Mathematics Education Journals
Vol. 5 No. 2 August 2021

ISSN : 2579-5724
ISSN : 2579-5260 (Online)
http://ejournal.umm.ac.id/index.php/MEJ

Mathematical Problem Solving for Students in the Superior Intelligence Quotient (IQ) Category

Suci Wulandari[1], Elly Susanti[2*], Sri Harini[3]

[1,2,3]Magister of Mathematic Education, Maulana Malik Ibrahim State Islamic University Malang,
Email : wsuci230223@gmail.com,
ellysusanti@mat.uin-malang.ac.id,
sriharini@mat.uin-malang.ac.id

Abstract

Mathematical problem solving is indispensable in learning mathematics. Problem solving also requires very high intelligence, including the superior intelligence quotient (IQ) category. Therefore, the purpose of this study is to describe the mathematical problem solving of students in the superior IQ category.This study uses a qualitative approach with an exploratory descriptive type. The subjects in this study were students who had done an IQ test with a superior IQ. This study describe 2 subjects based on relatively similar tendencies. Data collection techniques used documentation studies on IQ, math problem solving, think aloud, and semi-structured interviews. Data analysis in this study refers to Polya's research on mathematical problem solving. The validity of the data in this study used triangulation techniques. The results of this study indicate that students with superior IQ are able to fulfill the stages of solving mathematical problems, namely understanding the problem, planning strategies, implementing plans, and evaluating.

Keywords: Intelligence quotient; Mathematical problem solving; Superior

INTRODUCTION

Problem solving plays a very important role in everyday life as well as in learning, especially in learning mathematics (G Polya, 1945; Schoenfeld, 2016). The National Council of Teachers of Mathematics (NCTM, 2000) states that there are five important components that must be possessed by students, namely reasoning, problem solving, communication, representation and connection. Therefore, problem solving is very important in order to improve students' ability in learning mathematics.

The definition of problem solving is defined by many experts. Which is generally stated by Polya (1985). Problem solving is a systematic series using a certain process to solve a problem (G Polya, 1945; Schoenfeld, 2017; Shirali, 2014). Problem solving is part of a complex thinking process with methods such as understanding problems, planning, implementing and evaluating (Kuzle, 2017; G. Polya, 1957; G Polya, 1945). Therefore problem solving is very important for students' cognitive development.

Problem solving is a systematic process (Delahunty et al., 2020; Schoenfeld, 2016; Sternberg, 2013). The most famous problem solver is according to Polya.

ISSN : 2579-5724
ISSN : 2579-5260 (Online)
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Problem solving steps according to Polya are understanding the problem, planning a strategy, developing a strategy and evaluating. So that the resulting mathematical problems will get the maximum solution (G. Polya, 1957; 1945; 1985).

Trends in International Mathematics and Science Study (TIMSS) and the International Student Assessment Program (PISA) state that the reasoning and problem-solving abilities of students in Indonesia are low (PISA, 2012; Trends In International Mathematics and Science Study, 2011). This is shown by the TIMSS (2011) report where Indonesia with an average score of 386 is ranked 38th out of 42 countries . While PISA (2012) with an average score of 372, Indonesia is ranked 64th out of 65 countries that follow it. So that when students do problem solving, intelligence is needed, especially intelligence.

Intelligence is one that affects the problem solving performed by a person, this was stated by Liu, et al (2017) where mathematical problem solving is one of the components measured in the measurement of IQ. IQ is a general ability that includes various types of mental skills such as abstract thinking, mathematics, remembering, understanding, language, and so on to make adjustments to a situation or problem. Classification of intelligence (IQ) as follows (D Wechsler, 1999; David. Wechsler, 1940; David Wechsler & Wechsler, 2007): (1) >130 very superior category, (2)120-130 superior category, (3)110-119 bright normal category, (4) 90-109 average category, (5) 80-89 normal dull category, (6) 70-79 borderline category, (7) <70 mental defective category. The category of intelligence that will be used in this research is superior.

