ANALYSIS OF STUDENTS' ABILITY TO USE THE MATHEMATICAL INDUCTION PROOF METHOD IN CLASS XI SMK NEGERI 1 O'O'U

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Abstract

The purpose of this research is to describe students' abilities in using mathematical induction in Class XI at SMK Negeri 1 O'o'u. This study employs a qualitative approach with a descriptive method. The subjects of this research are 35 students from Class XI SMK Negeri 1 O'o'u. Data were analyzed through steps including data reduction, data presentation, and conclusion drawing. The data collection techniques used were tests and interviews. The results show that out of 35 students, 2 students fall into the very good category, 11 students into the good category, 9 students into the sufficient category, 6 students into the poor category, and 7 students into the very poor category. Thus, it can be concluded that students' ability to use the mathematical induction proof method is categorized as good, with a percentage of 31.42%. Based on these findings, the researcher suggests that students should deepen their understanding of the proof method and practice mathematical induction problems intensively, enabling them to solve various mathematical induction problems accurately.

Keywords: *Student Ability; Proof Method; Mathematical Induction*

Abstrak

Tujuan penelitian ini adalah untuk mendeskripsikan kemampuan siswa dalam menggunakan induksi matematika pada kelas XI SMK Negeri 1 O'o'u. Jenis penelitian ini adalah penelitian kualitatif dengan pendekatan deskriptif. Sumber dalam penelitian ini adalah siswa/I kelas XI SMK Negeri 1 O'o'u yang berjumlah 35 siswa. Data dianalisis dengan langkah-langkah reduksi data, penyajian data, dan penarikan kesimpulan. Teknik pengumpulan data yang digunakan adalah tes dan wawancara. Hasil penelitian menunjukkan bahwa dari 35 siswa terdapat 2 siswa memiliki kategori kemampuan sangat baik, 11 siswa memiliki kategori kemampuan baik, 9 siswa memiliki kategori kemampuan cukup, 6 siswa memiliki kategori kemampuan kurang, dan 7 siswa memiliki kategori kemampuan sangat kurang baik. Sehingga, dari data tersebut dapat disimpulkan bahwa kemampuan siswa dalam menggunaka metode pembuktian induksi matematika berada pada kategori kemampuan baik dengan persentase 31,42%. Berdasarkan hasil penelitian tersebut, peneliti penyarankan agar siswa lebih memahami konsep metode pembuktian dan mengerjakan masalah induksi matematika secara intens, sehingga mampu menyelesaikan berbagai masalah induksi matematika dengan benar.

Kata Kunci*:* *Kemampuan Siswa; Metode Pembuktian; Induksi Matematika*

A. Introduction

Since the creation of mankind, education has been established as a means to develop both the physical and spiritual potentials of individuals. One way to improve the quality of human resources is through education. The 1973 Guidelines for the General Principles of National Development (GBHN) state that education is essentially a conscious effort to develop personality and abilities both inside and outside of school, and it lasts a lifetime. According to the Indonesian Law No. 20 of

2003 on the National Education System (Sisdiknas), Chapter I Article I, education is a conscious and planned effort to create a learning atmosphere and educational processes so that students actively develop their potential to possess spiritual strength, self-control, character, noble moral intelligence, as well as the skills needed for themselves, society, the nation, and the state.

Education is a conscious and systematic effort not only to humanize individuals but also to make them aware of their position as creations of God. In Law No. 20 of 2003 on the National Education System, Chapter II Article 3, it is stated that the national education aims to develop the potential of students to become individuals who are faithful and devout to God Almighty, have noble character, are healthy, knowledgeable, skilled, creative, independent, and become democratic and responsible citizens. Based on the above explanation, it can be concluded that the general purpose of education is to develop the potentials of individuals so that they can fulfill their duties and obligations in life to achieve happiness in the present and the future.

