Students’ Multiple Intelligence in Visualization of Mathematics Problem Solving

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Abstract. The rate of development of a person's cognitive abilities is determined by intelligence, especially in solving mathematical problems. By using Gardner's theory of multiple intelligences, the selected respondents were representative of linguistic intelligence (ILK), Spatial intelligence (ISP), and mathematical logical intelligence (ILM). As for the specifics in this study were second year mathematics major students at State University of Makassar. This study reports data obtained through tests and interviews, the tests given to respondents consisted of several mathematical problems using multiple intelligence indicators then continued with interviews, and found that there were visual and structural differences in the problem solving process. The use of patterns and verbal mathematical relationships is dominated by ILK students, and transformation of forms to diagrams or images is dominated by ILM students, while ISP students use visualization and abstraction to solve the problems.

Keywords: Multiple Intelligence, Visualitation, Problem Solving, Mathematics

1. Introduction
Problem solving is the main focus in learning mathematics. In the process of learning and problem solving, a person can gain experience using the knowledge and skills he has. This experience then trains one's thinking power to be logical, analytical, systematic, critical, and creative in dealing with a problem [1], [2]

The researcher as an alumnus of mathematics education students at Makassar State University discovered the facts that occurred among students. One of them is the diversity of ways and forms in solving mathematical problems. so that it cannot be denied that the ability of each individual is different from one another. This is certainly influenced by the way of thinking which is a product of intelligence and general type of intelligence is not just one, but there are at least eight specific types [3].

In this case, intelligence becomes closely related to problem solving. Where solving the problem itself according to Branca can be interpreted in three different categories [4]. First, solving as a goal. This category focuses on learning how to solve problems. In this case, problem solving is free from procedures or methods and mathematical content itself. Second, problem solving is a process. This
category focuses on methods, procedures, strategies, and heuristics used in problem solving. Third, problem solving as a basic skill, one of which concerns the minimum skills possessed by someone in terms of mastering mathematics.

There are two main components that influence students' abilities. First, the component is an academic component which includes linguistic, logic-mathematical, naturalistic, and visual-spatial intelligence; and second, non-academic components which include kinesthetic intelligence, musical and social intelligence [5]. The research conducted does not specifically describe how intelligence including the academic component affects a specific field of science.

Furthermore, studies investigating the multiple intelligence profiles of science and mathematics teachers in secondary schools and teaching strategies based on multiple intelligences and the relationship between multiple teacher intelligence profiles and teacher teaching strategies were carried out revealed in the results of research that knowing teacher multiple intelligence profiles can improve understanding and interest in applying teaching strategies in science and mathematics classes [6]. Then, another study showed a relationship between kinesthetic, logical-mathematical, visual-spatial and naturalistic intelligence with science teaching [7]. In addition there is a correlation between kinesthetic and visual-spatial intelligence with science process skills.

According to Gardner intelligence is not entirely genetic and innate, intelligence can be nurtured and developed [8], [9]. So that it can be said that intelligence is an ability that can be changed according to the capacity possessed by someone.

Students with a dominant level of intelligence each have a different mindset in solving problems. This needs to be reviewed in more depth, about how each intelligence influences the process of solving mathematical problems.

2. Literature Review
2.1. Multiple Intelligence
Which is more appropriate, looking at intelligence as a general ability or as a number of different specific abilities?

Humans are blessed by God with the brain as a machine producing intelligence. However, it will only be useful if the brain is used properly. What is meant is learning. By learning, the work engine of the brain always works and makes people smart.

Ostroff states that "children's brains rely on neural pathways that have been formed to understand new information" [10]. Intelligence can be nurtured and developed, so the criteria for identifying components of intelligence according to Gardner are intelligence must be measurable, judged by one's culture, and in the form of power that is used by humans in creativity.

Intelligence only focuses on arithmetic, logical and verbal [11] Moreover, the human intellect is so much broader that it is an impossibility that intelligence cannot be measured. The interpretation of intelligence in our culture is too narrow. So Gardner defines intelligence as follows; ability to solve problems or fashion products which are consequences in a cultural atmosphere, skills make a person approach a situation where the goal must be achieved, ability to find the right direction / way to the target.
There are many specific intelligences or frame of mind [12]. Compound intelligence according to Gardner include: (1) linguistic intelligence, (2) spatial intelligence, (3) logical-mathematical intelligence, (4) musical intelligence, (5) interpersonal intelligence, (6) intrapersonal intelligence, (7) kinaesthetic intelligence and (8) naturalist intelligence.

