Jurnal Elemen, 10(1), 13-27, January 2024
https:/doi.org/10.29408/jel.v10i1.18348

e- ISSN: 2442 - 4226

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Learning obstacles in solving story problems on probability for vocational high school students

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Abstract

This research aims to determine and obtain actual data on the types of epistemological learning obstacles in solving probability story problems. This study was motivated by the low learning outcomes of students in solving probability story problems. The research uses a qualitative descriptive method with data collection techniques, including written tests, interviews, and documentation. Based on the analysis of the written test, interviews, and documentation data, it was found that out of 20 students who took the learning obstacle test, 11 scored below 60. The percentage of students who scored below the minimum completion criteria was 55%. These obstacles include errors in understanding the problem concept, errors in selecting and using solution procedures, errors in writing answers, and errors in operational techniques. It indicates that half of the students who took the learning obstacle test on probability story problems still experience learning obstacles, particularly epistemological obstacles, in solving such issues. It is reinforced by analysis and in-depth interviews with three vocational students that these students still participate in epistemological obstacles ranging from conceptual, procedural, and technical operational obstacles.

Keywords: epistemological obstacle; learning obstacle; probability

How to cite: Sartika, N. S., Mustika, S. M., Sahrudin, A., Meika, I., Mauladaniyati, R., & Yunitasari, I. (2024). Learning obstacles in solving story problems on probability for vocational high school students. *Jurnal Elemen, 10*(1), 13-27. https://doi.org/10.29408/jel.v10i1.18348

Received: 15 June 2023 | Revised: 10 September 2023
Accepted: 9 January 2024 | Published: 31 January 2024

Introduction

Mathematics is a scientific discipline that requires systematic, logical, and critical thinking. According to Telaumbanua (2020), Mathematics is a science obtained through reasoning that uses terms that are defined carefully, clearly, and accurately, its representation with symbols or symbols, and has meaning and can be used in solving numbers-related problems. Mathematics is also one of the fields of study that supports the development of science and technology. Thus, mathematics lessons are provided at all education levels, from primary school, junior high school, senior high school, or vocational school to higher education institutions (Izazah, 2019).

Mathematical concepts refer to newly formed understandings arising from thinking, encompassing definitions, meanings, characteristics, essence, and the core/essence of mathematical content (Boediono, 2009). In line with the opinion mentioned above, according to Sadikin et al. (2017), conceptual understanding is the ability demonstrated by students to comprehend the definitions, meanings, characteristics, essence, and core/essence of mathematics, as well as the ability to select appropriate procedures to solve problems (Apriliyana et al., 2023). Thus, mastery of mathematical concepts is the foundation for solving mathematical problems. However, until now, many students have not fully mastered mathematical concepts, leading to learning difficulties and failure to achieve learning objectives (Virgana, 2016).

The objectives of mathematics learning by the demands of the independent curriculum are as follows: (1) To understand mathematical concepts, explain the interconnections between concepts, and apply concepts or algorithms fluently, accurately, efficiently, and precisely in problem-solving; (2) To use reasoning in patterns and properties, perform mathematical manipulations in making generalizations, constructing proofs, or explaining mathematical ideas and statements; (3) To solve problems, including the ability to understand problems, design mathematical models, solve models, and interpret the obtained solutions; (4) To communicate ideas using symbols, tables, diagrams, or other media to clarify situations or problems; (5) To have an appreciation for the usefulness of mathematics in life, which includes having curiosity, attentiveness, and interest in learning mathematics, as well as a persistent and confident attitude in problem-solving. Thus, every mathematics lesson has learning outcomes and objectives, along with the criteria for achieving the learning objectives for each topic (Kamarullah, 2017).