Related to the importance of solving mathematical problems of students with superior IQ. Among them are Liu, et al (2017), Alifani, et al (2018), Liljedahl, et al (2016), Nite (2017) generally these studies discuss solving mathematical problems in students. However, this study has not discussed the mathematical problem solving of students with superior IQ.

RESEARCH METHOD

The purpose of this study is to describe the mathematical problem solving of students in the superior intelligence quotient (IQ) category. The criteria for the subjects chosen in this study were students who had a superior IQ from the study of documentation and had already received material on sequences, functions and geometry. If the subject has met these two criteria, then a test question related to problem solving is given along with think aloud and interviewed with a semi-structured interview type.

Data collection techniques by means of documentation studies on IQ, problem solving test questions accompanied by think aloud and semi-structured interviews. The instrument used in this study was adopted from Elly Susanti (2015) because the instrument is very suitable for measuring mathematical problem solving includes understanding the problem, planning a strategy, developing a strategy and evaluating. Before being given to the research subject, the instrument was tested for validity with the validation of experts. The data analysis technique is based on Polya's theory of mathematical problem solving reasoning. The validity of the data in this study is by triangulation technique in which the technique used is test questions related to solving mathematical problems accompanied by think

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aloud and semi-structured interviews. Triangulation techniques in this study compare data on work results, think aloud and semi-structured interviews for each subject so as to obtain the same tendency to solve mathematical problems in subjects with superior IQ categories. From this tendency, valid conclusions are obtained about solving mathematical problems of students with superior IQ categories.

RESULTS AND DISCUSSION

First, the research was conducted with a documentary study of IQ. Students with superior IQs who have taken IQ tests for the past three years. The superior subject coding is as follows:

Table 1. Superior Subject Coding

Unit	IQ of the subject	Code
Subject 1 Superior	123	S1
Subject 2 Superior	124	S2

Based on table 1, taking the subject is based on the IQ of 120 to 129. The data related to the ability of subjects with superior IQ is presented in table 2 as follows:

Tabel 2. Superior Subject IQ Ability

Subject	The ability of the subject	IQ category
S1	1) Medium verbal ability 2) Hight numerical ability 3) Hight spatial relation ability 4) Hight speed and accuracy 5) Hight abstract thinking ability 6) Hight social science ability 7) Hight mechanical ability	Superior
S2	1) Hight verbal ability 2) Hight numerical ability 3) Medium spatial relation ability 4) Medium speed and accuracy 5) Hight abstract thinking ability 6) Hight social science ability 7) Hight mechanical ability	Superior

The following is a description of the data exposure, research findings and discusision of each subject:

Problem Solving S1

S1 in working on the problem at the stage of understanding the problem can mention the definition of the level 2 stupa and can mention the definition of the unit cube from the outside it looks 5 sides, 3 sides, 2 sides, and can mention how many unit cubes are in the level 2 stupa according to what is known in the problem. The following is picture 1 of the 2nd level stupa carried out by S1:

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ISSN : 2579-5260 (Online)
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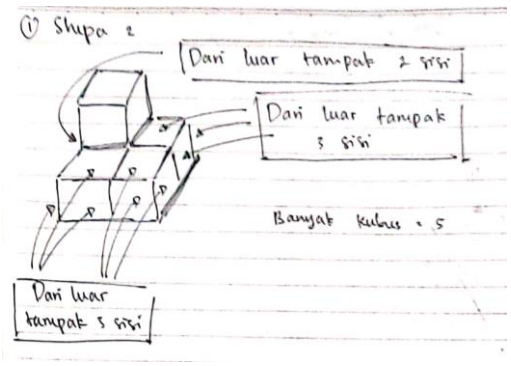

Picture 1. 2nd Level Stupa

From picture 1, it can be seen that S1 wrote down many cubes on the level 2 stupa as many as 5. It shows that the cube from the outside looks 3 sides and two sides. This is also supported by the following think aloud recordings:
"At the 2nd level stupa there are "1,2,3,4,5" there are 5 sides, with the unit cube from the outside it looks 3 sides as many as "1,2,3" totaling 3 and from the outside it looks 2 sides totaling 1. From the outside 1 side appears and 0 sides total 0 or none".

