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ANALYSIS OF STUDENT'S MATHEMATICS REPRESENTATION IN SOLVING MATHEMATICS PROBLEMS BASED ON SPATIAL COGNITIVE STYLE

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Abstract

Mathematical representation is important to be trained in learning so that students can express ideas in obtaining a solution to a problem. This study aims to describe the mathematical representation of students in solving math problems based on spatial cognitive style. This research is a descriptive research with a qualitative approach. The subjects of this study were three students of class XI MA Miftahul Qulub Pamekasan consisting of female students with hight mathematical abilities, but having different levels of spatial cognitive style, namely high, medium, and low. The instruments used in this study were spatial cognitive style test, math problem solving test, and interview guideline. The results of this study indicate that (1) Students with a high spatial cognitive style understand the problem by presenting the information on the questions with visual representations in the form of tables and mathematical expressions of mathematical inequalities; planning problem solving using representations of words; carry out problem solving plans using representations of mathematical expressions in calculations and visual representations in graphical form; re-check using representations of mathematical expressions, word representations, and visual representations. (2) Students with medium spatial cognitive style understand the problem by presenting the information on the questions with a visual representation in the form of tables and mathematical expressions of mathematical inequalities; planning problem solving using representations of words; carry out problem solving plans using representations of mathematical expressions in calculations and visual representations in graphical form; re-check using representations of mathematical expressions and verbal representations but have not been able to provide conclusions. (3) Students with low spatial cognitive style understand the problem by presenting some of the information on the problem with a visual representation in the form of tables and mathematical expressions of mathematical inequalities; planning problem solving using representations of words; carry out problem solving plans with representations of mathematical expressions; however, unable to re-check. Students with high and medium spatial cognitive styles can solve problem solving problems, but have different representational tendencies, while students with low spatial cognitive styles cannot solve problem solving problems. The results of this study can be a reference for teachers to pay attention to students' spatial cognitive styles in the learning process so that it is easier for students to understand the material and spatial cognitive style can be trained by giving questions or material in the form of pictures, because students with spatial cognitive styles acquire and process information with visual-spatial abilities.
Keywords: mathematical representation, mathematical problem solving, spatial cognitive style.

INTRODUCTION

One part of the curriculum that plays an important role in improving the ability to think systematically, critically, logically, and rationally in solving daily life problems or studying science for each individual is mathematics (Saputra, 2017). Studying mathematics is not only in terms of counting systematically, but learning to think systematically, critically, and being able to present mathematical problems in the form of representations (Sulianto & Mandarsary, 2012). Understanding of the material and content standards is a positive thing for the success of the learning carried out (Saputra, 2017).

The National Council of Mathematics states that students must have mathematical abilities, namely the ability to solve problems, reason and prove, communicate, connect, and represent (NCTM, 2000). The National Council of Mathematics also states representation models, namely graphics, physical objects, diagrams, images, and symbols (NCTM, 2000). One important component at all levels of education is mathematical representation because mathematical representation is something that always appears when someone is learning mathematics (Pramurti, 2015). So that in mathematics learning, the ability to present mathematical ideas is something that must be mastered by every student.

According to Cai, Lane, & Jacabcsin (1996 in Alisia, 2013), representation is a way that someone uses to communicate answers or solutions to something. In general psychology, representation is a process of converting concrete models in the real world into abstract models or symbols. The mathematical representation shown by a student is a student's way of expressing mathematical ideas that aim to understand a mathematical concept or to find a solution to a problem (NCTM, 2000). Based on some of the opinions above, it can be concluded that mathematical representation is a student's way of presenting mathematical ideas as a substitute for a problem that is used in finding solutions to the problems they are facing as a result of interpreting their thoughts.

There are two kinds of representations, namely internal representations and external representations. Internal representation is a person's mental activity in minds-on minds, so it is difficult to observe directly. However, the internal representation can be identified by the existence of an external representation through the disclosure of words, pictures, tables, graphics, symbols, or hands-on props (Mustangin, 2015). So that there is a reciprocal relationship between internal representations and external representations that influence each other in the process of finding a solution to a problem (Mustangin, 2015).

Manoy (2018) states that students use image representations, representations of mathematical expressions, and representations of written text in solving math problems. In this study, the researcher modified the form of mathematical representation from Manoy (2018) which is described in table 1.