One of the topics taught in 10th-grade vocational high school is probability. Probability is a part of mathematics because it represents the likelihood of an event or phenomenon occurring in an experiment or an event. It describes the chances of specific outcomes happening or not happening in the context of mathematics learning. Probability is closely associated with story problems that depict various possibilities. As a result, one of the factors contributing to the difficulty in problem-solving for students is the presence of story problems (Saniyah & Alyani, 2021). Story problems are essential in learning mathematics because students will better understand the nature of a mathematical problem when faced with story problems. In addition, story problems are beneficial for developing students' thinking

processes because solving the problems contained in story problems requires solving steps and reasoning. However, in reality, many students need help understanding the meaning of the sentences in the story problem, the lack of students' skills in translating mathematical sentences, and which elements must be formalized with one variable (Saniyah & Alyani, 2021).

Based on the interviews conducted by the researcher with the 10th-grade teachers at the vocational, it was found that most students scored below the minimum completion criteria in mathematics. The teachers also mentioned that "most students face learning difficulties in probability because they often make conceptual errors when solving story problems related to probability." It is consistent with the opinion (Jamal, 2014; Fitri & Abadi, 2021) that their research found that students struggle to learn mathematics, specifically probability. Common errors students make when solving story problems include reading errors, conceptual misunderstandings, formula misuse, calculation mistakes, difficulties in understanding symbols and signs, challenges in selecting and applying solution procedures, and mistakes in writing final answers. These student errors give rise to barriers during the learning process, which are known as learning obstacles (Yusuf et al., 2017).

Learning obstacles are phenomena observed in students, characterized by lower learning outcomes than their previous achievements. Additionally, students will face specific barriers in achieving their learning outcomes due to their varying levels of prior knowledge. Therefore, each student may experience different types of learning obstacles. According to Indasari and Ratna (2019), learning obstacles are the challenges faced by students in understanding mathematical problems during the learning process. Based on this statement, it can be understood that learning obstacles occur when students' acquired knowledge does not align with what is expected, resulting in low learning outcomes (Evayanti, 2017). According to Brousseau (2002), there are three types of learning obstacles: (1) Ontogenic obstacle, which refers to learning barriers that arise due to limitations within the students themselves, specifically related to the student's mental readiness for learning; (2) Didactical obstacle, refers to barriers that arise from the teaching practices conducted by the teacher; (3) Epistemological obstacle is a barrier that occurs due to the limitations in students' knowledge within a specific context (Faizin, 2019).

Epistemological obstacles arise due to an incomplete understanding of science or students only understanding certain content, resulting in students needing more mindsets regarding the concept of science (Khairani et al., 2019). In addition, according to (Rismawati et al., 2018), epistemological obstacles, namely difficulties in the learning process, occur due to the limited context that students know. In this case, students only receive a partial understanding of the concept, so when faced with a different context, they need help using it (Insani & Kadarisma, 2020).

In this research, the researcher focuses on the epistemological obstacle, a learning barrier caused by the limitations in students' knowledge within a specific context. It is in line with the findings of a previous study conducted by Hikmah (2021) titled "Identification of Learning Obstacles in Probability among 8th-grade students at SMP Negeri 2 Susukan, Semarang Regency, Academic Year 2021/2022." The research findings indicate students face

epistemological obstacles when solving probability story problems. These obstacles include difficulty determining the sample space and points, assigning probability values, relating probability concepts to other mathematical topics, understanding story problems, and contextual problem-solving. This research aims to identify the specific epistemological obstacles encountered by vocational high school students in solving probability story problems.

The field data indicates that out of 20 students who took the learning obstacle test, 11 students scored below the minimum completeness criteria of less than 60. This situation cannot be allowed to persist for long. Therefore, this research is expected to serve as a reference for teachers in developing instructional approaches that can anticipate and address the learning obstacles experienced by students when solving probability story problems. The benefit is that in the future, teachers can improve the learning process if students experience learning obstacles.

Methods

The research method used was descriptive research with a qualitative approach. According to Sugiyono (2016), descriptive research aims to describe or provide an overview of the researched object through the collected data or samples as they are, without conducting analysis or making generalizable conclusions. *Qualitative research* is an approach to understanding phenomena such as behaviors, perceptions, motivations, actions, and others holistically experienced by research subjects. It utilizes descriptive methods to present findings in words and specific natural contexts, employing various naturalistic methods (Faizin, 2019).