Mathematics is one of the subjects that is essential for daily life in order to develop living potential. According to Hudojo (2005:37), "Mathematics is a tool for developing ways of thinking." "Mathematics is not only related to numbers and their operations but also to spatial elements as its target. However, its quantitative representation does not fulfill other goals, which pertain to relationships, patterns, shapes, and structures," Tinggih (1972:37). From the above explanation, it is stated that mathematics is a way to develop human thought in various aspects. Therefore, it can be said that mathematics concerns structured ideas whose relationships are logically arranged.

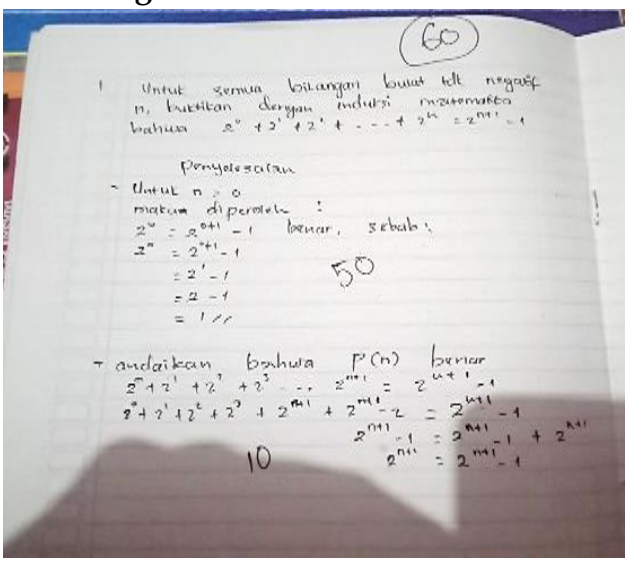
To conduct mathematical proofs, one essential ability that needs to be developed is the students' capability. A student's ability is their capacity to solve assigned tasks or problems and to analyze issues and prove them within a given problem. To assess this ability, one of the methods used is to provide questions involving cases of mathematical induction. Mathematical induction is a proof of statements that need to be validated. A statement can be proven true if it meets the principles of mathematical induction. According to Munir (2010:151), to prove the truth of a statement using the principle of mathematical induction, we need to demonstrate two things: first, that the statement: let P(n) be a statement related to natural numbers. To prove P(n) true, we must show that if (1) P(1) is true, (2) P(k) is true, then P(k+1) is true for every k in N, so P(n) is proven true for every n in N.

Mathematics is considered to play a significant role in shaping students to be potential and quality individuals because it serves as a means of thinking logically and systematically. Additionally, by confronting students with problem-solving tasks, their abilities in using mathematical induction will be trained, enabling them to prove and discover concepts related to the problems they need to solve.

Based on the preliminary study conducted by the author at SMK Negeri 1 O'o'u regarding class XI, the researcher found that the low ability of students to use mathematical induction is because they perceive mathematics as a very difficult subject, with many formulas that are hard to understand, and they are unable to apply them in solving problems. This aligns with the results obtained when the researcher

administered a test during the preliminary study.

Figure 1. Student Worksheet



Source: Researcher 2023

Based on the figure above, it shows that students' ability in mathematical proof using mathematical induction is very low. It is evident that students struggle to demonstrate the steps in solving the problem to prove its correctness. Students lack understanding of the meaning of assuming n=kn = kn=k and, as a result, are unable to correctly prove the assumption n=k+1n = k + 1n=k+1. This lack of precision leads to incorrect solutions. Therefore, there is a need for a more in-depth investigation into students' abilities in using the mathematical induction proof method.

In light of this explanation, the researcher intends to conduct a study titled "Analysis of Students' Ability in Using the Mathematical Induction Proof Method in Class XI of SMK Negeri 1 O'o'u."

The research problem in this study is: "What is the ability of students in using the mathematical induction proof method?" The purpose of this research is to describe students' abilities in using the mathematical induction proof method in Class XI of SMK Negeri 1 O'o'u.