Table 1. Mathemetics Representation

No	Representation	Operational Forms
1	Visual representation a.Diagram, table, or graph	1) Present data or information back into a diagram, graph, or table representation. 2) Using visual representations to solve problems
	b. Figure	1) Make a geometric patterns 2) Create images to clarify problems and facilitate resolution
2	Mathematical equations or expressions	1) Creating mathematical equations or models from other representations given. 2) Make a conjecture from a number pattern 3) Solving problems by involving mathematical expressions
	Verbal	1) Creating situations or problems based on data or representations given in words or written text. 2) Writing interpretation into words or written text 3) Writing down the steps for solving mathematical problems in the form of words or sentences that do not use mathematical symbols. 4) Arrange a story in accordance with a problem that is presented 5) Solve questions using explanations through words or written text

The mathematical representation is measured by the indicator achievement. According to Surya et al. (2013), representation indicators include the following aspects: (1) able to present problems in the form of mathematical equations (mathematical expressions) or mathematical models, (2) able to plan, implement strategies to solve problems, (3) be able to present problems in visual form (diagrams). , pictures, tables, and patterns), (4) Able to check answers to problem solutions, (5) Be able to systematically retell problems or be able to draw conclusions from answers that have been found, (6) Be able to explain problems obtained and solutions from the calculation results. The mathematical representation indicator in this study adopts the mathematical representation indicator from Surya et al. (2013).

Through mathematical representations, students can express mathematical ideas that are used to obtain solutions to mathematical problems they face as a result of interpreting their thoughts. Mathematical problems are mathematical questions whose final results cannot be obtained directly, because they cannot directly provide conclusions from known data (Xia, X., ChuanhanLu, & Wang, 2008). Problems are questions that require a solution and cannot be obtained directly (Husna, et al, 2013). Siswono (2018) argues that a problem is a condition found by someone who does not know the procedure for finding the answer. Based on some of the opinions above, it can be concluded that a mathematical problem is a mathematical problem that requires a solution but the way to obtain this solution is not immediately known.

A student must achieve one of the basic competencies in learning, namely solving math problems. Permendikbud Number 21 of 2016 suggests that learning mathematics focuses on the skills of a student in solving problems (Permendikbud, 2016). When students have math problems in classroom learning, they will try to understand these problems and solve them in a way that they know in accordance with previous knowledge. Problem solving is a method used by someone to get a solution to the problem at hand by using their previous knowledge, skills and understanding (Rasyid, 2017). Problem solving is an effort made by someone to find a solution to a problem and the results cannot be obtained directly (Lambertus., 2011). Problem solving is an individual effort to find a solution to a situation so as to achieve the expected goals (Herlambang, 2013). Based on these definitions, it can be concluded that mathematical problem solving is a method used by individuals to obtain solutions to mathematical problems obtained by using their knowledge, skills and understanding.

The mathematical problem solving stage is a step that can be used by students to get solutions to the math problems they get. Polya's problem solving stage is one of the stages in solving mathematical problems that can be used. There are 4 steps in problem solving, namely understanding the problem, planning problem solving, Carry out the plan, and re-check (Polya, 1973).

Research that has been conducted by Surya et al. (2013) stated that students had difficulty making graphs correctly, drawing diagrams, writing mathematical solutions and making problem solving strategies. Linear program material is often found in everyday life, one example is in determining the maximum profit in a company, determining the minimum amount of costs to be used, production limits with materials owned, the capacity of goods that can be loaded with existing constraints, and so on. One of the difficulties in linear programming problems is to graph the set of solutions for the linear inequality system from known constraints (Ariawan, 2015). Many students gave up at the beginning of solving questions because the process of solving questions on the linear program material required a lot of calculations and a long time, so that in the National Examination practice students did not work on questions related to the linear program (Rangga, 2018). Based on data from the Ministry of Education and Culture's Puspendik, in the 2018/2019 SHS National Exam mathematics questions (results of the respondent's National Exam) the mastery of exam material on the national level linear program was categorized as low, namely only 19% of students answered correctly (Kemdikbud, 2019). Based on the description of the stages of solving mathematical problems and indicators of representation, representational indicators can be arranged in solving mathematical problems which refer to Polya's problem solving stage and the representation stage that has been determined by the researcher, as follows:

