INTERNATIONAL CONFERENCE OF MOSLEM SOCIETY

ISSN 2622-5840, Volume 3, 2019, Pages 48-57

DOI: https://doi.org/10.24090/icms.2019.2327

Proceeding of 3rd International Conference on Empowering Moslem Society in the 4.0 Industry Era

Characteristics of Students' Intuitive Thinking in Solving Mathematical Problems

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Abstract: Intuition is one of important thing in the process of solving mathematical problems. It works as cognitive mediation. In this understanding, intuition can be made as a bridge to students' understanding so that it can be accessed in linking imagined objects with the desired alternative solutions. In other words, students can determine what strategies or steps should be taken to get a problem solution, especially contextual problems that have completion steps that cannot be accessed directly. Intuitive thinking often occurs in mathematical problem solving. This was also seen in the mathematical students of IAIN Purwokerto. Based on the teaching experience so far, it was found that many students gave spontaneous answers without analyzing first. So, the researcher studied how characteristics of students' intuitive thinking are. This research used qualitative with descriptive-exploratory type of research and used test to identify the characteristics of students' intuitive thinking in solving mathematical problems. Results showed that students' characteristics consisted of extrapolative, implicitly, persistently, coercively, and the power of synthesis.

Keywords: *intuitive thinking, mathematic, students*

A. Introduction

Problem solving skills are a person's basic ability to solve a problem that involves critical, logical, and systematic thinking. The importance of being given a mathematical problem because of its role in life, namely to develop one's ability to deal with problems. In mathematics learning, problem solving skills have an important role, i. e. as an initial ability for students to formulate concepts and provision of success in solving mathematical problems. The importance of problem-solving skills is also stated in Nurdalilah (2010) that problem solving is a part of a mathematics curriculum that is very important because in the learning and completion process, students are allowed to gain experience using the knowledge and skills they have to apply in problem solving.

Intuition plays an important role in the process of solving mathematical problems. Intuition functions as intermediate or mediating cognitive cognition. In this sense, intuition can be used as a bridge to a student's understanding so that it can make it easier to associate the imagined object with the desired alternative solution. In other words, it is able to determine what strategies or steps must be taken to reach the solution to a problem. Of course, this ability becomes very important in mathematical problem-solving activities,

especially when students are faced with contextual problems that have steps to solve that cannot be directly known. Intuition or intuitive thinking is often used in understanding mathematical problems. As revealed by Kustos (2010), that intuition can be a reason for strong understanding in relation to logic rather than against or contrary to logic. A mathematical statement sometimes requires evidence, but to reach evidence from a statement often requires intuition by immediately finding the pattern.

To explain the importance of intuition in mathematics, Fischbein attributed intuition to two other cognitions. As stated in his book, Fishbein revealed that in analyzing student behavior in mathematics learning, there are three aspects that need to be taken into account, namely formal cognition, algorithmic cognition, and intuitive cognition. Intuition or what he refers to as intuitive cognition, in addition to its role in making guesses or claims in a mathematical problem solving, also plays a role in giving meaning or informal interpretation to certain definitions, theorems, formulas and resolution strategies. Where the use of definitions and theorems is a feature of formal cognition, while the use of formulas and resolution strategies is a feature of algorithmic cognition. This shows that intuition supports the role of formal cognition and algorithmic cognition in a mathematical activity.

One of the goals of mathematics learning is to help students solve problems, both problems relating to understanding the mathematical concepts themselves and their applications. Polya (1980) defines problem solving as an effort to find a way out of a difficulty. This means that problem solving in mathematics is an activity to find solutions to mathematical problems faced by using the provision of knowledge and mathematical experience that already has. Based on some of the meanings above, it means that problem solving in mathematics is an activity to find solutions to mathematical problems faced by involving all knowledge provisions (having studied concepts) and provision of experience (trained and accustomed to dealing with or solving problems) that are not demanding a special pattern regarding the solution method or strategy. Thus it can be specified in at least two parts, namely first, when someone goes through formal / analytical step by step (such as using formulas, logic rules), the two may also sometimes be if the problem is foreign or even totally unrelated to one's informal knowledge can resolve directly, spontaneously, quickly and less regularly the steps in solving the problem, which means that the second part is classified as intuitive thinking.