This shows that S1 understands the information provided. Furthermore, from picture 1 and S1 write them in a table like picture 2 as follows:

Stupa	Banyak kubus	Dari luar tampak 3 sisi	Dari luar 2 sisi	Dari luar 1 sisi	Dari luar 0 sisi
Stupa 2	5	3	1	0	0
Stupa 3	14	6	9	2	1

Picture 2. Table of Stupa Level 2 and 3

From the stage of understanding the problem, S1 uses the superior IQ ability of spatial relations where this ability visualizes 2-dimensional to 3-dimensional shapes contained in the problem. Subjects with this superior IQ also have numerical abilities where numerical abilities here are subject to counting the number of stupas with different characteristics. This is in line with the research conducted by Liu, et al (2017) that at the stage of understanding the problem students use the abilities possessed by superior IQ.

Next, S1 plans a strategy by writing stupas level 4 to level 10 stupas on the number of cubes as a whole and the number of cubes from the outside looks 3 sides, 2 sides, 1 side and 0 sides. Picture 3 depicts a table of level 4 stupas to level 10 stupas as follows:

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ISSN : 2579-5260 (Online)
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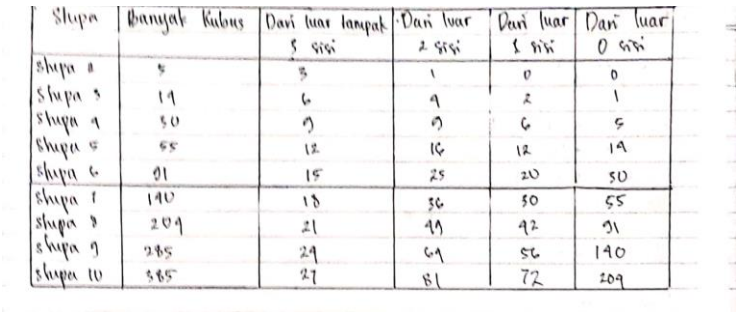


Stupa	Banyak kubus	Dari luar tampak 3 sisi	Dari luar 2 sisi	Dari luar 1 sisi	Dari luar 0 sisi
Stupa 1	1	1	0	0	0
Stupa 2	14	6	4	2	1
Stupa 3	30	9	9	6	5
Stupa 4	55	12	16	12	14
Stupa 5	91	15	25	20	30
Stupa 6	140	18	36	30	55
Stupa 7	204	21	49	42	91
Stupa 8	285	24	64	56	140
Stupa 9	385	27	81	72	204

Picture 3. Table Stupa Level 2 to Level 10

Picture 3 describes the process of solving mathematical problems at the stage of implementing the inner plan by calculating using images to visualize the image. Clarified by semi-structured interviews with S1:

Reseacher : *"How do you calculate the number of unit cubes as a whole and the number of cubes from the outside looks 3 sides, 2 sides, 1 side and 0 sides on the stupa each level?"*

S1 : *"By counting the cubes from the second level stupa first and then to the 3rd level each level and then I add them to form a row".*

From the description above, S1 performs the stages of solving mathematical problems in planning strategies using spatial relations abilities and numerical abilities. This is in line with Alifani, et al (2018) research that in carrying out her undergraduate plan she uses her abilities.

