Students’ mathematical reasoning in inquiry learning model

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Abstract. This research is a descriptive study that aims to identify student’s mathematical thinking in aspect reasoning on grade XI in topic sequences and series through the inquiry learning model. The test consists of one problem. The subject for this research were 3 students of XI IPA 1 class at SMA Negeri 1 Indralaya Selatan. The learning process adjusted with the inquiry phases. The data collection techniques used in this research are written tests and interviews. The result of this study indicates that subject 1 (S1) appears inductive reasoning only on the perception of generality and expression of generality in which logical analysis is gathering facts, assessing or proposing assumptions, and setting conclusions. Subject 2 (S2) appears all indicators of inductive reasoning and indicators of logical analysis, and subject 3 (S3) appears all indicators of inductive reasoning while indicators of logical analysis are submitting assumptions, assessing or testing assumptions, and setting conclusions.

1. Introduction

Mathematical thinking is important and needs to be taught in mathematics learning to develop mathematical thinking processes. Important aspects of mathematical thinking are reasoning, proof, abstraction, making guesses, generalizing, and specialization [1,2]. Expected objectives in learning mathematics according to National Council of Teachers of Mathematics (NCTM) is problem-solving, verification, reasoning, connection, communication, and representation. In this case, reasoning is a standard of ability that must be possessed by students in learning mathematics [3,4]. Mathematical reasoning is essential and at the heart of understanding and problem solving process [5]. According to [6], mathematical thinking aspects of reasoning include three types, namely inductive reasoning, deductive reasoning, and logical analysis. Students are able to do reasoning if they are able to use reasoning skills in patterns and traits, manipulate mathematics in generalizing or explain mathematical ideas and statements. The higher the level of students’ reasoning, the faster the learning process will be in achieving learning indicators [7]. Reasoning ability is needed when solving problems faced so that it will affect logically decision making [8].

One of the mathematics concept taught in semester 1 class XI students in the 2013 curriculum is the sequence and series [9]. Sequence and series material is one of the materials that require high problem-solving abilities, in other words, must have good mathematical reasoning abilities [10]. However, there are still many students who find it difficult to solve geometrical sequence problems and geometric sequences. This is because students lack understanding of the concept and pay close attention to the language of the problem so that students have difficulty in determining what is known from the problem [10]. Then, the facts in the field, students’ mathematical reasoning is still low, this is due to the ability of students to solve problems that do not understand and do not use good reasoning [11]. The results of students’ mathematics in national exam in 2017 are only 41.40%, in 2018 only 36.46%, and in 2019 students complained a lot in answering math questions [12]. PISA results show that Indonesian students...
are at the bottom level among the five levels of achievement in mathematics in the PISA version [13]. The results of the UN and PISA show that the reasoning ability of Indonesian students is low. That is, students have not been able to solve problems in the context of everyday life [12, 13].

In fact, solving a mathematical problem requires good knowledge, concepts and reasoning abilities [14, 15]. The reason for the low ability of students' mathematical reasoning is the learning process in the classroom does not involve students actively in the learning process, learning is still centered on the teacher and students are accustomed to solving problems based on the examples given [16, 17]. This model directs the learners to find the problem and then being able to solve the problems found scientifically [18]. So, we need the right model to improve students' mathematical reasoning abilities, which is one of the models is the inquiry learning model, where this model emphasizes maximum student activity to search and find. Inquiry learning model focuses students as learning subjects and students can find out for themselves both facts, concepts, principles, and theorems in mathematics [19, 20].

From the description above, this research is entitled "Students’ mathematical reasoning in inquiry learning model". This research aims to determine mathematical thinking in aspects of reasoning through the inquiry learning model of class XI students in the material sequence and series.

2. Method
In this research, the stages used are (1) the preparatory stage is preparing research instruments such as lesson plans, student work sheets and written tests (2) the implementation phase is implementing inquiry learning models at the first and second meetings, then at the third meeting do a written test, and (3) the data analysis stage is analyzing written test results and interview results. The subject of this research is class XI IPA 1 SMA N 1 Indralaya Selatan on the Sequence and Series through inquiry learning model. This model emphasizes the maximum activity of students to search and find so that later will lead students to conclude.