Krulik dan Rudnick (Sukayasa, 2012: 3) said that problem solving is the means by which an individual use previously acquired knowledge, skills, and understanding to satisfy the demands of an unfamiliar situation. It means that problem solving interpreted by someone (individual) using the knowledge previously obtained, skills, and understanding to meet the demands of a situation unknown. With the ability to solve problems obtained from the lesson mathematics, students are expected to bring it to solve internal problems daily life (Susanto, 2012: 38).

Dreyfus T. & Eisenberg T (1982) say that intuitive understanding is very necessary as a "bridge of thought" when someone attempts to solve problems and guide aligning initial conditions and conditions of purpose. In other words, for some students when solving mathematical problems, they already know or find a solution /answer to the problem before students write down the steps to solve it. Even so, when they find the initial idea in solving the problem or what steps are most suitable to solve the problem. The emergence of such an idea, of course, comes immediately or suddenly which is a thinking character that involves intuition.

In general, more complex problem-solving steps, usually through several stages, namely first, someone will try to the maximum and conduct experiments or estimates or guess and choose a strategy to obtain a scheme and model of settlement, may reject information or solutions that does not meet. Maybe he changed other activities or chose to take a break. The second stage, suddenly he gets a new solution or strategy that is more accurate that is obtained through the feeling to solve the problem. It may be that he does not yet have solving elements in the form of formal, analytical, deductive or inductive justification which are steps to solving problems. What comes to mind at the beginning is a global idea, global representation or a bridge towards solving problems. Such activities are classified as intuition activities. The third stage, an intuition associated with feeling and deep and strong beliefs, a feeling of certainty that occurs before the formal series of analytical-based done in solving problems.

B. Theory

In Indonesian Dictionary (Daryanto, 1997), intuition is defined as the ability to understand something without going through the thought process. Fischbein (1999) has presented the general characteristics of intuitive cognition in mathematics, which is something basic and very clear in an intuitive cognition. The characteristics of the intuition are as follows.

1. Direct, self-evident cognitions (direct cognition, self-evident cognition)

   Direct cognition, self-evident cognition in question is that intuition is cognition that is accepted as an individual feeling without requiring further checking and verification. For example: the closest distance between two points is a straight line. This is self-evident, statements received directly.

2. Intrinsic certainty

   Certainty of intuition cognition is usually associated with certain feelings of intrinsic certainty. The statement about the straight line above is subjective, feels like it has become a provision. Intrinsic means that no external support is needed to obtain a kind of direct certainty (either formally or empirically).

3. Coerciveness

   Intuition has the nature of leading to something that is believed. This means that individuals tend to reject alternative interpretations that will contradict their intuition. Usually students and even adults believe that multiplication will make it bigger and the division will make it smaller. This is because in childhood accustomed to operating natural numbers. Later after learning rational numbers it is still felt to obtain the same belief, which is clearly no longer appropriate.

4. Extrapolativeness

   An important characteristic of intuitive cognition is the ability to predict behind an empirical supporter. For example: the statement "through one point outside the line can only be drawn one and only one line parallel to that line" expresses the ability to extrapolate from intuition. There is no empirical and formal evidence that can support this statement. However, this is intuitively acceptable, a certainty, as self-evident.

5. Globality

   Intuition is global cognition that is contrary to cognition which is obtained logically, sequentially and analytically. For example: One child aged 4 to 5 years is given two sheets of the same A and B paper. On paper A the child is asked to draw a point (P1) and then asked to draw a point (P2) on paper B which is exactly the same as point P1 on sheet A.

> The child will usually draw point P2 on sheet B more or less the same place. If the child is asked to explain why he put the point on sheet B, the child cannot provide an explanation. He solved the problem intuitively, directly through estimates globally.

