Hass's Theory: How Is the Students' Spatial Intelligence in Solving Problems?

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ABSTRACT

Spatial intelligence is one of the eight crucial human bits of intelligence possessed by students in learning. Spatial intelligence can be defined as the ability to understand the visual-spatial world accurately and make changes to that perception. Based on Hass's theory, there are four spatial intelligence characteristics: imagination, concept, problem-solving, and pattern-seeking. This study aimed to describe how the students' spatial intelligence in solving geometrical problems. This research used qualitative research with instruments used are test instruments and interview guidelines that three validators have previously validated. The analysis process took place in three stages: reduction, presentation, and conclusion. This study showed errors on each characteristic of spatial intelligence. In the imagining, students had difficulty imagining the capacity of the building without the help of pictures. On characteristic of using the concept of students experiencing errors using the concept of triangles and building flat side spaces. On problem-solving characteristics, students had not been able to translate information and develop existing concepts to solve the geometry problems. On characteristics of pattern seeking, students had difficulty imagining the pattern presented. Future research will expect to focus on the causes of the low spatial ability or research to improve students' spatial intelligence.

Keywords: *Hass's theory, Problem-solving, Spatial intelligence.*

1. INTRODUCTION

The process of learning mathematics that is currently taking place is more complex and modern in line with the times. Learning carried out at various levels of education requires students to master various aspects of the material, including geometry. One of the standards given to geometry in schools is to use visualization, have spatial abilities, and geometric modeling in solving problems related to spatial structures [1]. Here are eight types of human intelligence (Multiple Intelligence), that one of them is spatial intelligence [2]. Spatial intelligence is the ability to perceive the visual-spatial world accurately. (For example, as a hunter, scout, or guide) and make changes to that perception (for example, as an interior decorator, architect, artist, or inventor). This intelligence involves sensitivity to lines, shapes, spaces, and relationships between these elements [3]. Students with high spatial abilities are significantly better able in their mathematics [4]. Spatial ability is said to be the main factor of a person's intelligence and is crucial in learning such as mathematics and science and is also needed in various professions [5]. Based on the context of mathematics, especially geometry, it can be concluded that spatial intelligence is essential for students.

There are several characteristics of visual-spatial intelligence: Imagination, conceptualization, problem-solving, and Problem-Seeking. First, Imagination is the tendency of students to see rather than listen and learn concepts based on what they see. The second is conceptualization, namely holistic students who hold concepts better than individual realities. Students build a conceptual framework to show the relationship between a particular topic and the whole object. The third is Problem-Solving.

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Spatial students are discrete thinkers who prefer unconventional solution paths and multiple strategies

for problem-solving. They enjoy playing with problems and sometimes come up with five or more strategies for problem-solving. This process is more interesting than the answers that students in general usually do. The last is Problem-Seeking, where students with high spatial abilities excel in finding patterns in numbers and are also able to find patterns sequentially and relate them to mathematical principles [6].

Spatial intelligence can be known by using a written test using questions that have been prepared according to the intelligence indicator. To measure students' spatial intelligence, it takes a question that can measure whether students can imagine an object constructed from an image in a particular pattern. The question can be in the form of a structural visualization test that has often been used.

Several studies that have been conducted related to students' spatial intelligence include: Profile of students' spatial ability in terms of personality type Florence Littauer [7]; Spatial visual intelligence and mathematical logic in solving geometry problems students of Class VIII A Junior High School 10 Jember (Visual Spatial and Logical Mathematical Intelligence in Solving Geometry Problems Class VIII A Junior High School 10 Jember) [8]. Description of Students' Visual Spatial Intelligence in Solving Problems of Constructing Flat Sided Spaces Based on the Initial Ability Level of Geometry in Class VII Junior High School Students [9]. This shows that spatial intelligence is an important part in the mathematics learning process, especially in solving geometry problems. Based on several references that have been described, there is a gap that needs to be investigated, namely how students' spatial intelligence is in the problem-solving process.

This research needs to be done as a finding related to students' spatial abilities in solving mathematical problems. The results of this study can be used as theoretical guidelines for further research, such as research related to efforts to overcome the low spatial ability of students, or the advantages of students who have high spatial abilities can be used as new indicators for the achievement of students who have low spatial abilities. If this research is not carried out, the spatial ability will stagnate. Therefore, this research needs to be carried out.