B. Research Methodology

This research employs a qualitative approach with a descriptive framework, meaning that the data collected consists of words, images, and not numerical values. Qualitative research is conducted based on paradigms, strategies, and qualitative model implementations. According to Dukeshire and Thurlow (2002:3), "Qualitative research pertains to non-numeric data, collecting and analyzing narrative data." This highlights that qualitative research involves analyzing data in the form of words.

The type of research used is qualitative research. Qualitative research involves observing or analyzing a problem that needs to be solved. Auerbach and Silverstein (2003:3) concur, stating that "Research that conducts analysis and interpretation of texts and interview results aims to find meaning in a phenomenon."

This study was conducted at SMK Negeri 1 O'o'u, located in the Hilinamazihono village of the O'o'u district, Nias Selatan Regency. The researcher chose this location because information indicated that students' abilities to use the mathematical induction proof method were still low, and students were not yet capable of solving mathematical problems using this method. The research took place in March 2024.

The data for this study were obtained directly from the source, specifically regarding internal factors affecting students' abilities to use the mathematical induction proof method in Class XI. In this study, the researcher collected data in the form of test results and interviews conducted directly for further analysis, based on the understanding of each informant. The data sources in this

study were 35 students from Class XI of SMK Negeri 1 O'o'u.

Data collection techniques refer to the methods used by the researcher to gather valid material or data in the study. Thus, data collection techniques can be defined as the processes employed by a researcher to collect data. The data collection techniques used in this study are as follows:

1 Learning Outcome Test

A test serves as a measurement tool in the data collection process. It is designed to assess the abilities of individuals or students, allowing for the acquisition of authentic data through these evaluations. In agreement with Arikunto (2018), a test is one that is conducted multiple times to ensure its validity. The learning outcome test is a data collection tool for teachers to determine students' scores. Through this test, the researcher can evaluate students' abilities in solving mathematical proof problems using mathematical induction.

The type of test employed here is a written test in the form of an Essay Test. An essay test (descriptive or subjective test) consists of questions that require students to provide explanations, descriptions, interpretations, or other forms of response to the given questions.

After administering the test to the students, the results concerning their ability to use the mathematical induction proof method will be analyzed based on categories and intervals, as shown in the table below:

Table 1. Categorization of Students' Abilities

Category	Interval
Very Good	81-100
Good	61-80
Sufficient	41-60
Poor	21-40
Very Poor	0-20

Source: Sudijono, (2008)

Formula for Calculating Percentage

To calculate the percentage of student performance based on the test results, you can use the following formula:

$$P = \frac{f}{n} \times 100\%$$

Where:

P= Percentage of students in a specific category.

f = Frequency of students who fall into that category (the number of students who received a specific score range).

n = Total number of students (the overall number of students who took the test).

2 Interview

An interview is a conversation with a specific purpose between two parties: the interviewer, who asks questions, and the interviewee, who provides answers to those questions. Thus, it can be concluded that an interview is a process to obtain clear information relevant to the researcher through a dialogue related to the analysis of students' abilities in using the method of mathematical induction at class XI of SMK Negeri 1 O'o'u.

In agreement with Sugiyono (2016:194), "Interviews are used as a data collection technique when the researcher wants to conduct a preliminary study to identify issues that need to be investigated and also when the researcher wants to understand more in-depth aspects from the respondents." In this study, the researcher aims to conduct interviews to obtain in-depth information from the respondents. Here, the respondents are the individuals being interviewed who provide the information requested by the researcher. Interviews can be conducted in a structured or unstructured manner.

3 Data Analysis

Data analysis is the effort or process of selecting, sorting, and categorizing data

to address two main questions: 1) what themes can be found in this data, and 2) to what extent can this data support those themes?

