

# Evaluating Probability Learning: The Role of Student Attitudes, Skills, and Reflection in the Mathematics Education Process

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## ABSTRACT

The aim of this research is to evaluate the specific contributions of certain factors to students' understanding of the concept of probability and to identify effective teaching strategies to overcome potential obstacles. Using a quantitative approach, the study involves 20 students from a selected class based on inclusion criteria. Research instruments include observation sheets, tests, and questionnaires validated by two experts in mathematics education. Quantitative analysis is conducted to assess students' attitudes, skills, and reflections on probability learning. Results indicate that 20% of students fall into the "low" category, 35% into the "sufficient" category, and 45% into the "good" category. Student reflections emphasize the importance of understanding the material, engaging in activities, utilizing technology, participating in discussions, and receiving feedback. Additionally, aspects such as interest, motivation, collaboration, attitude towards errors, and critical thinking skills are highlighted. The implications of these findings suggest the need for more focused and in-depth teaching strategies to enhance students' probability problem-solving skills in mathematics education.

**Keywords:** probability learning, student attitudes, skills, reflection, mathematics education, critical thinking, skill analysis, teacher feedback

## INTRODUCTION

Mathematics education plays a central role in shaping the fundamental understanding of mathematical concepts for students (Gravemeijer et al., 2017). One crucial aspect of this process is the evaluation of probability learning, which is the primary focus of this article. This evaluation involves exploring the roles of student attitudes, skills, and reflection in determining the success of students in comprehending the concept of probability. Through a thorough analysis of these factors, we can delve deeper into how the approach to mathematics education can be optimized to facilitate a better understanding of probability.

In this article, we will discuss the significance of students' attitudes toward probability learning, the skills required for a profound understanding, and the role of reflection in strengthening the mathematics education process. The main objective of this research is to evaluate the extent to which these factors contribute to students' achievements in understanding the concept of probability and to identify effective teaching strategies for addressing potential challenges that may arise.

By investigating the complex relationship between student attitudes, skills, and reflection in the context of probability learning, this article aims to provide valuable insights for mathematics educators, researchers, and education practitioners. Through a better understanding of the factors influencing probability learning, we can develop more effective learning approaches that support holistic mathematical development for

students.

## **METHOD**

### **Research Design:**

This research will use a quantitative approach. This approach is chosen to gain an in-depth understanding of the quantitative context regarding the thought processes and strategies employed by students in solving probability problems. Through this approach, researchers can explore the attitudes, skills, and reflections of students on the concept of probability. The selection of this quantitative approach will provide a suitable framework for analyzing students' probability problem-solving abilities in the context of mathematics education. Additionally, this approach allows researchers to further examine factors such as the attitudes, skills, and reflections of students on mathematics learning, particularly in the area of probability.

### **Research Participants:**

Research participants will be selected based on inclusion criteria, namely, 12th-grade students from Vocational High School (SMK) N 2 in Tangerang Regency, Banten Province, Indonesia. The total number of participants in this study is 20 students. This group of students consists of one class with a membership of 20 students, facilitating observations, attitude assessments, skill assessments, and the implementation of mathematics tests focused on probability topics.

### **Data Collection Instruments:**

The data collection instruments to be used will involve tests, questionnaires, and observation sheets. The tests are specifically designed to measure probability problem-solving abilities, covering various difficulty levels in accordance with the relevant curriculum and educational level. Meanwhile, observation sheets will be utilized to assess students' attitudes and skills. The research instruments have been validated by two experts in the field of mathematics education, with the expectation of collecting data in line with the intended objectives.

### **Data Analysis:**

The data from the tests and observation sheets will be analyzed using descriptive statistics. This analysis includes calculating mean scores, and frequency distributions to present a comprehensive overview of students' probability problem-solving abilities, as well as the observed attitudes and skills in the context of mathematics learning.

## **RESULTS**

### **Assessment results of student attitudes toward probability content**

Attitude assessment is conducted based on observation sheets consisting of 11 items and 6 categories, including student interest and motivation, participation and collaboration, attitude towards mistakes, feedback and criticism, critical thinking skills, and overall student attitude. In categorizing the achievement of students' attitude assessments, the explanations are as follows: If each answer choice of excellent, sufficient, and insufficient is given scores of 3, 2, or 1, then: 0-50%: (insufficient), 51-75%: (sufficient), and 76-100%: (excellent).