This study aims to describe students' spatial intelligence in solving problems. It is essential to know the description of spatial intelligence so that educators adjust the ongoing learning process. Hence, students can solve various geometric problems in everyday life. This is under research which suggests that every student should develop his spatial sensing and abilities, which are very useful in understanding relations and properties in geometry to solve mathematical problems and problems in life [10].

2. METHODOLOGY

2.1. Research Design

This research used a qualitative descriptive study, which describes students' spatial intelligence in problem-solving. Qualitative methodology is a research procedure that produces descriptive data in written or spoken words from people and observed behavior [11]. Qualitative research describes the data without any manipulation [12].

2.2. Participants

The subjects in this study were students of SMA N 5 Tebo Regency. The technique used in the selection of subjects is purposive Sampling. Purposive Sampling is a sampling technique of data sources with specific considerations [13]. The subject was chosen based on consideration; the subject was a class XI student who had obtained the geometry of flat-sided geometry and had good communication skills. In this article, the researcher describes working on five subjects who can represent other subjects.

2.3. Research Instruments

The instruments used in this study were tests and interview guidelines. According to Hass's theory, the test used is a description test with flat-sided geometry with indicators of spatial intelligence. The instrument used was validated by the validator, namely two expert lecturers in mathematics and one mathematics teacher who was an education expert.

Validator 1 is a lecturer in the Mathematics Education Study Program, Siliwangi University, Tasikmalaya. The validation process took place twice. In the first validation, the instrument was still not said to be valid, and some suggestions were given to improve the use of words so that students could understand the meaning of the questions and add questions to the imagining spatial intelligence indicators to be more specific. The validation process of the two instruments has been said to be valid. Validator 2 is one of the lecturers from the Mathematics Education Study Program, University of Muhammadiyah Surakarta. Validator 3 is a

Mathematics Teacher at SMA N 5 Tebo who provides suggestions for using more effective words and clarifying the order of the questions. Instrument validation continues until the questions are declared valid and can be used. Revisions are carried out according to the validator's direction so that students can understand the intent of each question given.

2.4. Data Collection Technique

Data collection techniques in this study consisted of spatial ability tests and semi-structured interviews [13]. The test is a tool or procedure to collect information and measure student success [14]. In this study, the researcher used the test method to explore students' conceptual understanding of data. The interview is a technique or procedure to obtain answers based on one-sided questions and answers with respondents [14].

After the test took place, interviews were conducted with selected subjects who could represent all subjects to dig deeper into information about the subject's spatial intelligence in solving geometric problems. The mathematical problems used to obtain spatial intelligence data based on Hass theory are presented in Figure 1.