This research was conducted at vocational high school 1 Malingping, located at Jl. Beyeh-Simpang Km. 02, Sukamanah Village, Malingping District, Lebak Regency, Banten Province, 42391. This study involved 20 class X vocational high school students as subjects from three different criteria. The subjects were selected by purposive sampling, namely, taking research subjects based on specific considerations (Sugiyono, 2017). Thus, to determine the research subjects, the test results were corrected after the students finished working on the test questions, and the students' scores were sorted from the largest to the smallest. Then, the score is divided into three criteria, namely students with high score criteria, medium scores, and low scores, and one student from each of these criteria is selected.

Data sources in this study were obtained from research subjects, namely sources or sources that provide data directly. Researchers collected data through direct research to schools, which included written tests, interviews, and documentation. Written tests were used to identify learning obstacles and types of epistemological learning obstacles in solving probability story problems. The test consisted of five description questions about probability material story problems that had been validated by material experts, namely vocational high school mathematics teachers and probability material expert lecturers. Interviews were

conducted with three students to explore the types of epistemological learning obstacles related to solving probability story problems more deeply. Furthermore, documentation in the form of photos of students working on problems as evidence of the implementation of the research.

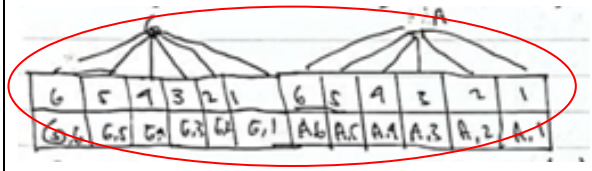
The data analysis technique uses: (1) Data collection, the data collected is data learning obstacles in solving probability story problems; (2) Data reduction, the data reduction process carried out by researchers is correcting student answers that have been collected, then classifying learning obstacles in solving probability story problems. Furthermore, researchers summarised the results of tests and interviews according to the needs of researchers; (3) Presentation of data, namely presenting data on the results of the learning obstacle test in a qualitative descriptive manner; (4) Concluding/verification researchers draw conclusions and verify the data explicitly obtained, or researchers draw conclusions about learning obstacles, especially the type of epistemological obstacle experienced by students in solving probability story problems.

Results

The researcher conducted a written test on class X vocational high school students and identified learning barriers, especially epistemological barriers. One of the student answers from the three research subjects shows learning epistemological obstacles in solving probability story problems. The figure below is an example of the responses of students who experience epistemological obstacles.

Question Number 1
A coin with two faces, a picture and a number, and a die with six faces numbered 1, 2, 3, 4, 5, and 6 are thrown simultaneously. Then determine the sample space, sample points, and the total number of sample space for both objects! Create a table to illustrate this.

Answer Number 1
Sampel points : (1), (2), (3), (4), (5), (6)
: (A,A), (A,G), (G,A), (G,G)
S : (A,A), (A,G), (G,A), (G,G)
Total number of sample space n(S) : 4
organise the members of the sample space with a tree diagram



Total number of sample space n(S) : 12

Figure 1. Example of student's answer

In the student's example answer, the student determined the total number of sample points for the simultaneous toss of a coin and a die. However, the student needed to identify the sample space and sample points. It indicates that the student faced conceptual, procedural, and technical operational obstacles, as they incorrectly mentioned the sample space and sample points, needed more understanding of problem-solving steps, had limited mastery of the question, and made errors in writing the answer. The following is an excerpt from the interview:

Researcher : *Do you understand question number 1?*
Student : *Not yet, sir/ma'am.*
Researcher : *Why don't you understand yet?*
Student : *I'm confused, sir/ma'am.*
Researcher : *What is causing your confusion?*
Student : *I'm confused about understanding the solution steps with the table diagram, and I also have a limited understanding of probability story problems, sir/ma'am.*

Based on the excerpt from the student's interview above, the student experienced a *learning obstacle* as they admitted to having a limited understanding or mastery of the question and a lack of understanding of probability story problems. As a result, they made errors in identifying the sample space and sample points for the simultaneous toss of a coin and a die.