According to Fischbein (1999), intuition is categorized into two, namely affirmatory intuition and anticipatory intuition. Affirmatory intuition can be in the form of statements, representations, interpretations solutions that can be accepted individually, self-evident, global and intrinsically sufficient. Anticipatory intuition is the intuition that arises when someone works hard to solve a problem, but the solution is not immediately obtained (not directly). Anticipatory intuition characteristics are as follows. a) The intuition presents a global idea. b) Intuition is contrary to conjecture in general, and this intuition is associated with feelings of truth, even though detailed justification or evidence has not been found.

What distinguishes affirmatory intuition and anticipatory intuition? Through affirmative intuition, people receive self-evident statements or interpretations. In anticipatory intuition, the facts observed, do not immediately produce a statement or interpretation. A statement or interpretation appears as an invention, as a solution to a problem, or as an interpretation, or a sudden claim of an attempt to resolve a previous problem.

Usodo, Budi (2012) concluded from his research on high school students, namely: 1) in understanding mathematical problems, male subjects with high, medium and low mathematical abilities used direct affirmative intuition, which was directly understood from the question text, subjects with mathematical abilities high, medium and low in understanding mathematical problems do not use intuition; 2) in making a settlement plan, male subjects with high mathematical abilities, are using global anticipatory intuition, namely the subject uses a sequence formula that is obtained from the understanding of the question text directly and the subject cannot explain in detail why to use the sequence formula, male subject men with low mathematical abilities. Subjects of women with high mathematical abilities use anticipatory global intuition and subjects with low mathematical abilities do not use intuition in making settlement plans; 3) in carrying out the completion plan, all research subjects did not use intuition; 4) in checking the answers to problems, subjects with high and moderate mathematical abilities both male and female do not use intuition, male subjects with low mathematical abilities in examining answers using anticipatory intuition that has characteristics contrary to expectations in general and in the form of inductive thinking.

Muniri (2013) conducted research on high school students. The study concluded that the intuitive thinking character used by the subject in solving mathematical problems as follows: 1) Characteristics of intuitive thinking used by AKF subjects (high group students) in solving mathematical problems, among others; extrapolative, implicitly, persuasive, and common sense; 2) Characteristics of intuitive thinking used by MSP subjects (medium group students) in solving mathematical problems, among others; extrapolative, implicit, per severable, coerciveness, and power of synthesis Some of these studies show that affective abilities have a positive effect on learning outcomes, meaning that the better the affective abilities of a student, the better the learning outcomes. Student-centered learning approaches, using realistic and contextual problems, and giving students the opportunity to discuss, working together to interact with each other can improve students' affective abilities.

Kamandoko & Suherman (2017) concluded that the intuition profile of students in solving mathematical problems for style cognitive (1) Field Independent students: (a) understand analyzing problems using intuition affirmation which is direct by reading and converting information into form picture and see the questions to find out who was asked, (b) design and plan solutions using anticipatory global intuition, (c) exploring solutions for difficult problem not using intuition, using the appropriate method of planning made, (d) verify the solution does not use intuition, check the answer by checking the formula which is used and recalculates the answers that have been obtained. (2) Field Dependent students: (a) understand and analyze problems using direct affirmatory intuition, having difficulty in determining what was asked, (b) designing and planning solution using global anticipatory intuition, although it can make plans in finding solutions but not to the final solution, (c) exploring solutions to problems difficult ones don't use intuition, use the method as planned, (d) verifying the solution does not use intuition, recalculating the answers that have been obtained in the same way.

C. Method

This study uses a qualitative approach with a type of descriptive-explorative research, which aims to describe the characteristics of students' intuitive thinking in solving mathematical problems. The subjects of this study were students of the Tadris Mathematics Study Program (TM) in the second semester of IAIN Purwokerto, amounting to 43 students. This is based on the consideration that TM students have varying abilities and have taken courses that involve the process of solving mathematical problems, and will still take courses that involve many mathematical problem solving processes.