Table 2. Indicators Representation in Solving Mathetatics Problems

Problem Solving Stage (Polya, 1973)	Indicator Representation (Surya, et al, 2013)	Research Indicators	Code
Understand the problem	Able to present problems in the form of mathematical equations (mathematical expressions) or mathematical models.	State known data, determine variables, state existing constraints, determine the objective function of the problem.	IP1
		Using knowledge in making mathematical equations (mathematical expressions) from known data from	IP2
Planning problem solving	• Able to plan, implement strategies to solve problems. • Able to present problems in visual form (diagrams, pictures, tables, and patterns)	Using experience in planning steps to solve math problems	IP3
Carry out the plan		Perform calculations according to the steps that have been planned	IP4
		Graph the function of the constraints	IP5
		Determine the settlement area	IP6
Re-check	• Able to check answers to problem solutions, • Be able to retell problems systematically or be able to draw conclusions from answers that have been found, • Able to explain the problems found and the solution from the calculation results.	Determine the points that are within the settlement area	IP7
		Test points systematically	IP8
		Use knowledge to summarize the results obtained by	IP9
		Confident that the correct troubleshooting result	IP10

Everyone has different ways of processing information and organizing activities. These differences affect the processes and results of the activities carried out, one of which is in learning activities (Al, 2012). This difference is called the cognitive style. Cognitive style is a person's way of obtaining information and arranging strategies in responding to stimuli in the environment. The characteristics of each person in making decisions, using cognitive-thinking functions, solving problems, remembering, organizing, producing and obtaining information, and others that are consistent for a long time are called cognitive styles (Argarini et al., 2014). Cognitive style is a unique effort that can be used by each individual in processing the information obtained to respond to environmental conditions and restating the information based on previous experiences (Dwi, 2017). Cognitive style is a characteristic of everyone in cognitive functioning consistently and for a long time (Desmita, 2009). Based on some of the opinions above, the researcher can conclude that cognitive style is a typical effort used by individuals to function consistent mental activities in the cognitive field, namely remembering, solving problems, obtaining and processing information.

The process and results of learning activities are influenced by differences in cognitive styles, such as when students try to get the final result or process the knowledge obtained while learning mathematics. One of the dimensions of cognitive style is spatial cognitive style (SCS). Keefe and Monk (1987 in Uno, 2005) state that the spatial cognitive style is related to the formation of the imagination of spatial objects and thoughts. Spatial cognitive style is related to the visual-spatial ability to get details, so that it can find patterns by arranging these details, then processing these patterns to gain knowledge that can be used in finding solutions (Gamon & Bragdon, 1998). Based on the opinion of experts, what is meant by spatial cognitive style is the way a person obtains and processes information with the visual-spatial ability to capture details and get patterns from these details, then process these patterns to gain knowledge that can be used in finding solutions.

Measuring and determining students' cognitive styles, there are several instruments that have been developed by experts such as the GEFT (Group Embedded Figure Test) (Al, 2012). The GEFT in this study adopted the GEFT instrument developed by Witkin et al. (1971) but using Indonesian. The test is to distinguish spatial cognitive style in three levels, namely high spatial cognitive style, moderate spatial cognitive style, and low spatial cognitive style. The level of spatial cognitive style can be seen in the following table :.

Table 3. Level of Spatial Cognitive Style

Level	Score
High	Value Test ⩾ 13
Medium	6 <Test score <13
Low	test scores ⩽ 6

Student representation is a form of expression of mathematical ideas or ideas that function to find solutions to problems faced and show student work (Farhan & Retnawati, 2014). The ability of each individual to understand and comprehend different lessons. Thus, each individual has different techniques to be able to process information. This difference is caused by several factors, one of which is cognitive style (Hotnida, 2016). The characteristics of each individual to use cognitive functions-think, remember, solve problems, make decisions, organize, produce information, and so on that are consistent and last a long time are called cognitive styles (Argarini et al., 2014). One of the cognitive styles related to linear programming problems is the spatial cognitive style.

Spatial cognitive style is related to students' visual-spatial ability to get details, use these details to find patterns, then match these patterns into understandable knowledge (Gamon & Bragdon, 1998). Linear programs are closely related to real problems in the form of stories, symbols / mathematical models, graphs, and tables that can make students find it difficult to make problems into simpler forms, so students must be able to interpret from one representation to another because representation is important. of representational competencies (Huinker, 2015). One kind of representation used is external representation. External representation, namely presenting ideas / ideas using words, symbols, pictures, graphics, tables, and hands-on props (Mustangin, 2015). The representation is influenced by the students' spatial cognitive style. It can be seen that solving mathematical problems on linear programming material requires a good representation, in accordance with one's spatial cognitive style.