Question Number 2
Feby has 3 coins of 1000 rupiah each and throws all three coins simultaneously. What is the probability of getting heads on all three coins? Create a tree diagram to illustrate this!

Answer Number 2
Known: there are 3 1000 rupiah coins.
because there are 3 coins then:
n(S) = $3^3 = 6$
A = Angka
G = Gambar
the possibilities that happen to the 3 coins are: (A,A), (A,G), (G,A) and (G,G)
so that if B denotes the 3rd appearance of the image then:

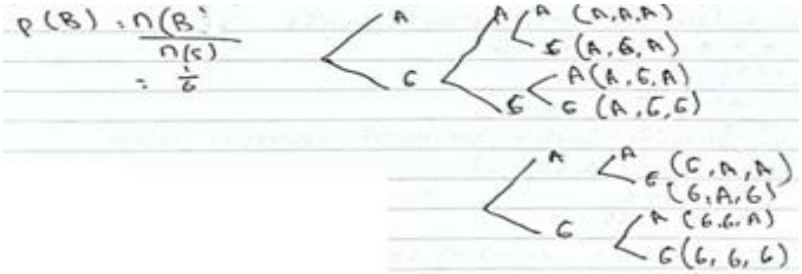
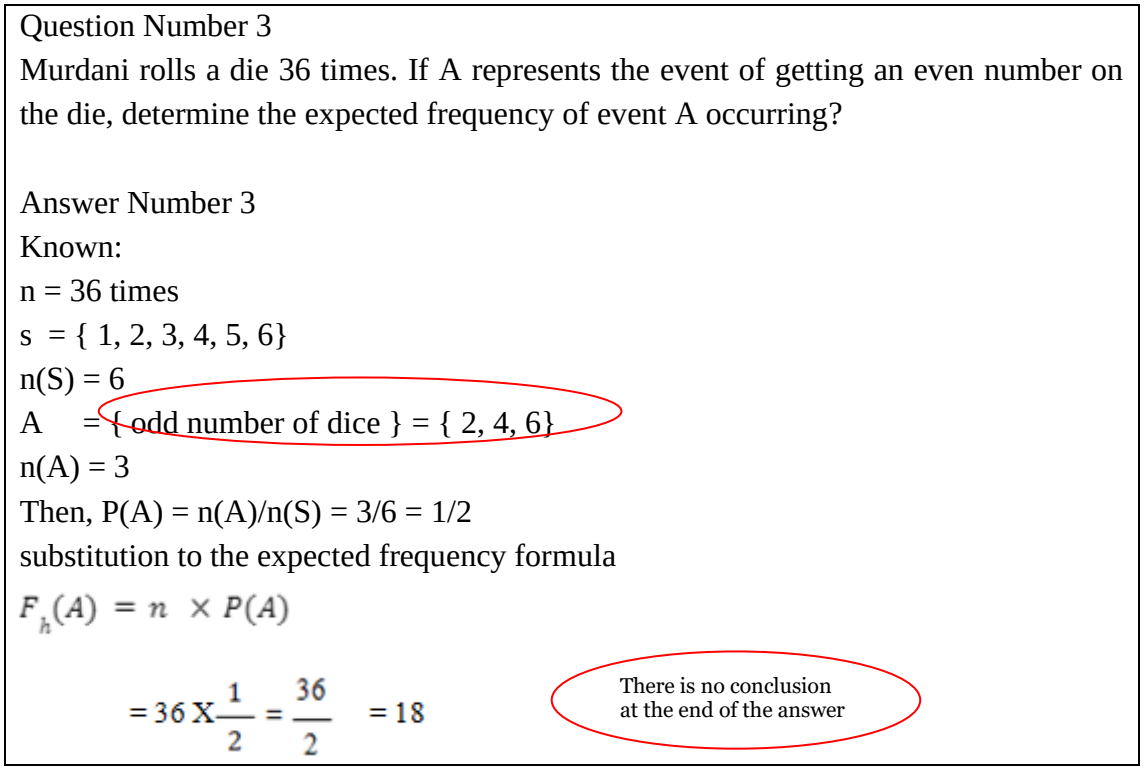