Therefore, data analysis is a process of selecting or resolving an issue. Sugiyono (2012:247) states that there are several important elements in qualitative data analysis that every writer should keep in mind during the analysis process, as follows:

a. Data Reduction

Data reduction is the process of simplifying data that has been managed or obtained from observations. According to Sugiyono (2012:247), data reduction means "summarizing, selecting essential elements, focusing on important aspects, and identifying themes and patterns." Thus, the reduced data provides a clear picture and facilitates the researcher in collecting further data as needed. The data obtained in this research consists of test results assessing students' abilities in using the method of mathematical induction in class XI of SMK Negeri 1 O'o'u. The stages of data reduction that the researcher needs to undertake include preparation before fieldwork, such as preparing questions for informants, conducting observations or scheduling interviews with informants, and collecting data related to the research focus from the research location. The data collection methods include interviews and documentation in the form of field notes and photographs with informants.

b. Data Presentation

Once the research data has been collected and reduced, the next step is data presentation. Data presentation is a key activity in creating a research report based on fieldwork, making it understandable and analyzable according to the desired objectives. In this research, data presentation can be done in various forms such as tables, graphs, diagrams, and others. This step will facilitate the researcher in understanding what is happening and planning subsequent research activities.

c. Drawing Conclusions

The next step is drawing conclusions. Drawing conclusions is a way to search for or understand the meaning of the obtained data. According to Sugiyono (2012:253), conclusions in qualitative research represent new findings that were not previously available. These may consist of descriptions or representations of an object that were previously vague or unclear, becoming clear after investigation; they may also include causal or interactive relationships, hypotheses, or theories.

C. Results and Discussion

This research was conducted in Hilinamazihono Village, O'o'u District, South Nias Regency. The research participants were 35 students from Class IX of the vocational school. Before conducting the study, the researcher prepared by validating the research instruments with three validators. The results of this validation concluded that the tests and interview guidelines developed by the researcher were suitable for use as research instruments. Following this, the researcher obtained a research permit from the Head of the Study Program and the Head of the Research and Community Service Institute (LPPM). The researcher then requested permission from the school principal through a letter of introduction from the campus to conduct the study.

The tests and interviews served as the research instruments used in this study. The student ability test was utilized to assess the students' competency in solving

problems, while the interviews aimed to gather qualitative data related to the students' abilities in solving mathematical problems using the method of mathematical induction verbally.

1 Presentation of Research Results

One of the research instruments used by the researcher was a test on the method of mathematical induction. The students' ability to utilize the method of mathematical induction was assessed based on their answers from the test.

After the students completed the test, the researcher corrected their answer sheets and analyzed the level of students' abilities as well as the difficulties they encountered while completing the test. The results indicated that many students were still unable to solve problems using the method of mathematical induction.

The correction of the test was conducted based on the scoring guidelines and answer keys provided in the appendix. This allowed for the categorization of students' abilities in using the method of mathematical induction, which is presented in the following table:

Table. 2. Student Ability Categorization

Category	Interval	Frequency	Percentage
Very Good	81-100	2	5,71%
Good	61-80	11	31,42%
Satisfactory	41-60	9	25,71%
Poor	21-40	6	17,14%
Very Poor	0-20	7	20%

Source: Researcher, 2024

Based on Table 2, the categorization of students' test scores in mathematical problem-solving ability shows that there are 2 students in the very good category, 11 in the good category, 9 in the satisfactory category, 6 in the poor category, and 7 in the very poor category. Thus, it can be concluded that the students' ability to use the method of mathematical induction is in the satisfactory to poor category.

From the test results completed by the XI grade students at SMK Negeri 1 O'o'u, the researcher identified various errors made by the students when solving problems. These errors can be categorized into several types:

Conceptual Errors: These occur when students mistakenly clarify a set of objects and misunderstand the definitions related to the method of mathematical induction.

Principle Errors: These occur when students incorrectly apply the mathematical induction formula.

Operational Errors: These refer to mistakes made by students in performing arithmetic operations.