S1 in carrying out the plan to arrange rows, determine differences, substitute into the formula for the total number of cubes as a whole, the number of cubes from the outside looks 3 sides, 2 sides, 1 side and 0 sides. This is also clarified by semi-structured interviews as follows:

Reseacher : *"How do you find the total number of cubes, the number of cubes from the outside looks 3 sides, 2 sides, 1 side and 0 sides on the k level stupa?"*

S1 : *"By writing down the sequence formed from the table and determining whether the sequence is arithmetic or multilevel after that I use a formula to solve it".*

The data shows that S1 implements the plan by using numerical abilities and abstract thinking. This is supported by Liu, et al (2017) statement that in carrying out the plan, superior IQ subjects use their abilities.S1 at the stage of the evaluation problem solving process can state the stupa k formula for the overall number of cubes, the number of cubes from the outside looks 3 sides, 2 sides, 1 side, and 0 sides. This is clarified by the semi-structured interview S1 on the number of cubes, the total number of cubes from the outside looks 3 sides, 2 sides, 1 side, and 0 sides of the k-level stupa as follows:

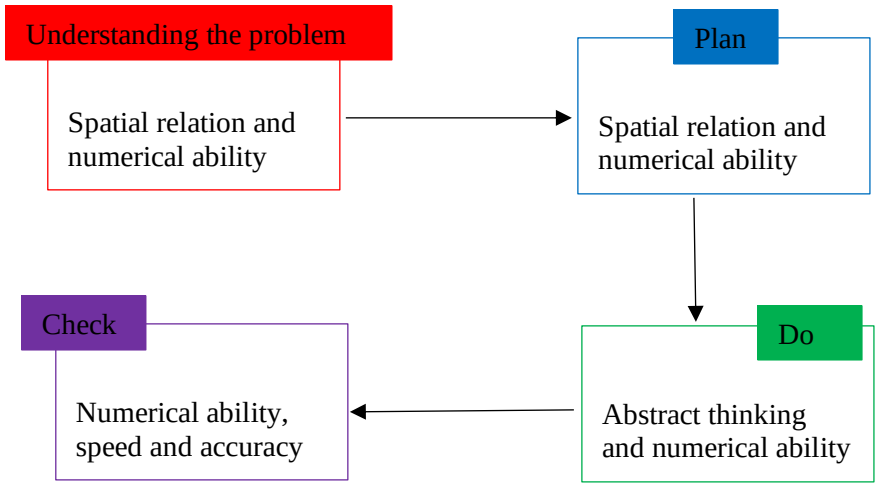
Reseacher : *"Are you able to determine the final formula and how to determine the final formula for the number of cubes. The total number of cubes from the outside looks 3 sides, 2 sides, 1 side, and 0 sides of the k level stupa?"*

S1 : *"Yes, I can determine the formula, by substituting what is known and processing it, I know the formula for the number of cubes. Overall, the*

ISSN : 2579-5724
ISSN : 2579-5260 (Online)
http://ejournal.umm.ac.id/index.php/MEJ

number of cubes from the outside looks like 3 sides, 2 sides, 1 side, and 0 sides on the k level stupa".

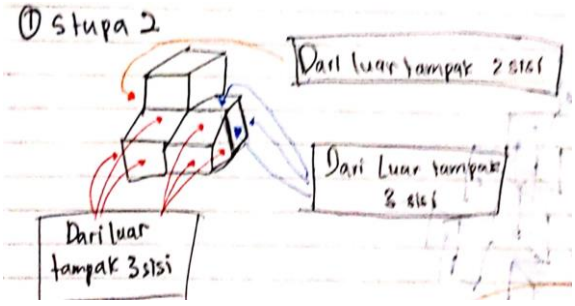
Based on these data, students with superior IQ can evaluate their work. The abilities used in the evaluation are numerical ability, speed and accuracy. This is supported by research conducted by Liu, et al (2017) which in carrying out the stages of problem solving evaluation uses its capabilities. The stages of solving the S1 problem can be seen in picture below:



Picture 4. Problem Solving S1

Problem Solving S2

S2 at the problem-solving stage understands the problem mentions the definition of the level 2 stupa and can mention the definition of the unit cube from the outside it looks 5 sides, 3 sides, 2 sides, 1 side and 0 sides and can mention how many unit cubes are in the level 2 stupa. about the 2nd level stupa that S2 did:



Picture 5.Stupa Level 2

From Picture 5 it can be seen that S2 writes that the cube from the outside looks 3 sides and two sides. This is also supported by the following think aloud recordings:
"At the 2nd level stupa there are "1,2,3,4,5" there are 5 unit cubes, with the unit cube from the outside looking 3 sides and 3 sides from the outside looking 2 sides".