The research that was conducted by Handayani, (2018) entitled " Analisis Kemampuan Representasi Matematis Siswa Pada Materi Program Linear Di Sma Negeri 1 Palembang " has something in common with this research, namely examining student representations in linear program material and the subjects used in the study are the same, students High school. While the difference lies in the types of questions and reviews. Researchers are interested in using problem-based questions, so the indicators used are also slightly different, namely considering the problem solving process. Another study conducted by Dwi (2017) entitled " Analisis Kemampuan Representasi Matematis Siswa Ditinjau dari Gaya Kognitif Spasial Materi Geometri Di SMA Muhammadiyah 1 Purbalingga ". Research conducted by Dwi (2017) analyzed students' representational abilities in geometry material and did not use problem solving stages. Whereas in this study, it aims to describe the mathematical representation of students in solving mathematical problems based on the spatial cognitive style so that the researcher wants to find out whether the level of spatial cognitive style will affect the mathematical representation of students in solving mathematical problems.

METHODS

The research method used in this research is descriptive qualitative which aims to describe the mathematical representation of students in solving mathematical problems in terms of spatial cognitive style. So this type of research is descriptive research with a qualitative approach. This is in accordance with the definition of qualitative research by (Siswono, 2018) which says that qualitative research is research that produces descriptive data such as writing, speech, and observable behavior. Descriptions of students' mathematical representations in solving mathematical problems in terms of spatial cognitive style are concluded based on representational indicators in solving mathematical problems obtained from written test data and interview results. The subjects of this study were three students with female gender, equivalent math ability and have different levels of spatial cognitive style, namely high, medium, and low in class XI one of the MA in Pamekasan in the even semester. Researchers also consulted teachers of mathematics as teachers to determine subjects who have equal mathematical abilities. The selection of the three subjects was carried out without differentiating gender and having equal mathematical ability, namely all high to avoid data differences that were influenced by gender and mathematical ability. In accordance with the research conducted by (Fuad, 2016), it is stated that gender affects mathematical representations and research that has been conducted by (Lette & Manoy, 2019) states that mathematical abilities affect mathematical representations.

The research instruments in this study were the GEFT (Group Embedded Figure Test) Questionnaire, Problem Solving Test (TPM), and interview guidelines. Students are selected based on the results of the GEFT Questionnaire scores and then grouped with high, medium, and low spatial cognitive styles. The GEFT questionnaire scoring adopts the scoring used by Dwi (2017) with a score of 0 to 18 where each correct answer is 1 and the wrong answer is 0. Dwi (2017) states that the high spatial cognitive style group has a value of $\geqslant 13$, the spatial cognitive style group moderate has a value of $6 < x < 13$, and for low spatial cognitive style has a value of $\leqslant 6$, according to table 3. After selecting 3 students, then given a second instrument, namely a problem solving test to find out the mathematical representation of students in solving math problems. In the problem solving test, there are two items regarding the Linear Program material. Interviews are conducted after students have finished working on problem solving test sheets to get more complete information from students such as ideas that are thought of, and additional information about verbal representations. The following are the TPM instruments used by researchers to find out the mathematical representation of students in solving math problems.

Kerjakan Soal di bawah ini dengan teliti

1. Sebuah perusahaan properti memproduksi dua macam lemari pakaian yaitu tipe lux dan tipe sport dengan menggunakan 2 bahan dasar yang sama yaitu kayu jati dan cat pernis. Untuk memproduksi 1 unit tipe lux dibutuhkan 10 batang kayu jati dan 3 kaleng cat pernis, sedangkan untuk memproduksi 1 unit tipe sport dibutuhkan 6 batang kayu jati dan 1 kaleng cat pernis. Biaya produksi tipe lux dan tipe sport masing-masing adalah Rp40.000,00 dan Rp28.000,00 per unit. Untuk satu periode produksi, perusahaan menggunakan paling sedikit 120 batang kayu jati dan 24 kaleng cat pernis. Bila perusahaan harus memproduksi lemari tipe lux paling sedikit 2 buah dan tipe sport paling sedikit 4 buah, berapa banyak lemari tipe lux dan tipe sport yang harus diproduksi agar biaya produksinya minimum?
2. Seorang pembuat kue mempunyai 8 kg tepung dan 2 kg gula pasir. Ia ingin membuat dua macam kue yaitu kue dadar dan kue apem. Untuk membuat kue dadar dibutuhkan 10 gram gula pasir dan 20 gram tepung sedangkan untuk membuat sebuah kue apem dibutuhkan 5 gram gula pasir dan 50 gram tepung. Jika kue dadar dijual dengan harga Rp 1.500,00/buah dan kue apem dijual dengan harga Rp 2.500,00/buah, berapa pendapatan maksimum yang dapat diperoleh pembuat kue tersebut?