From these types of errors, the percentage of students' mistakes in solving problems using the method of mathematical induction can be calculated using Sudijono's formula (2008) as follows:

$$P = \frac{f}{n} \times 100\%$$

Explanation:

P = Percentage
f = Frequency for which the percentage is being calculated
n = Total number of cases (total frequency)

To provide more clarity, the following table shows the occurrences of each type of error:

Table 3: Errors in Each Question

Question No	Conceptual Error K		P	O	-
1	6	12	5	12	
2	7	14	9	5	
3	10	9	16	0	
4	4	3	15	13	
5	11	0	11	13	
Total	38	38	56	43	
Precentage	21,71%	21,71%	32%	24,57%	

Source: Researcher 2024

Based on Table 3 above, it can be seen that the 35 students completed 5 questions, resulting in a total of 175 attempts, which include:

1) **Conceptual Errors (K)** for questions 1 to 5 occurred 38 times, with a percentage of $\frac{38}{175} x\ 100\% = 21{,}71\%$
2) **Principle Errors (P)** for questions 1 to 5 also occurred 38 times, with a percentage of $\frac{38}{175} x\ 100\% = 21{,}71\%$
3) **Operational Errors (O)** for questions 1 to 5 occurred 56 times, with a percentage of $\frac{56}{175} x\ 100\% = 32\%$
4) T **Principle Errors (P)** for questions 1 to 5 also occurred 38 times, with a percentage of $\frac{43}{175} x\ 100\% = 24{,}57\%$

After the students completed the test on their ability to use mathematical induction, and after the researcher corrected the tests, the researcher conducted interviews with 35 students to understand the challenges they faced in solving the test questions and the strategies they employed to overcome these challenges.

From the interviews conducted with the eleventh-grade students at SMK Negeri 1 O'o'u, several common issues were identified when they attempted to solve the questions, as follows:

The lack of understanding among students in comprehending the questions led to their inability to solve the given problems. Specifically:

1 Students struggled to grasp the concepts or formulas relevant to the problems they were working on.
2 There was a noticeable lack of precision among students during calculations, as they focused mainly on the final results rather than the process.
3 Many students demonstrated difficulty in proving the formulas they were using.
4 Students also found it challenging to prove statements related to inequalities.

Based on the analysis of the test data regarding students' ability to use mathematical induction, several research findings emerged, as follows:

a. Conceptual Errors

Based on the research findings, the students' work and interviews conducted by the researcher with the subjects indicate that students made conceptual errors. Conceptual errors refer to students' misunderstandings of what is being asked in problems related to mathematical induction, leading to their inability to solve the problems correctly. This aligns with findings from Putra et al. (2018), who stated that students struggle to articulate the underlying concepts and relationships between mathematical concepts and objects, as well as to model real-life problems mathematically. Often, students approach problems without paying attention to what is known and what is being questioned, particularly when working with mathematical induction. The analysis of test data from 35 sampled students revealed that 21.71% of the overall answers contained conceptual errors.

b. Principle Errors

The research findings also revealed that students committed principle errors. These errors occur when students incorrectly apply the formulas for mathematical induction, resulting in unsatisfactory answers. This issue stems from students' limited understanding of mathematical formulas, often exacerbated by insufficient study both at school and at home, which hinders their ability to answer or solve problems using mathematical

induction. The analysis of test data from the 35 sampled students indicated that 21.71% of the overall answers contained principle errors due to a lack of understanding of the existing formulas.

c. Calculation Errors

The findings from the research showed that students also made calculation errors. Calculation errors are mistakes made during arithmetic operations, often due to a lack of precision, leading to incorrect answers. For instance, a student might incorrectly compute 5 × 15 as 45 instead of the correct answer, 75. According to Hudojo (1998) in Aisyah et al. (2007:53), "Problem-solving is the process undertaken by an individual to resolve a problem until it no longer exists." To prevent calculation errors, students must understand the intent of the problems and master basic arithmetic operations—addition, subtraction, multiplication, and division. Such mistakes frequently occur among students, resulting in incorrect solutions. The analysis of test data from the 35 sampled students revealed that 32% of the overall answers contained calculation errors, and interviews indicated that these errors often resulted from miscalculations during arithmetic operations.