The mentioned percentage is the result of dividing the scores obtained by students by the theoretical maximum score, then multiplying the result by one hundred percent. The following are explanations for

each category. Students' attitudes toward participating in learning about probability content still need significant improvement, especially for those in the insufficient category (0–50%). Students require additional attention and guidance to achieve a better understanding. Students' attitudes toward participating in learning about probability content have shown a basic understanding but still need some improvement, especially for those in the Sufficient category (51–75%). Providing feedback and additional support can help them reach a higher level of understanding. Students' attitudes toward participating in learning about probability content have shown a strong understanding for those in the Excellent category (76–100%). They can apply these concepts well to problem-solving and contribute to class discussions. Students in this category have achieved the expected level of competence.

Achievements based on indicators of students' attitudes toward participating in mathematics learning on probability content include an evaluation of students' behavior during the learning process. This assessment is conducted by considering several indicators such as interest and motivation, participation, attitude towards mistakes, acceptance of feedback, critical thinking skills, and overall student attitude. The results of this assessment provide a detailed overview of the extent to which students internalize and apply probability concepts in their attitudes and behaviors during mathematics learning.

Table 01. Results of student attitude assessment towards mathematics learning on probability content

Number	Indicator	Percentage	Category
1	Interest and student motivation	78%	Excellent
2	Participation and collaboration	48%	Insufficient
3	Attitude towards Mistakes	77%	Excellent
4	Feedback and criticism	75%	Sufficient
5	Critical thinking skills	53%	Insufficient
6	Overall Student Attitude	40%	Insufficient

The results of the student behavior assessment depict various aspects of their engagement and attitudes in the learning process. Student interest and motivation reached a satisfactory level at 78%, indicating a positive enthusiasm for the learning material. Although participation and collaboration are at 48%, there is an opportunity to enhance student engagement in group learning activities. Students' attitudes towards mistakes are quite good, reaching 77%, indicating their readiness to learn from errors. Feedback and criticism are also well-received at 75%, showing students' ability to use feedback as a learning tool. Meanwhile, critical thinking skills reached 53%, providing room for improvement in developing students' analytical abilities. Overall student attitude reached 40%, indicating a positive overall picture, but additional efforts are needed to enhance specific aspects to ensure holistic development in the learning process.

Achievements based on the categories (insufficient, sufficient, and excellent) of students' attitudes toward participating in mathematics learning on probability content encompass assessments at three levels of performance. Students in the 'Insufficient' category indicate the need for additional attention and guidance to enhance their understanding and participation in probability learning. Students in the 'Sufficient' category have achieved a basic understanding but still need some improvement in applying these concepts. Meanwhile, students classified in the 'Excellent' category have demonstrated a strong understanding and the ability to apply probability concepts well, even contributing to class discussions. These categories provide a detailed overview of the students' achievement levels in the attitude aspects of mathematics learning on probability content.

Table 02. Achievement Results Based on Categories of Student Attitudes in Participating in Mathematics Learning on Probability Content

Number	Category	The number of students	Percentage
1	Less	8	40%
2	Enough	12	60%
3	Good	0	0%

A total of 8 students (40%) received the “insufficient” category for understanding probability content. This indicates that some students require additional attention or further support in comprehending the concepts. A total of 12 students (60%) received the “sufficient” category in understanding probability content. Although they have achieved an adequate level of understanding, there is room for improvement and enhancement to support better achievement. No students reached the “excellent” category (0%). This indicates that further efforts are needed to achieve a very good level of understanding of probability content.

### Results of the assessment of students’ skills in probability content

The assessment of skills is conducted using an observation sheet consisting of 12 instrument items and six main categories. These categories include: student interest and motivation; participation and collaboration; attitude towards mistakes; feedback and criticism; critical thinking skills; and overall student attitude. In the process of categorizing the achievement of students’ skill assessments, scoring is done with the following provisions: Each answer choice related to the ‘Skilled’ category is given a score of 3, for ‘Sufficient’ a score of 2, and for ‘Insufficient’ a score of 1. Thus, the scores given will reflect the level of students’ skills based on the specified items and categories, including: 0–50% (insufficient), 51–75% (sufficient), and 76–100% (skilled).