Data collection instruments used in this study were tests and interviews. The test takes the form of a description of the question and is answered by the procedure of how the material in the sequence and sequence of geometry is arranged. Interviews were conducted to see the mathematical thinking process aspects of student reasoning and see abilities that have not been seen when answering test questions. In this case, the reasoning seen in this study is inductive reasoning and logical analysis. The subject of the interview was chosen based on the results of the test answers which were considered quite interesting with the ability to appear different indicators. In this study, there were 3 research subjects. The data obtained from the results of the interview were analyzed by changing the results of the interview into written form and analyzing the answers of the interviews.

3. Result and Discussion
This research was conducted in XI IPA 1 class at SMA N 1 Indralaya Selatan from October 7th, 2019 to October 14th, 2019. The research was conducted in 3 meetings consist of 2 learning activities meetings and one final meeting for tests of mathematical thinking aspects of reasoning. Learning is carried out by the stages of the inquiry learning model. Data on mathematical thinking aspects of student reasoning were obtained from test and interview results using the type of mathematical thinking aspects of reasoning questions.

According to [21], the inquiry learning model has six stages: (1) Orientation, this stage is the first step in managing and conditioning the atmosphere so that students are responsive to learning. (2) Formulate the problem, at this stage, students are faced with problems that will be sought for a solution. Problems in inquiry learning contain clear concepts that encourage students to find and find them. (3) Formulate a hypothesis, after formulating the problem, students formulate hypotheses or temporary answers. To prove it, students will be motivated to think further. (4) Collecting data, at this stage, students collect or solicit related data or information to test hypotheses through questions, explanations, as well as their concepts and principles. (5) Test the hypothesis, Hypothesis testing is the process of determining the level of truth and confidence in the answers given based on data. (6) Formulate conclusions, the final step of inquiry learning. The findings obtained by students are described based on
testing the hypothesis to get a conclusion. The following test questions are given to see the mathematical thinking ability of inquiry reasoning aspects.

3.1. Answer The First Subject or S1

The results of first subject (S1) with indicators that appear are perception of generality and expression of generality (inductive reasoning) and gathering facts, assessing or testing assumptions, and establishing conclusions (logical analysis). The following picture is the answers of S1:
Based on the results of S1 that the indicators that emerge are perception of generality and expression of generality (inductive reasoning) and gathering facts, assessing or testing assumptions, and establishing conclusions (logical analysis). From the problems given, it appears that S1 has been able to write all the information contained in the problem. Then, S1 has also shown the pattern found in the problem by finding the ratio, for picture I the terms continue to increase to 2 × the previous syllable, because for picture I requested up to 260 minutes then the terms obtained at $U_{13}$ and figure II terms-the next number increases to 4 × from the previous syllable, because for picture II requested up to 240 minutes, the syllable obtained at $U_{6}$. However, in this case, S1 mistakenly did the calculation in Figure I, seen an error from S1 in determining $U_{11}$, $U_{12}$, $U_{13}$, resulting in inaccurate conclusions [22].

After working on the test questions, the researchers conducted interviews to look at the students' mathematical thinking processes and to accurate data that had been obtained from the test results. At the time of the interview the researcher asked whether the answer was correct from $U_{10}$ to $U_{11}$ to $U_{13}$, S1 began to check the answer and realized its error in making calculations so that when the researcher asked for the correct answer, S1 was able to answer correctly and correctly. In addition, the researcher asked the allegations before doing the calculation, S3 suspected that there were more bacteria in the picture II because there were more bacteria in the picture II so that the indicators of the assumption (logical analysis) appeared and the researchers asked S3 for the indicators that did not yet appear, namely symbolic of generality and manipulation of generality, when asked S3 was able to answer that is for picture I the pattern formed $1 \times 2^{n-1}$ and for picture II the pattern formed $2 \times 4^{n-1}$. In this case, S1 is not careful enough in doing calculations which causes inaccurate inference, according to the internal factors of diagnosis of learning difficulties, namely concentration in learning [22].