The instrument used in this study is a test to identify the characteristics of intuitive thinking of students in solving mathematical problems. This test contains a description of the mathematical material in the course "Study of Junior High School Mathematics Material" which includes sets, comparisons and scales, social arithmetic, speed, and statistics. The problem description is used to be able to find out not only the final answer from the student, but also analysis, explanation, reason or other similar forms according to the question. The results of this test data are used as the basis of the analysis material regarding the characteristics of intuitive thinking in solving mathematical problems.

In summary, the process of analyzing data in this study is carried out by the following steps: preparing and transcribing data for analysis, reading the entire data, coding data, connecting hypotheses with evidence of the emergence of intuitive thinking, presenting data, interpreting the emergence of intuitive thinking, and draw a conclusion.

D. Results

In this study, several questions were used in the test questions to obtain an intuitive description produced by the subject. The following is a discussion of the results of research from several subjects in solving mathematical problems. Intuitive thinking that occurs is a solution that arises when students have difficulty solving math problems given. Next is a discussion of the results of problem solving by several subjects for each question.

The first problem is about probability:

"If the opportunity for Monday's rain is 40%, and the chance for Tuesday's rain is 60%, determine the chance for rain Monday or Tuesday!"

The solution to the number 1 generated by Student 1 (S1) raises intuitive thinking when S1 determines the chance of rain

Monday or Tuesday. Without first calculating the full chance of rain Monday and Tuesday, S1 performs ordinary algebraic calculations to get 76%. In understanding problems, S1 does not use a particular process, for example illustrating or describing in advance what they understand. However, S1 understands directly the problem given by using the formula that he remembers. S1 does not describe in detail what information is obtained from the question, what is asked and what completion plan will be done. The S1 answers are as follows:

The chance for Monday or Tuesday rain is

= 0.4 + 0.6 - (0.24)

= 0.76

If connected with the opinion of Fischbein (1987), then S1 uses the first component of affirmatory intuition, namely to understand the problem using direct cognition (self-efficacy). That is, cognition is received directly by individuals without requiring further checking and verification. Whereas if it is associated with a study from Kustos (2010), then there is an instinct component. That is, understanding the problem with the emergence of a response in thinking about the problem at hand.

Based on the results of problem solving carried out by S1 in the previous answer, it can be concluded that S1 uses intuitive thinking because S1 does not use a long way of calculating answers first. Intuitive thinking that is raised in the form of ideas suddenly as a strategy in making decisions based on feeling, intrinsic, and intervention so as to produce answers to solving problems faced. If it is associated with the opinion of Kustos (2010), the method used by S1 is included in the perception and global components because S1 produces the answer solution correctly. Understanding directly from the question text without reasoning can be called an immediate cognition. In addition, the truth of the writing from the S1 work and the S1 statement in the answer does not require justification or evidence, the writing of the S1 work in understanding the problem is not based on procedures, algorithms and does not take place step by step and is not a perception.

Subjects use intuition or not intuition in solving problem solving test questions, using five intuition criteria so that it can be said that S1 uses intuition in understanding problems. As stated by Fischbein (1999) that intuition is immediate cognition (immediate knowledge) that is approved directly without justification or evidence. Because S1 in understanding the problem directly from the question text after reading the questions given so that the intuition used in understanding the problem is affirmative intuition that is self-evident, intuition appears as a statement that is immediately accepted without the need for justification by formal evidence or empirical support.

The second problem is about area of sphere:

"The roof of a building in the shape of a half sphere with a diameter of 20 m. The roof is made of aluminum sheets. If every square meter is IDR 15,000, what is the cost needed to make the roof? "

The problem solving produced by Student 2 (S2) raises intuitive thinking supported by supporting factors for the emergence of intuitive thinking. Intuitive thinking appears when S2 determines the area of a half sphere. Without calculating the area of a sphere as a whole, S2 performs normal algebraic calculations so that it gets 628 results, then multiplied by 15,000. In understanding the problem, S2 does not use a particular process, for example illustrating or describing in advance what it understands. However, S2 directly understands the problem given. This direct understanding is not because S2 has had experience doing problem solving as given or has read the writing about the same

problem. However, in understanding the problem S2 really obtained shortly after reading the problem text. The following is an answer from S2:

Cost = $2\pi r^2 \times 15000$
= 2 . 3,14 . 100 × 15000
= 628 × 15000
= 9420000

In the opinion of Fischbein (1999), S2 uses the first intuition affirmatory component, namely to understand the problem using direct cognition (self-efficacy). That is, cognition is received directly by individuals without requiring further checking and verification. Whereas if it is associated with a study from Kustos (2010), then there is an instinct component. That is, understanding the problem with the emergence of a response in thinking about the problem at hand. Based on S2 answers to the problem solving, it can be concluded that S2 uses intuitive thinking because he does not use a long way to count answers first. Intuitive thinking that is raised in the form of ideas suddenly as a strategy in making decisions based on feeling, intrinsic, and intervention so as to produce answers to solving problems faced. If it is associated with the opinion of Fischbein (1999) using anticipatory intuition, namely solving problems contrary to expectations in general. This means that S2 claims an unusual procedure. Whereas if it is associated with the opinion of Kustos (2010), the method used by S2 is included in the perception and global components because S2 produces the answer solution correctly.

The third problem is about average:

"The average math test score of class IX B students is 5,1. Because of being clever, one of the students had 8 math grades transferred to class IX A. The average math test score in class IX B now is 5. How many students in class IX B before students who are clever are moved?"

In this mathematic problem, S3 does problem solving by generating intuitive thinking processes. This intuitive thinking is seen when S3 solves problems without using the usual procedures or formulas used. In solving the third problem, S3 first identifies what information is contained in the question, then writes what is asked about the question. In implementing problem solving, S3 does not use many mathematical concepts such as average formulas. S3 do a trial by putting the number of students first. First, he specifies the number of students 20, then calculates the value of students before being moved and after being moved. Difference in value is obtained by 7 (not fulfilling). Furthermore, S3 specifies the number of students is 30, the difference in value obtained is 8 (fulfilling).

Very visible in understanding the problem, S3 does not use a particular process, for example illustrating or describing in advance what it understands. However, S3 understood directly the problem given. This direct understanding is not because the S3 has experience doing problem solving as given or has read the writing about the same problem. However, in understanding the problem S3 is experimenting with numbers that he believes are right. It can be concluded that S3 uses intuitive thinking. Intuitive thinking is based on feeling, intrinsic, and intervention so as to produce answers by trial and error without using mathematical theorems or formulas. Whereas if it is associated with the opinion of Kustos (2010), the method used by S3 is included in the perception component because S3 performs perceptions of the solution to the answer that will be produced, then resolves to obtain results.

Meanwhile, S4 does a problem solving that is somewhat different from what was done by S3. Based on the results of written work, S4 in making problem solving plans, using the average formula by connecting between things that are known and using all important information contained in the

problem. So, what S4 does in making a problem solving plan is based on a definition or theorem. Based on the answers made by S4, S4 can explain its plans in planning problem solving, can explain the reasons for choosing the plan, plan using the concepts of statistical and arithmetic formulas, and be able to implement the steps in the plan. S4 uses procedures, mathematical algorithms and takes place in step by step.

S4 implements a problem solving plan, it appears that there is no thought from S4 in the form of immediate cognition. In addition, S4 in making a plan for problem solving is based on definitions or theorems, uses procedures, algorithms and takes place in step by step, this is not included in the criteria of intuition. S4 does not use intuition in solving problem solving test questions, it can be said that S4 does not use intuition in making problem solving plans.

The fourth problem is about arithmetics:

"In a city, the population growth every year is always constant. In 2005, and 2011 the population in the city was 600.000 and 900.000 people respectively. What is the population of the city in 2015? "

Based on the results of the written answers Student 5 (S5) in understanding the problem, S5 can write down what is known and what is asked by the problem. Understanding directly from the question text without reasoning and not from experience can be called an immediate cognition. In addition, the correctness of the writing of the work S5 does not require justification or evidence, the writing of the results of the S5 work in understanding the problem is not based on procedures, algorithms and does not take place in step by step and is not a perception. Although S5 tried to use the concept of comparison in its completion, the subject did not explain why he used the concept.