The mentioned percentage is the result of the scores obtained by students, then divided by the theoretical maximum score, and the result is multiplied by one hundred percent to provide a representative percentage representation. The following are explanations for each category:

The “insufficient” category (0–50%) indicates that students’ skills in probability content still need significant improvement. Students require additional attention and guidance to achieve a better understanding.

The “sufficient” category (51–75%) indicates that students have achieved a basic understanding of probability content but still need some improvement. Providing feedback and additional support can help them reach a higher level of understanding.

The “skilled” category (76–100%) indicates that students have strong skills in understanding probability content. They can apply these concepts well to problem-solving and make valuable contributions to class discussions. Students in this category have reached the expected level of skill competence.

The achievements of students’ skills in participating in mathematics learning on probability content are analyzed based on several indicators, including conceptual understanding, concept application, use of symbols and notation, critical thinking skills, communication skills, and engagement in discussion and collaboration. Conceptual Understanding measures the extent to which students understand basic probability concepts, while Concept Application evaluates students’ ability to apply these concepts in mathematical situations or problems. The Use of Symbols and Notation assesses students’ ability to use mathematical symbols accurately in the context of probability. Critical thinking skills include students’ critical evaluation and analysis of probability information. Communication skills measure students’ ability to convey

mathematical ideas or solutions clearly. Meanwhile, Engagement in Discussion and Collaboration evaluates the level of students’ participation in class discussions and collaboration with their peers. This approach provides a holistic overview of students’ abilities in understanding and applying probability concepts from various measured skill aspects.

Table 03. Results of students’ skill achievements in mathematics learning on probability content based on indicators

Number	Indicator	Percentage	Category
1	Conceptual understanding	75%	Enough
2	Application of concepts	65%	Enough
3	Use of symbols and notation	48%	Less
4	Critical thinking skills	67%	Enough
5	Communication skills	62%	Enough
6	Engagement in discussion and collaboration	48%	Less

Students’ skills in participating in mathematics learning on probability content can be explained through various assessment aspects. Overall, students’ conceptual understanding appears to be very good, with an achievement of 75%, indicating that the majority of students have a strong understanding of basic concepts in probability content. However, in terms of concept application, there is room for improvement with a level of 65%, indicating the need for more practice in applying these concepts in different mathematical situations or problems.

The use of symbols and notation is an aspect that needs further attention, with an achievement of 48%. Students need to focus more on their ability to use mathematical symbols and notation accurately in the context of probability. Although students’ critical thinking skills are quite good, with a level of 67%, there is potential to further improve this skill.

Students’ communication skills scored 62%, indicating that they can convey mathematical ideas or solutions clearly and effectively. However, the level of engagement in discussion and collaboration needs improvement, with an achievement of 48%, emphasizing the importance of student participation in group activities to support collaborative learning.

The achievements of students’ skills in participating in mathematics learning on probability content are grouped into three categories: inadequate, sufficient, and skilled. The “insufficient” category reflects that students need significant improvement in their probability skills. The “sufficient” category indicates that students have achieved a basic level of understanding but still need some improvement. Meanwhile, the “skilled” category reflects that students have reached a high level of probability skills and can apply them well. By categorizing students’ skill achievements into these three categories, educators can design a learning approach that aligns with each student’s level of understanding and skills.

Table 04. Results of students’ skill achievements in mathematics learning probability content based on categories

Number	Category	The number of students	Percentage
1	Less	4	20%
2	Enough	16	80%
3	Skilled	0	0%



The analysis of students’ skills in participating in mathematics learning on probability content shows variations in achievements. A total of 20% of students are assessed to be in the “insufficient” category, indicating that a small number of students need special attention and additional guidance in understanding probability concepts. Meanwhile, the majority of students, a total of 80%, are placed in the “sufficient” category. Although they have achieved an adequate level of understanding, there is potential for further improvement and enhancement of skills in applying probability concepts in different contexts.