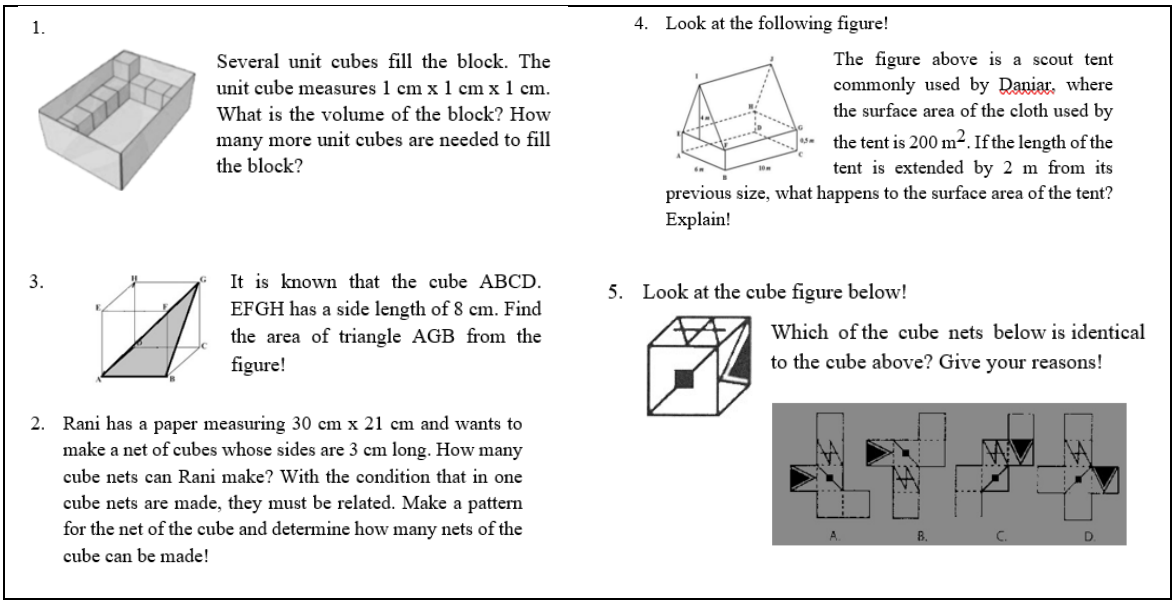

Figure 1 Mathematical problems

2.5. Data Analysis

The data analysis used in this study is data reduction, data presentation, and conclusion drawing [13]. Data reduction is made to summarize the data obtained, choose the main things, and focus on the essential things. The data that has been reduced is then presented in the form of a description of the students' spatial intelligence in solving the problems given. The last stage is drawing conclusions based on data and information obtained by researchers.

The conclusion is a procedure at the end of the research that answers the problem formulation based on the reduced research data. The triangulation carried out in this study is technical triangulation, which obtains data from the same source with different techniques [13], namely comparing the data obtained through the test method and the interview method [15].

3. FINDINGS

The study was conducted at SMA Negeri 5 Tebo Regency in Class XI IPA and was attended by 30 students as research subjects. After the research was conducted, the researcher analyzed the answers, and five students were selected who represented other subjects on each characteristic of visual-spatial intelligence. Furthermore, from the five selected subjects, an in-depth interview will be held to find out the subject's problems in solving geometry problems.

Researchers conducted interviews based on interview guidelines that had been validated previously. The following is a presentation of research results in the form of visual-spatial intelligence test results and interviews with research subjects based on visual-spatial intelligence levels:

3.1 Analysis of the First Subject (S1)

Based on the results of S1 work on question number 1 with the characteristics of the imagination indicator shows the wrong answer. In question number one, students are asked to calculate the number of cubes needed to fill the volume of the block based on the figures provided. S1 firstly answers by finding the volume of the cube. Then, finding the volume of the cube. Here (Figure 2) are the results of S1's answer.

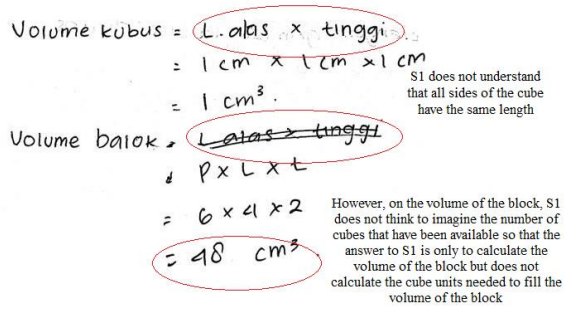

Figure 2 S1 answer sheet.

When interviewed, S1 admitted that he was still confused between cubes and blocks and did not think about finding the unit cube needed to fulfil the volume of the block. When asked, S1 tends to have difficulty visualizing the number of cubes needed in the block room.

R : *Do you understand the meaning of the question? What does it mean?*
S1 : *Understand. Yes, it is asked to find the volume of blocks and cubes.*
R : *How do you solve this problem?*
S1 : *I calculated the volume from the known Length.*
R : *Did you not count the number of unit cubes in the block?*
S1 : *No. I think only the volume is being asked*
R : *Now, show me which are the cubes and blocs?*
S1 : *This is a cube isn't it and this is a block? Uh. backwards? (Doubtful)*

3.2 Analysis of the Second Subject (S2)

Based on the results of the S2 work on question number two (Figure 3) with an imagination indicator character. S2 has not been able to answer the questions correctly. In question number two, students are asked to describe the nets of a cube and estimate the number of cubes made with a square sheet of paper whose size has been determined. Here are the results of S2's answer:

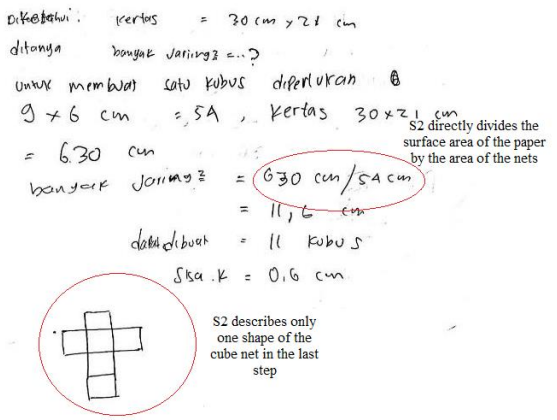

Figure 3 S2 answer sheet

On the answer sheet S2, the first step used is to find the surface area of the cube and find the amount of paper that will be made of nets—followed by dividing the area of the paper by the surface area of the cube used. S2 does not describe how the cube nets first. When asked in the interview, Master said that the cube nets' shape was only one shape like nets in general and did not think about other shapes.