2.1.1. Linguistic
An individual who has linguistic intelligence has the ability to process words, language (verbal) which has a complex and detailed structure [8], [10]. Competencies of linguistic intelligence include: (a) reading ability; (b) writing ability; (c) ability to discuss; and (d) the ability to argue. so that the core component of this type of intelligence is sensitivity to sound, structure, meaning, function, word and language.

So that in solving problems, this becomes an important indicator that someone in conveying his reasoning needs a tool that is language. Which is where mathematics is also the language itself. In interpreting the problem and finding a relationship, it is necessary to have oral or written communication in accordance with mathematical goals [13].

2.1.2. Spatial
Spatial intelligence is intelligence that plays an important role in learning mathematics. Its relation to the ability to transform problems into various forms, perceives problems into space or [12], [14]. Competencies of spatial intelligence include: (a) drawing ability; (b) photographing ability; (c) making sculptures and designing. So that this component of spatial intelligence is sensitivity to feel and imagine images and space accurately.

2.1.3. Logic Mathematic
Mathematical logical intelligence is the ability to solve mathematical operations logically, and structured in the theory of multiple intelligences is mathematical logical intelligence. A person has a high mathematical logic intelligence understands the principles underlying a causal system, the way a scientist or user logic does something, or can manipulate numbers, quantity and operations, such as the way that mathematicians do. So that the processes used in this type of intelligence include: categorization, classification, conclusions, generalizations, calculations, and hypothesis testing.

| Table 1. The Indicators of Linguistic, Spatial and Logic Mathematic Intelligences’ |
|-------------------------------|---------------------------------|------------------|
| **Linguistic**                | **Spatial**                     | **Logic Mathematics** |
| The ability to understand the language of mathematics. | The ability to draw space in three dimensions accurately | The ability to calculate systematically (computing) |
| The ability to translate everyday language into symbolic language | The ability to design space in a dimension | The ability of mathematical reasoning |
| The ability of oral communication in conveying mathematical reasoning | The ability to draw a function on a graph or table. | The ability to think logically and structured |

An educator must have good linguistic abilities in order to be able to construct knowledge in understanding problems and solving non-routine problems [15], educators must have spatial abilities to represent problems in visual form, and educators must have mathematical logical abilities so that
they can link mathematical patterns or relationships logically and good computing skills. Because teaching mathematics is not just teaching how to memorize multiplication, divide, reduce and add up. More than that, educators at least have the intelligence needed in an effort to develop their profession

It appears that there is a relationship between the profiles of mathematical problem solving with the three multiple intelligences that play an important role in mathematical needs.

2.1.4. Mathematics Problem

In general, students find it difficult to understand a problem and do not understand what to do in the problem solving process. This is nothing but a lack of understanding of the concepts students have. When students are not able to do problem solving, it can be concluded that students do not have experience about the subject as their initial knowledge. Lack of knowledge is an obstacle to the reasoning process that brings students to the thought that he is unable to solve the problem.

The problem is the gap between the present and the goals to be achieved, while we do not know what must be done to achieve that goal. Thus the problem can be interpreted as a question that must be answered at that time, whereas we do not have a clear plan of solutions. So that it can be said that a certain situation can be a problem for certain people, but not necessarily a problem for others.

A question is a problem or not a problem is relative. This means that not all students say that the question is a problem. Some consider that the question is a problem and others assume that the question is not a problem for them.

The relationship between solving problems with intelligence can also be seen based on the definition of intelligence according to Gardner that intelligence is used as a tool to solve problems in the process of thinking [1], [16], [17]. Therefore, intelligence cannot be observed directly but must be interpreted from various concrete actions which are manifestations of the rational thinking process.

In this study the related material is a problem grouped in three types, 1) linguistic problems, 2) logical mathematical problems, 3) spatial problems. These problems are non-routine, as explained. The problems in mathematics are classified into two types of problem searching (problem to find) and proving questions (problem to prove). In other words, a mathematical problem in question is a non-routine problem [18]–[21]

3. Research Method

This type of research is descriptive research with a qualitative approach. This study describes qualitative data and describes in detail the ability to solve mathematical problems based on multiple intelligences. In this study, the data obtained were data from multiple intelligence tests, results of problem solving tests, and data from interview transcripts. The subjects in this study were the second year mathematics education study program students, namely as many as three students each of whom had a level of dominant linguistic, logical mathematical, and spatial intelligence obtained from multiple intelligence tests. Furthermore, the data collection technique in this study is by providing a problem solving test that has been designed and validated by experts based on the type of problem, namely the problem, namely linguistic, logical and spatial problems. Next the subjects were interviewed based on the problems that had been solved in the problem solving test. The data validity technique used is 1) careful observation, 2) increasing perseverance, 3) time and technique triangulation, and 4) member check. The intended time triangulation is to compare subject data on the
results of problem solving tests and interview transcript data conducted in different times, then proceed with triangulation techniques, namely comparing problem solving test data with interviews conducted at a later stage by giving problems similar to problems in problem solving test.