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ISSN : 2579-5260 (Online)
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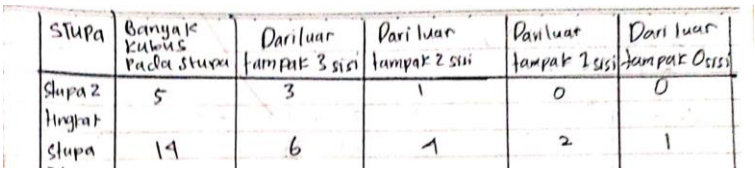
The think aloud shows that masters can understand the cubes that make up the level 2 stupa. This is also reinforced by semi-structured interviews as follows:

Reseacher : "Do you understand the information contained in the picture?"
S2 : "I understand the number of cubes in the 2nd level stupa and the number of cubes from the outside looks 3 sides, 2 sides, 1 side and 0 sides".

Next, S2 writes a table relating to level 2 and level 3 stupas as shown in Figure 6 as follows:

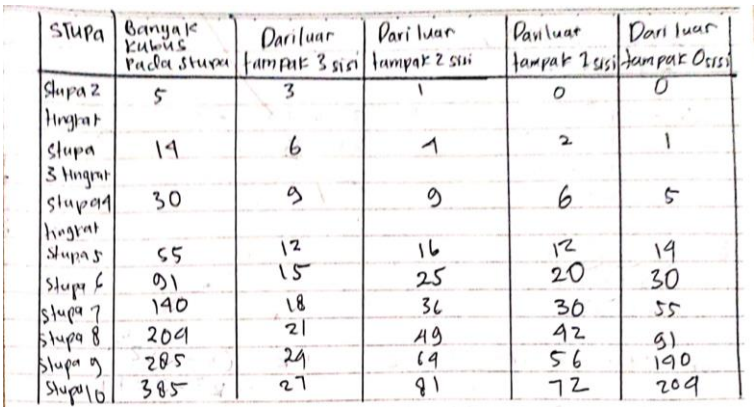


Stupa	Banyak Kubus Pada Stupa	Dari luar tampak 3 sisi	Dari luar tampak 2 sisi	Dari luar tampak 1 sisi	Dari luar tampak 0 sisi
Stupa 2	5	3	1	0	0
Tingkat					
Stupa	14	6	1	2	1

Picture 6. Table Stupa Level 2 and 3

Based on this, S2 can go through the stage of understanding the problem. The ability used is the ability of spatial and numerical relations. This is in line with Alifani, et al (2018) opinion which in understanding the problem requires the ability of spatial and numerical relations for superior students.

Furthermore, S2 also carried out the stage of planning a strategy to conclude a level 4 stupa to a level 10 stupa on the total number of cubes and the number of cubes from the outside it looked 3 sides, 2 sides, 1 side and 0 sides. The following is a picture of 7 tables of stupas level 4 to level 10:



Stupa	Banyak Kubus Pada Stupa	Dari luar tampak 3 sisi	Dari luar tampak 2 sisi	Dari luar tampak 1 sisi	Dari luar tampak 0 sisi
Stupa 2	5	3	1	0	0
Tingkat					
Stupa	14	6	1	2	1
3 tingkat					
Stupa 4	30	9	9	6	5
tingkat					
Stupa 5	55	12	16	12	14
Stupa 6	91	15	25	20	30
Stupa 7	140	18	36	30	55
Stupa 8	204	21	49	42	91
Stupa 9	285	24	64	56	140
Stupa 10	385	27	81	72	204

Picture 7. Table Stupa Level 4 to Level 10

It is then reinforced in a semi-structured S2 interview. The following is a semi-structured interview for Masters:

Reseacher : "How do you calculate the number of unit cubes as a whole and the number of cubes from the outside looks 3 sides, 2 sides, 1 side and 0 sides in the stupa of each level?"
S2 : "Observing the picture first, then I count on the picture how many stupas there are".