S5 uses intuition in solving problem solving test questions, using five intuition criteria so that it can be said that S5 uses intuition in understanding problems. As stated by Fischbein (1999) that intuition is immediate cognition (immediate knowledge) which is approved directly without justification or evidence. Because S5 in understanding the problem directly from the question text given so that the intuition used in understanding the problem is an affirmative intuition that is direct (self evidence), intuition appears as a statement that is immediately accepted without the need for justification by formal evidence or empirical support. According to Fischbein (1999), affirmatory intuition is an intuition that is used to assert statements, interpretations or representations used in understanding mathematical problems that can be received directly. From the answer analysis it was found that the intuition used by the subject S5 to solve the problem of mathematical puzzles was affirmatory intuition and anticipatory intuition. The nature of the affirmatory intuition of the S5 subjects that emerged were self evidence, intrinsic certainty, coerciveness, extrapolativeness, and implicitness. Then the anticipatory intuition of the subject S5 that appears is globality only.

Indications of intuitive thinking are also seen in the answers written by student 6 (S6) and student 7 (S7). S6 solves problems without using certain procedures, algorithms or formulas in mathematics. S6 describes the problem solving process using his own method and language. In solving the problem, S6 first calculates the difference in population between 2005 and 2011, then calculates the population growth from 2015 to 2015, the number of population per year, until finally counting the population in 2015.

Based on the results above, it can be concluded that S6 and S7 use intuitive thinking. Intuitive thinking is based on

feeling, intrinsic, and intervention so as to produce answers by trial and error without using mathematical theorems or formulas. Whereas in the opinion of Kustos (2010), the method used by S6 and S7 is included in the perception component because S6 and S7 do perceptions of the answer solution that will be produced, then resolved until the correct results are obtained.

The fifth problem is about probability:

"In a box there are 9 balls, consisting of 5 red balls and 4 white balls. If you take 3 balls at a time randomly, what are the chances of getting 1 red ball and 2 white balls? "

Based on the answers written S8, in solving problems first S8 writes down what is known and what is asked by the problem. Understanding directly from the question text can be called an immediate cognition. Although S8 uses a combination concept in the problem solving process, S8 does not explain the reason for using the concept. In addition, the correctness of written work S8 does not require justification or evidence, the writing of the results of the S8 work in understanding the problem is not based on mathematical procedures and algorithms, and does not take place in step by step and is not a perception. S8 uses intuition in solving problem solving test questions, using five intuition criteria so that it can be said that S1 uses intuition in understanding problems. As stated by Fischbein (1987) that intuition is immediate cognition (immediate knowledge) which is approved directly without justification or evidence.

In understanding the problem S8 understands the problem directly from the question text given so that the intuition used in understanding the problem is affirmatory intuition that is direct (self evidence), intuition appears as a statement that is immediately accepted without needing justification by formal evidence or empirical support. According to Fischbein (1999), affirmatory intuition is an intuition that is used to assert statements, interpretations or representations used in understanding mathematical problems that can be received directly. Based on the analysis of answers it was found that the intuition used by S8 subjects to solve mathematical problems was affirmative intuition and anticipatory intuition. Some of the properties of affirmatory intuition from S8 subjects that appear are self evidence, intrinsic certainty, extrapolativeness, and implicitness. The anticipatory intuition of the subject S8 that emerges is globality.

E. Conclusions

Characteristics of intuitive thinking used by subjects in solving mathematical problems include: extrapolative, implicitly, persistently, coercively, and the power of synthesis. Based on the conclusion, it is recommended that the mathematical problem solving process should collaborate the use of analytical thinking and intuitive thinking, so that the resulting completion is more accurate. Intuitive thinking is very much needed or appears when experiencing a deadlock in understanding or solving problems. In other words, the role of intuitive thinking is an opening tool for developing ideas when the analytical process no longer has the ability to continue the solution. Therefore it is necessary to design mathematical learning that involves and fosters students' intuition when understanding and solving problems.

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