R : *Are there other cube nets you can think of? Why did you only describe one?*
S2 : *Hmmm, not anymore. this is only because what is asked for the nets must be related.*
R : *Can you imagine other forms of nets? Is there anything else?*
S2 : *Oh yes, I didn't think of drawing anything else while I was working on it, like only this image that often appears.*

3.3 Analysis of the Third Subject (S3)

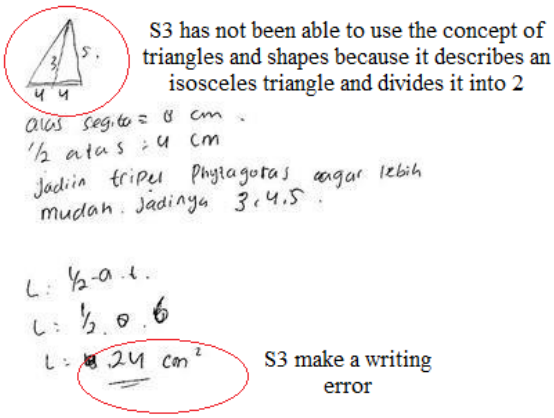

Figure 4 S3 answer sheet

Based on the results of the S3 work on question number 3 (Figure 4), which is a question with the characteristics of the indicators of the use of the

concept. S3 has not been able to answer the questions correctly. In question number 3, students are asked to express the known figure and answer the problem based on the given conditions.

The results of the answer, S3, assume that the triangle formed when divided by two shows the sides of a Pythagorean triple right triangle where it is known that the base of the triangle is 8 x ½ = 4 cm. So, the hypotenuse of the triangle is 5 cm, and the height is 3 cm. When asked at the interview session, S3 stated it was due to a typing error and did not understand the concept of space and the difficulty imagining diagonal long diagonal and diagonal field in the wake of the space.

R : *What triangle is formed from the diagonals of the cube?*
S3 : *isosceles triangle*
R : *Do you still remember the concept of a triangle that you have learned previously?*
S3 : *Hehe, I don't really understand, what I remember is the Pythagorean triple numbers.*
R : *Do you remember how to find the length of a side of a triangle if the other 2 sides are known?*
S3 : *Remember. which is* $a^2 = b^2 + c^2$ *right?*
R : *Why don't you use that?*
S3 : *I think it's an isosceles triangle*

3.4 Analysis of the Fourth Subject (S4)

Question number 4 is a question with the characteristics of problem-solving indicators, where students are asked to solve the problem of the area of the wake if the length of one of the available lengths is extended. Here are the results of S4's answer (Figure 5).

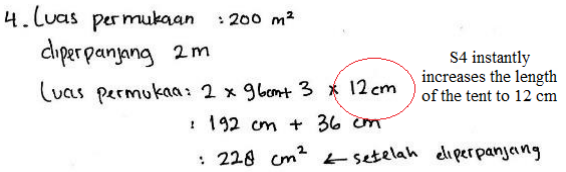

Figure 5 S4 answer sheet

In the results of the S4 answer, the subject tends to forget the formula for finding the surface area of the prism. So, the length of the block is added up to 12 cm without recalculating the surface area of the prism. S4 only remembers the prism area formula but is unable to solve the new problems presented because he does not understand the concept of building a flat side space.

R : *What is the problem with this question?*
S4 : *I was asked to find the area, but the length was added by 2 cm.*
R : *How do you solve this problem?*
S4 : *The length is added by 2 cm and then the area is found based on the known length.*
R : *What is the shape in the picture?*
S4 : *Prism and beam, but I forgot the formula for the area of a prism. So, I added it manually.*

3.5 Analysis of the Fifth Subject (S5)

Question number 5 is a question with the characteristics of a pattern search indicator. Students are asked to find a pattern of nets that are identical to the known cube. Based on the answer S5, the nets identical to the cube are the nets in choice D. Subjects were asked to provide reasons for the selection but did not give a clear answer in writing. When asked, the subject admitted that he chose the D nets because the most suitable pattern formed was the D nets. Here are the results of S5's answer (Figure 6).