Figure 2. Example of student's answer

In the student's response example, the student appears to be able to create a tree diagram. However, the student failed to determine the probability of getting a specific image when tossing three coins simultaneously. It indicates that the student faced conceptual, procedural, and technical operational obstacles, where the student is mistaken in determining the probability value, lacks mastery of the problem, and makes errors in writing the answers. Here is an excerpt from the interview:

Researcher : *Do you understand the story problem number 2?*
Student : *Not fully, sir/ma'am.*
Researcher : *Why don't you understand?*
Student : *Because I didn't read the problem carefully, and I find it difficult to comprehend the story problem.*

Based on the excerpt from the student's interview above, the student experienced *a learning obstacle* because they admitted to having a limited understanding of comprehending story problems, resulting in errors in determining the probability of specific images appearing during the simultaneous tossing of three coins.


Question Number 3
Murdani rolls a die 36 times. If A represents the event of getting an even number on the die, determine the expected frequency of event A occurring?

Answer Number 3
Known:
n = 36 times
s = { 1, 2, 3, 4, 5, 6}
n(S) = 6
A = { odd number of dice } = { 2, 4, 6}
n(A) = 3
Then, P(A) = n(A)/n(S) = 3/6 = 1/2
substitution to the expected frequency formula

$F_h(A) = n \times P(A)$

$= 36 \text{ X} \frac{1}{2} = \frac{36}{2} = 18$

There is no conclusion at the end of the answer

Figure 3. Example of student's answer

In the student's example answer, the student could determine the expected frequency of pictures in an event. However, the student made errors in writing the answer and did not include a conclusion at the end of the answer. It indicates that the student faced conceptual, procedural, and technical operational obstacles, as they needed a greater understanding of the

complete problem-solving steps and made errors in writing the answer. Here is an excerpt from the interview:

Researcher	:	*What do you think, is question number 3 considered easy?*
Student	:	*It's easy, sir/ma'am.*
Researcher	:	*Why do you consider it easy?*
Student	:	*Because questions like this have been tested several times before.*
Researcher	:	*But why did you write odd number of dice but the content is even number?*
Student	:	*I was not focused, sir/ma'am, so I made a mistake in writing the answer*
Researcher	:	*Why didn't you draw a conclusion at the end of the answer?*
Student	:	*I forgot, sir/ma'am.*
Researcher	:	*Once again, you forgot, right?*
Student	:	*Yes, sir/ma'am.*
Researcher	:	*Why do you often forget?*
Student	:	*Maybe because I am fasting, so I am less focused on solving probability story problems.*

Based on the excerpt from the student's interview above, the student experienced a learning obstacle as they admitted to having a lack of focus, resulting in errors in writing the answer and forgetting to include a conclusion at the end.

Question Number 5
Tatang has a box containing 15 identical cards labeled 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15. If one card is drawn, what is the probability of drawing a card that is either odd or prime?

Answer Number 5
Known:
S = (1,2,3,4,5,6,7,8,9,10)
A = the event that an odd-numbered card is drawn.
= { 1, 3, 5, 7, 9, 11, 13, 15 }, n(A) = 8

$$P(A) = \frac{n(A)}{n(S)} = \frac{8}{15}$$

B = the event that a prime numbered card is drawn.
= { 2, 3, 5, 7, 11, 13 }, n(B) = 6