Despite these errors, some students were able to solve problems and correctly complete mathematics tasks using mathematical induction. These students achieved good scores due to their commitment to studying and consistent practice both at home and at school, enabling them to apply problem-solving skills effectively. According to Gagne in Suherman (2003:33), "In learning mathematics, students can achieve two types of objectives: direct and indirect. Indirect objectives include skills in investigating and solving problems, independent learning, positive attitudes toward mathematics, and understanding how to learn effectively. Direct objectives consist of facts, skills, concepts, and rules." The analysis of test data from the 35 sampled students indicated that 24.57% of the overall answers correctly solved problems and completed tasks using mathematical induction.

Discussion

The errors frequently made by students in Class XI at SMK Negeri 1 O'o'u when solving problems using the method of mathematical induction include conceptual errors, principle errors, and calculation errors. The causes of these errors stem from students' difficulties in understanding what is known and what is being asked in the problems. Many students forget the principles or formulas needed to solve the mathematical induction problems, and they struggle to perform calculations accurately.

Mathematics learning emphasizes various skills that students must possess, including the ability to use the method of mathematical induction. However, students often struggle to understand each problem presented, especially those related to the method of mathematical induction. They may fail to apply existing concepts or formulas and find it challenging to draw accurate conclusions. As a result, these types of problems become a significant challenge for students. According to Runtukahu and Kandou (2014), "Problem-solving involves a series of mental operations performed by an individual to achieve a specific goal."

Not all mathematical problems are difficult for students; rather, the challenges arise with problems where the procedures for solving them are not immediately apparent, requiring skills and

understanding of previous materials. This aligns with Lencher's view as cited in Hartono (2014:2), who states, "Mathematical problems are those for which the solution strategies are not directly visible, requiring knowledge, skills, and understanding learned beforehand." Consequently, students face difficulties in resolving these problems. Based on test results and interviews with students, it was found that many still struggle with identifying the elements that are known and what is being asked in the problems, leading to conceptual errors, principle errors, and calculation errors.

D. Conclusion

Based on the results and discussions presented in Chapter IV, the research on the analysis of students' abilities in using the method of mathematical induction can be summarized in several points: conceptual errors, principle or formula errors, calculation errors, and the ability to solve problems.

The conceptual errors identified in this study amounted to 21.71%. This percentage reflects the students' difficulties in understanding the concepts, indicating that they are not fully grasping what is being asked in the questions and struggle to classify the objects in question. Additionally, the errors related to principles or formulas were also 21.71%, which signifies that students often misunderstand the formulas, leading to mistakes when attempting to solve the problems.

The next category of errors is calculation errors, which accounted for 32% of the total. This represents the highest percentage of errors made by students, indicating that they may be less capable or less careful when performing calculations. Furthermore, a portion of students, specifically 24.57%, were able to solve problems correctly, showcasing their problem-solving abilities.

The following are some recommendations that can be made based on this research:

1 Encouragement for Mathematics Teachers: Mathematics teachers should habituate students to solve problems effectively and accurately.
2 Improvement in Student Abilities: Students are encouraged to enhance their capabilities in using the method of mathematical induction.
3 Innovative Problem-Solving: Students should not only rely on the procedures provided by their teachers but should also seek to add other, quicker, and more practical ideas in their problem-solving approaches while still aiming for the desired outcomes.
4 Reference for Future Researchers: Other researchers interested in studying related topics are encouraged to use this research as a reference and foundation for further investigation.

In conclusion, it is hoped that this study can contribute positively to the field of mathematics education.

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