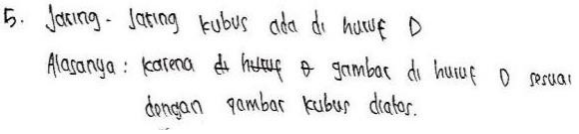

Figure 6 S5 answer sheet

Based on the answer S5, the nets identical to the cube are the nets in choice D. Subjects were asked to provide reasons for the selection but did not give a clear answer in writing. When asked, the subject admitted that he chose the D nets because the most suitable pattern formed was the D nets.

R : *Can you imagine the pattern that best fits the picture of the problem?*
S4 : *In my opinion, D is the most appropriate because when viewed from the liner side, this is the most appropriate.*

4. DISCUSSION

Based on the results of work and interviews on selected subjects, there are still many geometric problems that students cannot solve correctly at each level.

At the level of Imagination, students can solve the given space geometry problems with the help of the images provided but still have difficulty imagining the capacity of the space. Without the help of images,

students have difficulty imagining various patterns of nets that might form a cube. When the students describe a shape, they imagine the shape of a shape which is then poured into a figure. At the level of Conceptualization, students still do not understand the concept of triangles and flat-sided shapes studied previously, and students are also not careful in calculating numbers. To solve problems, problem solvers must master the things that have been previously learned and use them in new situations. Subjects can recall the concept of Pythagoras to solve problems by connecting the information obtained, experience, and knowledge that has been studied previously [16]. At the level of Problem-Solving, students have not been able to translate information and develop existing concepts to solve newly encountered geometric problems. At the stage of compiling a problem-solving plan (make a plan), the subject looks for the relationship between the information provided and the unknown [17]. At the Problem-Seeking level, students have difficulty imagining the patterns presented. Students with visual-spatial abilities not only excel in finding patterns in numbers but are also able to find patterns sequentially and relate them to mathematical principles [18].

The difficulty in solving the geometry problems may occur because the learning process that has taken place so far only focuses on the material without involving direct sensing. Students are usually only given figures and formulas directly and then work on the questions without understanding the concept and imagining how to get the formula. Though understanding the concept is more important than just memorizing formulas. If the concept's understanding is correct and enters long-term memory in the brain, the concept is still remembered and known to students even though the lesson has long passed [18] .

Spatial intelligence is crucial for students to support the material at the next level. Students with visual-spatial intelligence not only excel in finding patterns in numbers but are also able to find patterns in the sequence and relate them to mathematical principles [4]. In addition, it also requires good spatial skills to be able to learn and solve engineering problems [19]. Spatial abilities play an important role in everyday interactions with the environment, such as navigation, recognizing and manipulating objects, academic tasks, and finding places [14].

5. CONCLUSION

In conclusion, it showed that students still have difficulty in employing Hass theory for problem-solving. On the characteristics of the imagining indicator, students had difficulty imagining the capacity of the space, and without the help of figures, students had difficulty imagining various patterns of nets that might form a cube. On the characteristics of the indicators of the use of concepts, students still did not understand the concept of triangles and flat-sided shapes studied previously, and students are not careful in calculating numbers. In the indicator of problem-solving, students had not been able to translate information and develop existing concepts to solve geometric problems that had just been encountered. On the characteristics of the level indicator, students had difficulty imagining the pattern presented. Based on the findings, the researcher suggests for further researchers to focus on the causes of students' low spatial ability in solving mathematical problems, or the efforts to improve students' spatial intelligence either through learning media that can make it easier for students to imagine spatial shapes that given or through other media.

REFERENCES

[1] National Council of Teacher of Mathematics (NCTM), “No Title,” Princ. Stand. Sch. Math., p. 232, 2000.

[2] S. Syarifah, “Konsep Kecerdasan Majemuk Howard Gardner,” Sustain. J. Kaji. Mutu Pendidik., vol. 2, no. 2, pp. 176–197, 2019, doi: 10.32923/kjmp.v2i2.987.