$$P(B) = \frac{n(B)}{n(S)} = \frac{6}{15}$$

(A ∩ B) = { 3, 5, 7, 11, 13 } → n (A ∩ B) = 5

$$P(A \cap B) = \frac{n(A \cap B)}{n(S)} = \frac{5}{15}$$

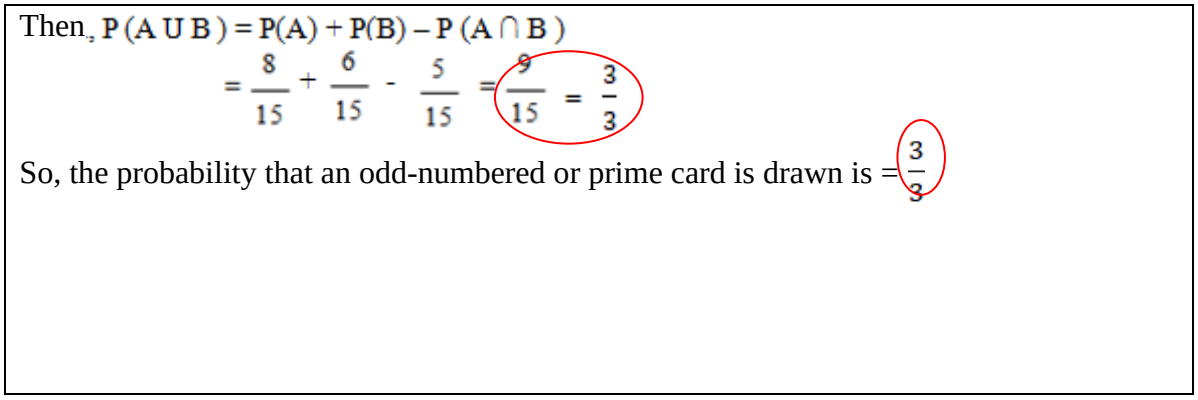


Figure 4. Example of student's answer

In the example of the student's answer, the student appears to understand the problem well. However, they made a mistake in simplifying the final answer to its simplest form. This indicates that the student faced technical, operational obstacles, as they miscalculated the final value and did not simplify it correctly. Here is an excerpt from the interview:

Researcher	:	*Do you understand question number 5?*
Student	:	*Yes, sir/ma'am.*
Researcher	:	*Take a look! What is the simplest form of 9/15?*
Student	:	*It's 3/5, sir/ma'am*
Researcher	:	*Why did you write 3/3?*
Student	:	*Uh...yes, sir/ma'am, I miscalculated and wrote it incorrectly. I meant to write 3/5.*

Based on the excerpt from the student's interview above, the student experienced a *learning obstacle* as they admitted to making a calculation error and incorrectly writing the fraction in its simplest form.

The results of the analysis of learning obstacles experienced by students in solving probability story problems are obtained from the recapitulation of the types of epistemological obstacles from the three interviewed students as follows:

Table1. Recapitulation of the types of epistemological obstacles

Question Number	Student 1	Student 2	Student 3
1	The student did not experience any learning obstacles, including conceptual, procedural, and technical operational obstacles.	The student experienced conceptual obstacles, procedural obstacles, and technical, operational obstacles, as they made mistakes in identifying the sample space and sample points, had a limited understanding of the problem, and	The student experienced conceptual, procedural, and technical operational obstacles, as they made mistakes in identifying the sample space and sample points, did not understand the steps to solve the problem, had a limited understanding of the problem, and made errors in writing their answers.

Question Number	Student 1	Student 2	Student 3
		made errors in writing their answers.	
2	The students experienced procedural obstacles, as they had a limited understanding of the steps to solve the problem and lacked proficiency in the subject matter.	The students experienced procedural obstacles, as they had a limited understanding of the steps to solve the problem and lacked proficiency in the subject matter.	The students experienced conceptual, procedural, and technical operational obstacles, as they made mistakes in determining the probability values, lacked proficiency in the subject matter, and made errors in writing their answers.
3	The students experienced procedural obstacles, as they had a limited understanding of the steps to solve the problem.	The students experienced procedural and and technical operational obstacles, as they had a limited understanding of the steps to solve the problem and made errors in writing their answers.	The students experienced procedural and technical operational obstacles, as they had a limited understanding of the steps to solve the problem and made errors in writing their answers.
4	The students experienced procedural obstacles, as they were unable to simplify their answers to the simplest form and had a limited understanding of the steps to solve the problem.	The students experienced procedural obstacles, as they were unable to simplify fractions and had a limited understanding of the steps to solve the problem.	The students experienced conceptual and procedural obstacles, as they incorrectly mentioned that the number of dice faces was 5 and 6, and they were unable to simplify fractions and had a limited understanding of the steps to solve the problem.
5	The students experienced procedural obstacles, as they had a limited understanding of the steps to solve the problem.	The students experienced procedural obstacles, as they were unable to simplify their final answers to the simplest form.	The students experienced technical operational obstacles, as they made errors in calculating the final answer to the simplest form.

