world objects. In line with Agustina, Syaifudin, dan Supriadi (2019) they argue that by applying real-life problems to story problems related to mathematics, students will understand the material better. Therefore, it is essential for teachers to provide more examples of real-world applications of mathematical concepts to help students understand and use them more widely.

The findings of this study show that the students' understanding of probability concepts in SMK is still considered low. This is due to the fact that the students' learning tends to prioritize memorizing formulas rather than understanding the concepts, which makes it difficult for them to connect various complex problems. The students' low ability in restating concepts and classifying objects indicates that the learning process has not established a strong conceptual foundation. The main reason for this low understanding is not just the students' focus on memorization but also the limited application of probability in real-life situations.

These results are consistent with previous findings, such as those by Handayani & Aini (2019), who showed that students' ability to understand probability concepts only reached 31.25%, and Putridayani & Chotimah (2020), who identified difficulties students faced in understanding probability concepts, especially in story problems and using the correct formulas. This study also supports the findings of Setiani, Roza, & Maimumah (2022), who found that students often had difficulty presenting the concept of probability correctly. Therefore, it is necessary to shift teaching methods from memorizing formulas to understanding concepts and developing more contextual and real-world application-based learning.

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Conclusion and Suggestion

Based on the results of this research, it can be concluded that students' ability to understand mathematical concepts related to probability is still categorized as low, with an average of only 20% across all indicators tested. The main findings show that most students have difficulty restating the concept verbally, applying the probability concept in algorithmic form, classifying objects based on the concept, and connecting different mathematical concepts. The main obstacles identified are the lack of understanding of basic probability theory and students' tendency to memorize formulas without understanding their applications.

To help SMK students better understand probability concepts, it is suggested that teachers apply a problem-solving-based approach in their teaching. This method encourages students to actively search for solutions, so they do not just memorize formulas but truly understand the concept. By presenting real-life situation problems, students can see how probability is used in everyday life, making the material more relevant and easier to understand.

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