Figure 1. TPM Instruments

RESULTS AND DISCUSSIONS

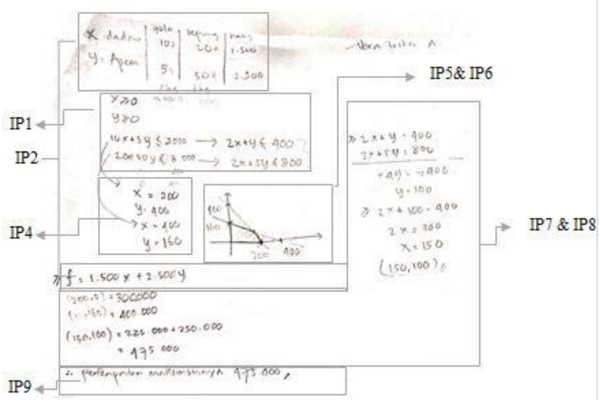
RESULTS

Based on the results of the Group Embedded Figure Test (GEFT), there were 5 students with low spatial cognitive styles, 18 students with moderate cognitive styles, and 9 students with high spatial cognitive styles. From these data, the researcher chose 3 subjects with three different levels of spatial cognitive style as follows:

Table 4. Value of the Spatial Cognitive Style Questionnaire (GEFT)

Name	Score	Level SCS
NEA	13	Hingh
AZF	11	Medium
LM	6	Low

The results of the work of students NEA Number 1:



Based on Figure 2, the NEA subject has fulfilled all the research indicators in the work of question number 1. In IP1, the NEA mentions variables, existing constraints, and mentions known data in tabular form. The objective function is written after determining the linear inequality system. In IP2, NEA can already represent the information obtained in the form of mathematical expressions, namely linear inequalities. Based on the inequality obtained, NEA determines the intersection of the lines (which are represented by the equation) with the two coordinate axes as an aid to drawing graphs in finding solutions, this satisfies IP4. After determining the intersection coordinates, NEA draws a graph then determines the set of solutions, it satisfies IP5 and IP6. In IP7, NEA determines corner point coordinates that limit the set of solutions obtained, NEA gets 3 points. Then the NEA performs a point test. During the point test, the NEA senses that there is an error in the set of solutions obtained. So that the NEA redraws the graph according to known constraints, it satisfies IP8. Based on NEA02 (Table 5), it can be seen that NEA is hesitant when it comes to a corner coordinate that limits the set of solutions obtained.

Figure 2. NEA's Answer Number 1

Table 5. Snippets of Interview with NEA

Code	Interview
P01	How many corner point coordinates limit the set of solutions?
NEA01	There is only one.

P02	Are you sure? How do I get the coordinates of the corner points?
NEA02	Not too sure, because rarely do I find only one corner coordinate limiting the set of solutions, but from the image I got only one corner coordinate limiting it. The intersection of x ⩾2 and y ⩾ 4, so the coordinates of the intersection are (2,4).

There was an error drawing the graph because it was not using the same scale. Based on NEA02, it can be seen that the NEA draws based on the approximate placement of its points. In IP9, the NEA represents in words and summarizes the results obtained. This was explained in the NEA04 interview. IP3 and IP10 were fulfilled in the interview process NEA03 and NEA04 (Table 6).

Table 6. Snippets of Interview with NEA

Code	Interview
P03	What plans have you made to get answers to these questions?
NEA03	First write whatever is known from the problem and determine the objective function. After that, create a table to make it easier to make the inequalities. After that makes the inequality. Then look for the intersection of the lines with the two coordinate axes in finding the solution of the linear inequality to make a graph. Then graph and determine the set of solutions. Then find the coordinates of the corner points that limit the set of solutions obtained. Then substitute the point in the objective function in order to determine the answer. Don't forget, always draw conclusions from the answers you get.
P04	Have the conclusions you provided answered the questions in the questions?
NEA04	Yes, in the question of asking the number of luxury cabinets and sports cabinets so that the costs used are minimum. The answer is 2 lux cabinets and 4 sports cabinets.