Based on the recapitulation of epistemological obstacles from the interviews with the three students, on average, the students experienced conceptual obstacles, as they incorrectly

mentioned the members of the sample space and the sample points. They also encountered procedural obstacles, as they needed a greater understanding of the steps to solve the problem, lacked mastery of the subject matter, and faced technical and operational obstacles, as they made errors in calculations and writing their answers. Thus, the results of the analysis of learning obstacles, predominantly epistemological obstacles experienced by students in solving probability story problems, obtained a recapitulation of the number of students whose scores were below the minimum completeness criteria of less than 60, which can be seen in Figure 5 below:

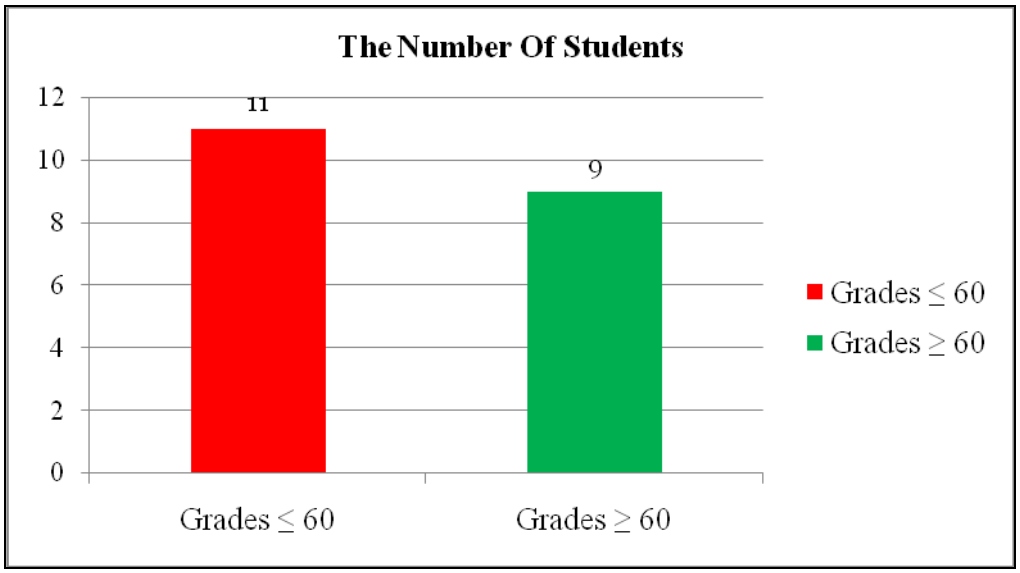


Figure 5. Recapitulation of the number of students with scores below the minimum completeness criteria

Based on Figure 5 on the recapitulation of the number of students who scored below the minimum completeness criteria, 11 students scored less than 60, and 9 students scored more than 60, which means 11 students out of 20 students who took the learning obstacle test scored below the minimum completeness criteria. It shows that students still experience epistemological obstacles.

Discussion

In this study, the authors found that the majority of students scored below the minimum completion criteria, and the majority of students lacked understanding of probability material, lacked mastery of the questions, miscalculated, and were less careful in working on problems marked by errors made by students when working on probability story problems. From these student errors, obstacles arise when learning, known as learning obstacles (Utami et al., 2020; Hikmah, 2021). It means that students experience learning obstacles in solving probability story problems. This student learning obstacle is a type of epistemological obstacle. Epistemological barriers are closely related to learning errors and difficulties experienced by students while learning because epistemological barriers are obstacles during learning caused

by students' limited knowledge in a particular context (Brousseau, 2002). Students' knowledge can only be understood in one context; if they find a different context, the knowledge in the previous context will affect the acceptance of the next context. So that students experience limited mindsets in the concept of science (Izazah, 2019). According to Suryadi (2019), the limited context that students learn is because they only receive an understanding of the concept, not as a whole, so when faced with a different context, they need help using it (Mahmud et al., 2023). It is in line with the opinion (Cesaria & Herman, 2019) that epistemological barriers are an obstacle for someone to understand material due to knowledge that is limited to certain contexts and, in other contexts, cannot use the knowledge they have (Maarif et al., 2020). There are three indicators to determine the existence of epistemological barriers: conceptual, procedural, and operational technical. The explanation is as follows:

Conceptual barriers are errors made by students in understanding terms, concepts, facts, properties, and principles (Dewi et al., 2021). Conceptual barriers occur due to students' need to understand the material being studied thoroughly. This incomprehension results in errors in solving mathematical problems, namely in determining the next step (Maarif et al., 2020). It is in line with the opinion of Elfiah et al. (2020) that conceptual barriers can be found in indicators of errors in determining formulas, inappropriate use of theorems or definitions, formulas, theorems, or definitions are not written to answer questions. The conceptual barriers, according to Dewi et al. (2021), include (1) Errors in determining formulas, theorems, or definitions to solve problems; (2) Inconsistencies in the use of formulas, theorems, or definitions with the prerequisite conditions for the application of formulas, theorems, or definitions; (3) Formulas, theorems, or definitions not being used to solve a problem (Hikmah, 2021).

Procedural barriers are students' errors in formulating systematic steps, symbols, and rules in solving a problem (Dewi et al., 2021). Procedural barriers can be found when preparing steps and symbols in answering a mathematical problem (Elfiah et al., 2020). Procedural barriers, according to Dewi et al. (2021), include: (1) The steps instructed to solve a problem are not aligned with the steps followed by the student; (2) The student is unable to simplify the problem to its simplest form, requiring additional steps to be taken (Hikmah, 2021).

Operational barriers are errors students make in writing and calculating their answers (Dewi et al., 2021). Operational and technical barriers are often found in student errors in writing, causing student errors in calculations (Elfiah et al., 2020). This obstacle occurs because students must still be more careful and thorough in answering a problem. The operational technique barriers, according to Dewi et al. (2021), include (1) Errors in calculations, often caused by incorrect substitution of values into mathematical formulas and mistakes in addition, subtraction, multiplication, and division; (2) Errors in writing, often resulting from incorrect notation or substitution of values into formulas and other mistakes that lead to incorrect values (Hikmah, 2021).

To address these issues, the teacher's active role is crucial in assisting students in mastering the topic of probability. The teacher should employ enjoyable teaching methods, provide sufficient and repetitive exercises, and utilize instructional aids to enhance students'

overall understanding. It will help reduce learning barriers when solving story problems related to probability.

Conclusion

Eleven of 20 students scored below the minimum completion criteria. Thus, the percentage of students who scored below the minimum completion criteria was 55%. Learning obstacles, especially the epistemological obstacles experienced by students on probability story problems identified in this study, are conceptual, procedural, and operational technical obstacles.

The findings of this study can be a reference for teachers in developing learning approaches that can anticipate and overcome learning obstacles experienced by students in solving probability story problems. For example, teachers can evaluate and innovate the learning process on probability by reviewing or repeating the material that has been delivered or by compiling and preparing engaging teaching media to increase students' understanding of probability to improve student learning outcomes. The limitation of this research is that more respondents can be added to get more in-depth findings.

Acknowledgment

The researchers would like to thank the Faculty of Teacher Training and Education, Mathla'ul Anwar University Banten, for the support and permission given so that this research can be carried out properly, as well as the principal, teachers, and staff of the vocational high school for the assistance and permission given to carry out research at the school.

Conflicts of Interest

The authors declare no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies, have been completed by the authors.

Funding Statement

This work received no specific grant from any public, commercial, or not-for-profit funding agency.

Author Contributions

Nenden Suciyati Sartika: Conceptualization, writing - original draft; **Siti Mega Mustika:** formal analysis; **Asep Sahrudin:** Validation and supervision; **Ika Meika:** Writing - review & editing; **Ratu Mauladaniyati:** Methodology; **Ika Yunitasari:** Editing, and visualization.

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