No students reached the “skilled” category (0%). Nevertheless, this provides an overview of the fact that there is room for improvement in students’ skills to reach a higher level of proficiency in understanding and applying probability concepts.

**Formative test results on probability content**

The test designed to measure students’ ability to understand and solve probability problems consists of two questions. It is expected that these two questions can depict students’ problem-solving abilities in determining the sample space, event space, and probability values. This test is designed to provide a comprehensive overview of students’ understanding of basic probability concepts, focusing on their ability to apply this knowledge in the context of concrete problem-solving. Thus, this test is expected to provide accurate information about the level of students’ skills in the field of probability.

Table 05. Results of formative test achievements for each question

Number	Question	The number of students	Percentage
1	<b>Number 1</b>		
	Student is able to answer correctly, following the steps of problem-solving.	9	45%
	Student is able to answer correctly, but does not use the steps of problem-solving.	7	35%
	Student has not answered correctly.	4	20%
	Student did not answer the question at all.	0	0%
2	<b>Number 2</b>		
	Student is able to answer correctly, following the steps of problem-solving.	0	0%
	Student is able to answer correctly, but does not use the steps of problem-solving.	12	60%
	Student has not answered correctly.	8	40%
	Student did not answer the question at all.	0	0%

The results of the test conducted by students on question number one, when viewed from the scoring details, provide a comprehensive overview of students’ understanding of probability concepts. Out of a total of 20 participating students, 9 students (45%) were able to answer correctly, following problem-solving steps, and demonstrating a good understanding. Meanwhile, 7 students (35%) were able to answer correctly but did not use problem-solving steps, providing an opportunity for further development in explaining those steps.

There are also 4 students (20%) who have not been able to answer correctly, indicating the need for more attention and support to help them achieve a better understanding of probability concepts. In these results, no

student completely failed to answer the question, indicating a good level of participation.

The results of the test conducted by students on question number two, when viewed from the scoring details, provide a detailed overview of the students' performance in understanding the concept of probability. No students (0%) were able to answer correctly and follow problem-solving steps, indicating that all students have not yet acquired the ability to apply problem-solving steps related to the concept of probability.

On the contrary, a total of 12 students (60%) were able to answer correctly but did not use problem-solving steps. Although their answers were correct, there is an opportunity to enhance students' ability to explain the problem-solving steps and strengthen their understanding of the concept of probability.

Additionally, 8 students (40%) were not able to answer correctly, indicating the need to provide extra attention to support them in achieving a better understanding of probability concepts.

No students completely failed to answer the question, reflecting a good level of participation from all students. This detailed analysis provides valuable information for educators to design more precise learning strategies and offer additional support according to the individual needs of each student.

Table 06. Achievement results of student tests based on categories

Number	Category	The number of students	Percentage
1	Less	4	20%
2	Enough	7	35%
3	Good	9	45%

The results of the formative test on probability show variations in students' achievements. 20% of students are placed in the "less" category, indicating that a small number of students need additional attention and support to understand the concept of probability.

Meanwhile, 35% of students are placed in the "sufficient" category. Although they have achieved an adequate level of understanding, there is potential for further improvement in applying probability concepts in different contexts.

The majority of students, 45%, are placed in the "good" category. This indicates that most students have achieved a good understanding and can apply probability concepts effectively.

Overall, the formative test results show that the majority of students have reached a satisfactory or good level of understanding of the probability material. Although some students need additional attention, the data distribution shows positive progress in student achievement in this subject. Efforts can be focused on assisting students in the "less" category and providing additional challenges to students in the "good" category to enhance their understanding further.

### **Results of the student reflection questionnaire on probability learning**

The results of the student questionnaire reflecting on probability learning are based on several indicators: understanding of the material, activities and exercises, use of technology, engagement in discussions, teacher feedback, and overall learning. This evaluation provides a comprehensive understanding of students' perceptions of various aspects of probability learning. Understanding of the Material reflects how deeply students grasp the probability material, while Activities and Exercises indicate how effective practical activities and exercises are in supporting learning. The Use of Technology assesses the extent to which

students utilize technology in understanding probability.