Based on the data above, S2 has a superior IQ at the strategy planning stage. The ability used in this stage is the ability of spatial and numerical relations. This

ISSN : 2579-5724
ISSN : 2579-5260 (Online)
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is in line with the research conducted by Alifani, et al (2018) in the stage of planning strategies for students who have a superior IQ using spatial and numerical relations skills.

S2 in carrying out the plan to arrange a line for the number of cubes on the k level stupa. This is also clarified by semi-structured interviews as follows:

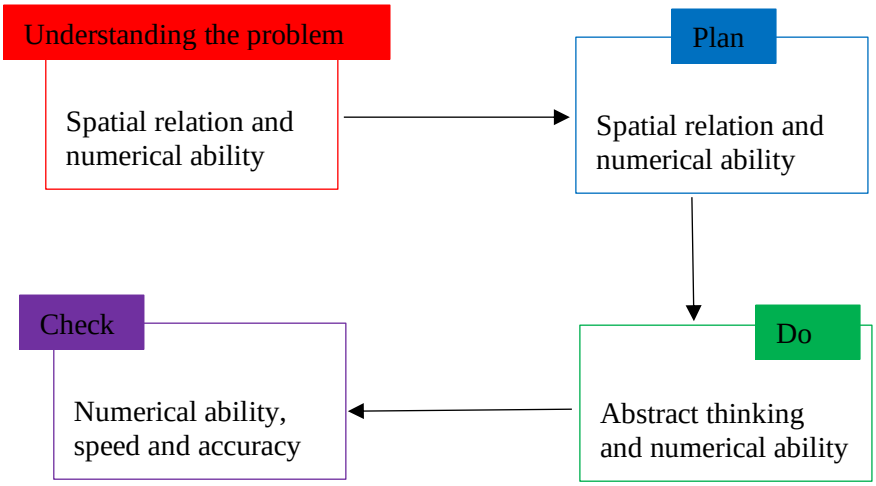
Reseacher : "How do you find the number of cubes in a k-level stupa?"
S2 : "By arranging the rows formed from the table of the number of stupas, then using a formula to solve them".

Based on the data above, masters who have a superior IQ can go through the stages of implementing the plan. The skills used are numerical abilities and abstract thinking skills. This is in line with the research conducted by Liu, et al (2017) that students with superior categories in carrying out plans use their abilities

S2 at the evaluation stage of the mathematical problem solving process can state the stupa k formula for the overall number of cubes. This is supported by semi-structured S2 interviews as follows:

Reseacher : "Are you able to determine the final formula and how do you determine the final formula for the total number of cubes in the k-level stupa?"
S2 : "Yes, I can determine the formula, the method is almost the same as before, after substituting what is known and processing it, I know the formula for the number of cubes from the outside, it looks like 2 sides on the k level stupa".

Based on these data, students with superior IQ can evaluate their work. The abilities used in the evaluation are numerical ability, speed and accuracy. This is supported by research conducted by Liu, et al (2017) which in carrying out the stages of problem solving evaluation uses its capabilities. The stages of solving the S2 problem can be seen in picture below:



Picture 8. Problem Solving S2

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ISSN : 2579-5260 (Online)
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CONCLUSION

The conclusion in this study is that the superior category students in the problem solving process pass through all stages of problem solving, namely understanding the problem there are abilities used in spatial and numerical relations, planning strategies there are abilities used, namely numerical and spatial relations, carrying out plans there are abstract thinking and the last stage of evaluation is numerical ability, speed and accuracy. Suggestions in this study are for future researchers to be able to reveal more about solving mathematical problems that are influenced by students' IQ.

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