[3] T. Amstrong, 7 Kinds of Smart: Menemukan dan Meningkatkan Kecerdasan Anda Berdasarkan Teori Multiple Intelligences, Informatik. Jakarta: Gramedia Pustaka Utama, 2002.

[4] E. Syahputra, “Peningkatan Kemampuan Spasial Siswa Melalui Penerapan Pembelajaran Matematika Realistik,” J. Cakrawala Pendidik., vol. 3, no. 3, pp. 353–364, 2013, doi: 10.21831/cp.v3i3.1624.

[5] H.-D. BARKE and T. ENGIDA, “Structural Chemistry and Spatial Ability in Different Cultures,” Chem. Educ. Res. Pr., vol. 2, no. 3, pp. 227–239, 2001, doi: 10.1039/b1rp90025k.

[6] S. C. Haas, “Upside-Down Brilliance: The Visual-Spatial Learner.,” 1989.

[7] I. N. Hibatullah, Susanto, and L. A. Monalisa, “Profil Kemampuan Spasial Siswa Ditinjau Dari Tipe Kepribadian Florence Littauer,” FIBONACCI J. Pendidik. Mat. dan Mat., vol. 6, no. 2, pp. 115–124, 2019, [Online]. Available: jurnal.umj.ac.id/index.php/fbc.

[8] V. D. Librianti, "Kecerdasan Visual Spasial dan Logis Matematis dalam Menyelesaikan Masalah Geometri Siswa Kelas VIII A SMP Negeri 10 Jember (Visual Spatial and Logical Mathematical Intelligence in Solving Geometry Problems Class VIII A SMP Negeri 10 Jember)," Artik. Ilm. Mhs., vol. 1, no. 1, pp. 1–7, 2015.

[9] A. Syafiqah, "Deskripsi Kecerdasan Visual Spasial Siswa dalam Memecahkan Masalah Bangun Ruang Sisi Datar Ditinjau Berdasarkan Tingkat Kemampuan Awal Geometri pada Siswa Kelas VII SMP," Issues Math. Educ., vol. 4, no. 1, pp. 68–82, 2020.

[10] E. Yanty Putri Nasution, "Meningkatkan Kemampuan Spasial Siswa Melalui Pembelajaran Geometri Berbantuan Cabri 3D," M A T H L I N E J. Mat. dan Pendidik. Mat., vol. 2, no. 2, pp. 179–194, 2017, doi: 10.31943/mathline.v2i2.45.

[11] L. J. Moleong, Metodelogi Penelitian Kualitatif. Bandung: Remaja Rosdakarya, 2016.

[12] M. N. Kholid, C. Sa'dijah, E. Hidayanto, and H. Permadi, "How are students' reflective thinking for problem solving?," J. Educ. Gift. Young Sci., vol. 8, no. 3, pp. 1135–1146, 2020, doi: 10.17478/JEGYS.688210.

[13] Sugiyono, Metode Peneitian Kuantitatif, Kualitatif, dan R&D. Bandung: Alfabeta, 2017.

[14] S. Arikunto, Dasar-Dasar Evaluasi Pendidikan Edisi 3, 3rd ed. Jakarta: PT Bumi Aksara, 2021.

[15] M. N. Kholid, A. Imawati, A. Swastika, S. Maharani, and L. N. Pradana, "How are Students' Conceptual Understanding for Solving Mathematical Problem?," J. Phys. Conf. Ser., vol. 1776, no. 1, 2021, doi: 10.1088/1742-6596/1776/1/012018.

[16] L. Nofianti, T. Sugiarti, and Susanto, "Kecerdasan Visual-Spasial dan Logika Matematika dalam Menyelesaikan Soal Geometri Siswa Kelas XI IPA 8 SMA Negeri 2 Jember," Artik. Ilm. Mhs., vol. 1, no. 1, p. 17, 2015.

[17] N. Jafar and R. Lefrida, "Oleh Siswa SMP Ditinjau Dari Kecerdasan," no. 2013, 2014.

[18] C. Utami, "Kesalahan Siswa dalam Menyelesaikan Soal Kemampuan Spasial Matematis," Al-Khwarizmi J. Pendidik. Mat. dan Ilmu Pengetah. Alam, vol. 8, no. 2, pp. 123–132, 2020, doi: 10.24256/jpmipa.v8i2.1177.

[19] Shannon Research Press, "Volume 3 Number 1 March 2002," Int. Educ. J., vol. 3, no. 1, 2002.