3.2. Answer The Second Subject or S2
The results of the answer of the second subject or S2 with indicators that appear are perception of generality, expression of generality, symbolic of generality, and manipulation of generality (inductive reasoning) and gathering facts, submitting assumptions, assessing or testing assumptions, and setting conclusions (logical analysis). Figure 3 is the results of the answers to S2.
Based on the results of the S2 answers, students have been able to solve the problems given and all the indicators appear all from both inductive reasoning indicators and indicators of logical analysis. Because judging from the completion steps done by S2, the researcher conducted an interview to confirm...
the answer from S2. The researcher interviewed S2 by asking S2 why choosing such a solution and S2 answered because he tried to look for it one by one, after getting the ratio of each ratio of picture I and picture II, then S2 wrote down one by one the patterns that exist in the requested tribes picture I for 260 minutes i.e. \( U_{13} = 4096 \) bacteria and picture II for 240 minutes namely \( U_{6} = 2048 \) bacteria. Next, the researcher asks what pattern is formed from this problem and S2 answers \( U_n = a \times r^{n-1} \). So, base on the results of written tests and interviews with S2 indicators of mathematical thinking aspects of reasoning have emerged.

3.3. Answer The Third Subject or S3

Based on the answers to the third subject or S3, the indicators that emerge are perception of generality, expression of generality, symbolic of generality, and manipulation of generality (inductive reasoning) and make assumptions, assess or test assumptions, and establish conclusions (logical analysis). It can be seen from the results of S3’s answers that indicators that do not emerge from logical analysis are gathering facts. Then, the way to solve from S3 is almost the same as S1, but S3 indicators of inductive reasoning appear all, marked by S3 writing general formulas or generalizing patterns of problems and S3 trying to test them with the general formulas he has made. Because, there are indicators that do not appear so researchers conducted interviews to see mathematical thinking processes that have not been seen from the test results. After the interview is conducted the researcher gets the data that the indicator of logical analysis is gathering facts, actually S3 is able to answer the researcher’s questions at the interview, only S3 says that why he did not write down information or things that are known from the problem because to shorten time. The following picture is the answer from S3.
After learning with the inquiry learning model, students show the emergence of mathematical thinking indicators of reasoning aspects. The selected research subjects also showed the emergence of the indicators. Judging from the answers of the research subjects, they try to make guesses of the temporary answers before carrying out calculations and they also write information or gather data on the problems that have been given so that indicators arise from submitting assumptions (logical analysis) and gathering facts (logical analysis).

This is as stated [23], that the purpose of inquiry learning is that students are able to build their knowledge and students are able to find their own concepts through the investigations they carry out. Furthermore, from the allegations that they make it is necessary to do testing, in this case testing the hypotheses of the allegations they made before, in that problem almost all subjects write the regularity of the pattern meaning the indicators that appear are on inductive reasoning (perception of generality, expression of generality, symbolic of generality, and manipulation of generality) but what is more dominant is only perception of generality and expression of generality.

From the results of the answers of subjects both S1, S2, and S3, almost all subjects are able to draw conclusions, so the indicators that emerge determine conclusions (logical analysis). This is in line with the characteristics of the inquiry learning model revealed by [24] among others (1) emphasizing the activities of students to the maximum to search and find, (2) all activities carried out by students are directed to look for and find their own answers to something that is questioned, (3) develop the ability to think systematically, logically and critically, or develop intellectual abilities as part of mental processes. Based on the results of this study, the results of the written test S1 appear indicators in inductive reasoning only perception of generality and expression of generality and logical analysis that is gathering facts, assessing or testing assumptions, setting conclusions.

However, after the interview all indicators have appeared. For S2 all indicators appear both inductive reasoning and indicators of logical analysis, and S3 appears all indicators of inductive reasoning while indicators of logical analysis are submitting assumptions, assessing or testing assumptions, and setting conclusions. Indicators of logical analysis can appear simultaneously with inductive reasoning.

4. Conclusion
Based on the results of research in class XI IPA 1 of SMA Negeri 1 Indralaya Selatan, the results obtained that mathematical thinking aspects of reasoning through inquiry learning models on S1 indicators that appear inductive reasoning are only perception of generality and expression of generality while logical analysis is gathering facts, assessing or submitting assumptions, setting conclusions. S2 appears all indicators of inductive reasoning and indicators of logical analysis, and S3 appears all indicators of inductive reasoning while indicators of logical analysis are submitting assumptions, assessing or testing assumptions, and setting conclusions. Indicators of logical analysis can appear simultaneously with inductive reasoning.

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