Because there is an error in determining the point that limits the set of solutions, the point substitution process in the objective function and the conclusion given by the NEA is not quite right.

The results of the work of NEA Number 2 students:

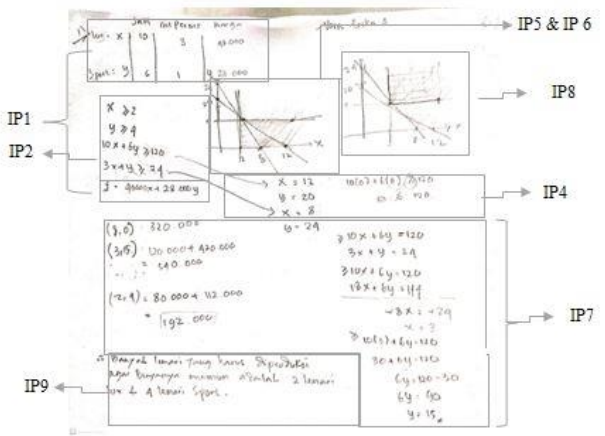


Figure 3. NEA's Answer Number 2

Based on Figure 3, NEA fulfills all research indicators. NEA subjects can solve problem number 2 with the same completion steps as number 1. In IP1 the NEA represents the information on the questions in table form and writes the objective function. In IP2, NEA represents information from tables in the form of mathematical expressions, namely a system of linear inequalities. IP4, NEA determine the intersection of the lines (which are represented by the inequality) with the two coordinate axes as an aid to graph drawing in finding solutions to graphs. IP5 and IP6 NEA graph the solution obtained from the linear inequality and determine the set of its solutions. In IP7 and IP8, from the set of solutions obtained, NEA determines the coordinates of the corner points that limit the set of solutions and substitutes these points for the specified objective function. After calculating and getting the results, the NEA provides conclusions to represent the answers in words, it fulfills IP9. IP3 and IP10 were fulfilled in the interview process NEA05 and NEA06 (Table 7).

Table 7. Snippets of Interview with NEA

Code	Interview
P05	What plans have you made to get answers to these questions?
NEA05	Same as the first question. Writing the known things from the problem and determining the objective function, making tables of the known things, making inequalities, finding the intersection of the lines with the two coordinate axes in finding solutions to linear inequalities, making graphs, making graphs and determining the set of solutions limit the set of solutions and point substitutions to the objective function in order to determine the answer. Lastly make a conclusion.
P06	Have the conclusions you provided answered the questions in the questions?
NEA06	Yes, on the question of asking for the maximum income earned. So the income is IDR 475,000.

The results of the work of AZS Number 1 students:

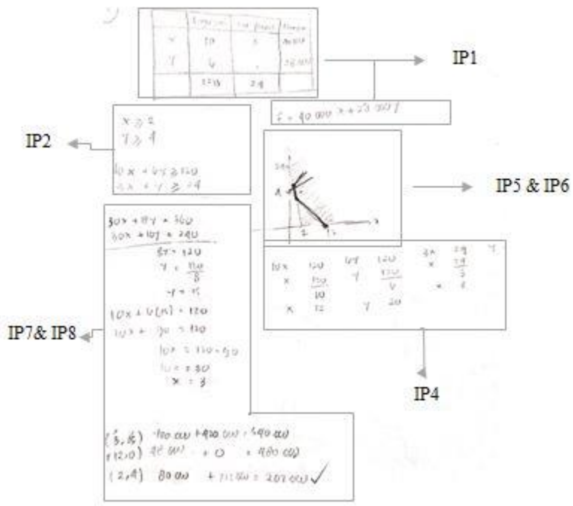


Figure 4. AZS's Answer Number 1

Based on Figure 4, the AZS subject can fulfill several research indicators. In IP1, AZS represents the data contained in the questions in tabular form and writes the objective function of the questions. In IP2, AZS represents in the form of mathematical expressions, namely a system of linear inequalities according to known constraints. Based on the inequality obtained, AZS determines the intersection of the line (which is represented by the equation) with the two coordinate axes as an aid to drawing graphs in finding a solution, it satisfies IP4. After obtaining a solution, AZS graphs and determines the set of solutions, it satisfies IP5 and IP6. From AZS01 (Table 8), it can be seen that in the process of making graphs, AZS felt confused, because from known limitations, AZS could not draw lines on the graph. AZS believes that the graphics were drawn wrong. Due to AZS 'ignorance in drawing the constraint function graph, the graph and the set of solutions obtained are also less precise. From AZS02 (Table 8), it can be seen that when determining the corner point coordinates that limit the set of solutions, AZS guesses the coordinates of one of the points, this is because AZS is confused with the graph that it draws (IP7). For IP8, AZS substitutes corner point coordinates that delimit the set of solutions with the objective function. IP3 and IP10 were fulfilled in the interview process AZS03 and AZS04 (Table 8).