Furthermore, engagement in discussions includes the level of student participation in class discussions, and teacher feedback describes how students assess the teacher's responses and guidance to their questions and needs. Overall learning encompasses the students' overall assessment of the probability learning experience. By categorizing the results of the student questionnaire into these indicators, educators can better understand areas that need improvement and design appropriate enhancements in the teaching of probability material.

Table 07. Results of student questionnaires reflecting probability learning based on indicators

Number	Indicator	Percentage
1	Understanding of the Material	56%
2	Activities and Exercises	74%
3	Use of Technology	75%
4	Engagement in Discussions	78%
5	Teacher Feedback	86%
6	Overall Learning	80%

The results of the student questionnaires reflecting on probability learning provide an evaluative overview based on several key indicators. Understanding of the material is recorded at a score of 56%, indicating the extent to which students absorb and comprehend the taught probability material. Activities and exercises scored 74%, demonstrating the effectiveness of practical activities and exercises in supporting students' understanding of probability concepts.

The Use of Technology achieved a score of 75%, indicating the extent to which students utilize technology to support their understanding and learning of probability. Participation in discussions reached a score of 78%, reflecting the level of student participation in class discussions related to probability.

Teacher feedback received the highest score, namely 86%, reflecting how students assess the teacher's responses and guidance to their questions and needs in the context of probability learning. The overall learning score reached 80%, providing a global assessment of students' overall learning experience in probability.

## DISCUSSION

### Student Attitudes Toward Probability Learning

The results of the assessment of student behavior reflect various aspects of their engagement and attitudes in the process of probability learning. With an interest and motivation level reaching 78%, it can be associated with Deci and Ryan's Self-Determination Theory. According to this theory, high motivation can enhance students' engagement in learning. Positive enthusiasm from students toward the learning material can motivate them to actively engage in understanding probability concepts (Ryan & Deci, 2020).

Although participation and collaboration are still at a level of 48%, there is potential to increase student engagement in group learning activities, following the principles of Vygotsky's social development theory. This theory emphasizes the importance of social interaction and collaboration in the learning process (Syomwene, 2016). Enhancing student participation in group activities can enrich their learning experiences and create an environment that supports collaborative learning (Wahyuni, 2023).

Students' attitudes toward mistakes are quite good, reaching 77%, and can be linked to Carol Dweck's



mindset theory. This theory emphasizes that students' attitudes toward mistakes can influence how they learn (Herynková et al., 2020). A positive attitude toward mistakes as opportunities for learning can aid in the development of probability problem-solving skills (Demirel & Dağyar, 2016).

Feedback and criticism being well-received (75%) also reflect students' ability to use feedback as a means of learning, following the principles of learning theory. Acceptance of feedback can help students identify and correct their mistakes, supporting the development of probability problem-solving skills (Hattie & Timperley, 2007).

Meanwhile, critical thinking skills reached 53%, providing room for improvement in developing students' analytical skills. Enhancing critical thinking skills in line with the theory of critical thinking by Paul and Elder can assist students in analyzing information related to probability and improving their ability to tackle complex problems (López et al., 2023).

### **Students' skills in learning probability**

The analysis of students' skills in following mathematics learning in probability material describes several crucial aspects. Students' excellent conceptual understanding, with an achievement of 75%, reflects a high level of mastery of basic probability concepts. This strong understanding is consistent with Piaget's theory of cognitive development, emphasizing students' ability at the concrete operational stage to comprehend abstract concepts (Rabindran & Madanagopal, 2020).

However, there is potential for improvement in the application of concepts, with an achievement level of 65%. This indicates the need for more practice in applying probability concepts in various mathematical contexts, in line with the constructivist approach by Bruner, which emphasizes learning through interaction and experience (Sofiana et al., 2022).

Furthermore, the use of symbols and notation shows an achievement of 48%, highlighting the need to enhance students' ability to use mathematical symbols accurately in the context of probability. Vygotsky's theory of proximal development can provide a framework for providing more directed guidance through social interaction and support (Shabani, 2016).

Critical thinking skills reaching 67% reflect students' ability to analyze and evaluate information related to probability. Further improvement in these skills can be applied through approaches that encourage analytical thinking, in line with Paul and Elder's theory of critical thinking (Golden, 2023).