4. Results and Discussion
Data on multiple intelligences of students in this study were obtained from the results of multiple intelligence tests on students of mathematics education study programs at State University of Makassar. As many as 76 students from classes A1 and A2 who were then based on the results of multiple intelligence tests, as many as 56% or 58 students had one dominant intelligence. Subjects were chosen based on the dominant level of linguistic intelligence, logical mathematics and spatial. So that 3 students were taken as the subject of research which then represented each of these intelligence domains. The following are the results of multiple intelligence tests of students who have a level of dominant intelligence.

4.1. Problem solving for students with a dominant level of linguistic intelligence
Every subject with certain intelligence has their own characteristics in solving problems. These characteristics are influenced by the types of dominant intelligence possessed by each subject, so that the skills and problem solving process differ between subjects with each other.

In the subject of ILK, linguistic problem solving skills are superior compared to problems that are logical-mathematical and spatial. However, in general when compared to the other two subjects, namely the subject of ILM and the subject of the ISP, the subject of ILK is superior in the problem solving process.

The dominant intelligence possessed by ILK is linguistic intelligence which leads to the ability to express language that has a complex structure. So that the subject in solving problems uses the ability to read repeatedly to understand the problem, the ability to argue in communicating in writing and verbally in conveying his ideas.

Its language ability is caused by the main function of the brain in the left temporal part and frontal lobe. In addition, the dominance of the left brain prefers language or words, detailed, structured, and special description. So that in completing each given problem, subjects with linguistic dominant intelligence use words (verbal) and structured [22] so that in completing mathematics, the subject starts from 1) Identifying the problem, 2) defining the problem, 3) constructing the strategy, 4) representing the strategy, 4) obtaining a problem solving solution, 5) checking the solution given, 6) using different alternatives in prove the solution given.

4.2. Problem solving for students with the dominant level of mathematical logical intelligence
In the subject of ILM, the dominant intelligence it has is mathematical logical intelligence. In general, subjects have complicated thoughts and strategies in finding solutions. The subject tries to interpret the problem by modeling the problem into mathematical form and simplifying it into other forms such as images and diagrams.

Mathematical logical intelligence lies in the left frontal lobe and the right pariental lobe. So that subjects prefer thinking that is measurable, quantitative and analytical. This is evident in the subject of
ILM which states that he prefers problems in the form of numbers rather than problems in pictures and story problems (language).

So that the problem solving steps provided by the subject of ILM include: 1) simplifying the problem in the form of a tree diagram, 2) constructing the strategy using a sequence of patterns, 3) representing the strategy to obtain a solution, 4) checking the solution given. In addition, the solutions provided by the ILM subject in problem solving tests are more structured and analytical which states that mathematical logical intelligence is the ability to think abstractly and find problem solving through existing patterns.

4.3. Problem solving for students with the dominant level of spatial intelligence

The spatial intelligence is in the area of the brain in the right rear hemisphere and occipital lobes. The dominance of the brain possessed by the subject of the ISP is the right brain. In this study, the brain likes a general picture, spontaneity, and places itself in various.

In solving problems, in general the subject of the ISP is more interpreting the problem in the visual world. Some of the solutions given are generally not systematic, but they have the ability to explain visually. Therefore, the ability possessed by spatial intelligence is the ability to interpret problems in their thinking and reflect on them in various perspectives.

So that, the ISP subject in solving mathematical problems starts with 1) identifying the problem, 2) visualizing the problem abstractly, and 3) obtaining a solution. When solving mathematical problems, the subject orientates itself into spatial matrices. That is, a person with spatial intelligence has the ability to process the information based on his vision or intuition in three-dimensional space.

The subject of mathematical problem solving process can be described based on the tendencies made by the subject on each type of mathematical problem. Students who have the dominant level of linguistic intelligence in solving problems generally use strategies to find patterns and relationships between statements based on their heuristics. In solving problems, the strategy of stating the problem in detail is one of the characteristics possessed by a person with linguistic intelligence. Students who have the dominant level of logical-mathematical intelligence in solving problems generally use strategies to simplify the problem into other forms, such as images and diagrams, which are characteristic of this intelligence, namely analyzing the problem carefully and details in finding facts in its abstraction. Students who have a dominant level of spatial intelligence in solving problems generally have strategies in their abstraction. Visualize in his mind, so that he does not have clear steps in solving the problem.

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