Table 8. Snippets of Interview with AZS

Code	Interview
PQ07	How do you graph the function you got?
AZS01	I can draw from the two inequalities that I get, but I am confused to describe the constraints of x⩾2 and y⩾4. I'm sure my chart is wrong, but I don't know the justification.
P08	How do I get the coordinates of the corner points that limit the set of solutions?
AZS02	For the first point, the result of the intersection of the lines 10x + 6y = 120, and 3x + y = 24 using elimination and substitution. For the second point, the intersection of the lines 10x + 6y = 120 and y = 0 is chosen. For the third point, I can approximate the coordinates.
P09	What plans have you made to get answers to these questions?
AZS03	Create tables from known data, create inequalities, create graphs, find the set of solutions, find corner coordinates of the set of solutions, finally substitute and get answers.
P10	Are you sure of your answer?
AZS04	A little doubt, because the final answer is at a point which I roughly coordinate.

The results of the work of AZS Number 2 students:

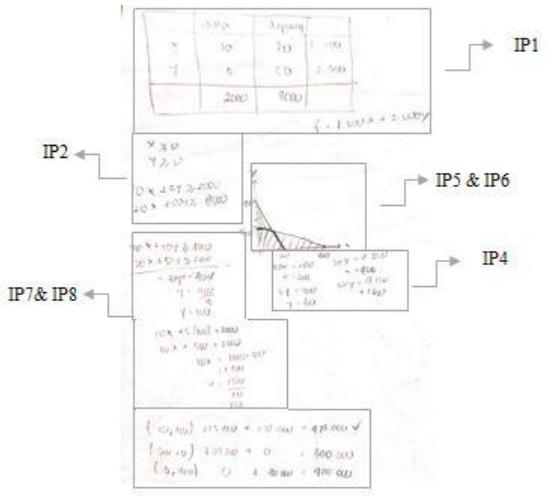


Figure 5. AZS's Answer Number 2

Based on Figure 5, the AZS subject can fulfill several research indicators. In IP1, AZS can represent the known data in the questions in tabular form and write the objective function. AZS can also represent in the form of mathematical expressions, namely a system of linear inequalities, this fulfills IP2. However, there is a sign error, AZS should write ⩽ but write ⩾. On graphing the AZS is correct to determine the shaded area. In IP4, AZS determines the intersection of the line (which is represented by the equation) with the two coordinate axes as an aid to drawing graphs in finding solutions, this satisfies IP4. After determining the intersection coordinates, AZS draws a graph then determines the set of solutions, it satisfies IP5 and IP6. In IP7, AZS determines the corner point coordinates that limit the set of solutions, but from AZS06 (Table 9), it can be seen that AZS cannot explain why the solution set is like the graph because it does not represent the graph of the constraint function. In IP8, AZS substitutes a point that has been found on a predetermined destination function. IP3 and IP10 were fulfilled in the interview process AZS07 and AZS08 (Table 9).

Table 9. Snippets of Interview with AZS

Code	Interview
P11	How to determine the set of solutions from the graph that has been drawn?
AZS05	From the area traversed by two shading.
P12	Why didn't it come to quadrants 2, 3, and 4? If the line is extended it should be the area of the set of solutions traversed by the two shading to quadrants 2, 3, and 4.
AZS06	I don't know, but I believe my chart is correct.
P13	What plans have you made to get answers to these questions?
AZS07	Same as question number 1.
P14	Are you sure of your answer?
AZS08	Very sure.