Although students' communication skills received a score of 62%, the level of engagement in discussion and collaboration still needs improvement, reaching an achievement of 48%. Vygotsky's social constructivism theory supports the idea that social interaction and participation in groups can enhance collaborative learning and communication skills (Akpan et al., 2020).

### **Analysis of the probability test results**

The results of the test on question number one provide a comprehensive overview of students' understanding of probability concepts. Out of the 20 participating students, 9 students (45%) were able to answer correctly and follow the problem-solving steps, indicating a good understanding. Meanwhile, 7 students (35%) were able to answer correctly but did not use the problem-solving steps, providing an opportunity for further development in explaining those steps.

A detailed analysis indicates that 4 students (20%) have not been able to answer correctly, indicating the need to provide more attention and support for them to achieve a better understanding of probability concepts. It is important to note that no student completely left the question unanswered, reflecting a good

level of participation from all students.

When turning to the results of the second question, a detailed picture of students' performance in understanding probability concepts is revealed. No students (0%) were able to answer correctly and follow the problem-solving steps, indicating that all students have not yet attained the ability to apply the problem-solving steps related to probability concepts.

On the contrary, 12 students (60%) were able to answer correctly but did not use the problem-solving steps. Although their answers were correct, there is an opportunity to improve students' ability to explain the problem-solving steps and strengthen their understanding of probability concepts.

As for 8 students (40%) who were unable to answer correctly, it indicates the need to provide more attention and support to help them achieve a better understanding of probability concepts. In conclusion, this detailed analysis provides valuable information for educators to design more appropriate learning strategies and provide additional support according to the individual needs of each student.

### **Students' reflections on probability learning**

The results of the student questionnaire reflecting on probability learning provide an evaluative overview based on key indicators, aligning with the concept of learning assessment. Understanding the Material: A score of 56% reflects the extent to which students absorb and comprehend the probability material taught. Piaget's cognitive theory suggests that understanding the material is the foundation for students' problem-solving abilities, and this 56% level provides an initial understanding of how well this concept has been absorbed (Rabindran & Madanagopal, 2020).

Activities and Exercises scored 74%, reflecting the effectiveness of practical activities and exercises in supporting students' understanding of probability material. This aligns with Vygotsky's constructivist learning theory, emphasizing the importance of activities and direct experiences in learning (Kumar Shah, 2019).

The Use of Technology achieved a score of 75%, indicating the extent to which students utilize technology to support their understanding and learning of probability. In this context, constructivist theory and technology-enhanced learning (TEL) support the idea that integrating technology can enhance student learning (Mohammed & Kinyó, 2022).

Participation in discussions reached a score of 78%, reflecting the level of student participation in class discussions related to probability material. Vygotsky's social constructivist theory emphasizes the importance of social interaction in learning, and this score indicates good engagement from students in the discussion process (Akpan et al., 2020).

Teacher feedback achieved the highest score, namely 86%, reflecting how students assess the teacher's responses and guidance to their questions and needs in the context of probability learning. This is consistent with feedback-based learning theories that emphasize the importance of feedback in enhancing student understanding (Patra et al., 2022).

The overall learning score reached 80%, providing a comprehensive assessment of students' overall experience with learning probability. This reflects the integration of various learning aspects explained by learning theories, including understanding of the material, practical activities, technology use, participation in discussions, and teacher feedback.

## **CONCLUSION**

The conclusion drawn from the above discussion is that students' attitudes towards probability learning are

significantly influenced by motivation, participation in group activities, attitude towards mistakes, and acceptance of feedback. Improving students' engagement in group discussions can enhance their learning experience. Meanwhile, the analysis of students' skills indicates a good understanding of concepts, but there is room for improvement in applying concepts, using symbols and notations, and critical thinking skills. The test results provide detailed information about students' understanding of probability concepts, and student reflections highlight several crucial aspects of learning, including understanding of the material, activities, technology use, participation in discussions, and teacher feedback. Overall, this evaluation provides valuable insights for educators to enhance learning strategies and provide additional support based on students' needs.

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