The results of the work of LM student number 1:

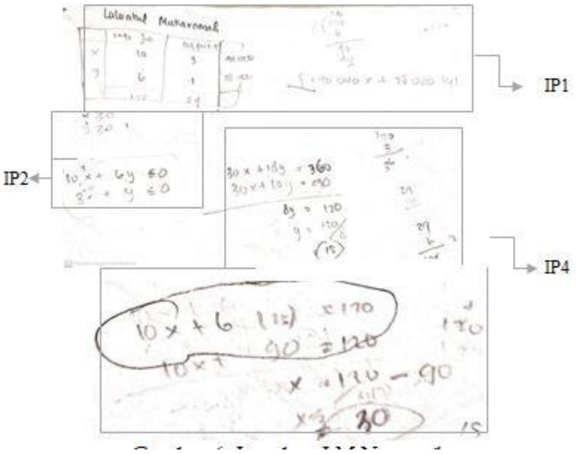


Figure 6. LM's Answer Number 1

Based on Figure 6, the LM subject fulfills several research indicators. In IP1, LM can represent the information contained in the questions in table form and write the objective function. However, from LM01 (Table 10), it can be seen that LM making the table takes a long time, approximately 15 minutes. In IP2, LM represents a mathematical expression that is linear inequality, but this representation is not precise, because there should be a constraint function, the hyphen is inverted, and it should not be 0 but 120 and 24. From LM02 (Table 10), it can be seen that LM can explain with the detailed steps it must take, it satisfies IP3. From LM02 (Table 10), it can be seen that LM was constrained by making graphs in the processing process. In the LM02 interview process (Table 10), LM also wrote down his explanation with the condition if he could make the desired graph, Figure 7.

Table 10. Snippets of Interview with LM

Code	Interview
P15	How do you write down the information you have received about the problem?
LM01	I know all the information, but it is very difficult to convert it in tabular form. But I know that changing it into a table will make it easier to work on the problem. It took me approximately 15 minutes to make the table.
P16	What plans have you made to get answers to these questions?
LM02	First have to know all the information from the problem, then make tables, write the objective function, make inequalities, draw graphs. However, I had a hard time drawing the graphics. Suppose I have drawn the graph, the next step is to determine the set of solutions, then find the coordinates of the corner points that limit the set of solutions, then substitute these points in the objective function. Finally, choose what is asked by the question.

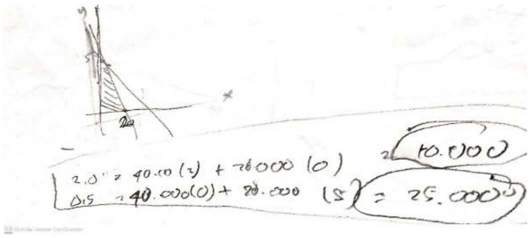


Figure 7. LM Explanation

In IP4, LM performs calculations to find solutions of linear inequalities to graph. The calculation performed by LM is the elimination and substitution that should be done when it has determined the set of solutions. In the calculation process an error also occurred.

The results of the work of LM student number 2:

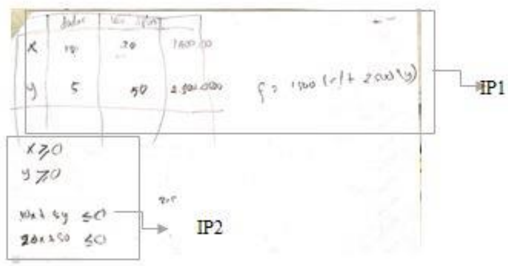


Figure 8. LM's Answer Number 2

Based on Figure 8, the LM subject fulfills 2 research indicators. In IP1, LM represents the information contained in the questions in tabular form and writes the objective function. However, some information was missing, namely the total supply of flour and sugar. LM was also wrong in determining the variable, the variables of the question should be omelette and apem. In IP2, LM represents the information obtained in the form of a mathematical expression, namely linear inequality. However, there is a writing error, it should not be 0, but 2000 and 8000, the error is because LM did not write the information in the table. IP3 was fulfilled in the LM03 interview process (Table 11).

Table 11. Snippets of Interview with LM

Code	Interview
P17	What plans have you made to get answers to these questions?
LM03	Same as question number 1, I still have problems making graphs and time has run out.

DISCUSSION

Based on the results and data analysis that has been done, the following will present a discussion of the analysis of students' mathematical representations in solving mathematical problems in terms of spatial cognitive style. Wetting is based on the theory of Polya's problem solving stages (Polya, 1973), namely understanding the problem, planning problem solving, implementing plans, and re-check. Wetting is also based on the mathematical representation form of (Manoy, 2018) according to the description in table 1.

1. Students' Mathematical Representations in Solving Mathematical Problems in terms of High Spatial Cognitive Style

Students with a high spatial cognitive style can solve mathematical problems in accordance with the 4 stages of problem solving by Polya (1973). At the stage of understanding the problem, NEA uses visual representations and representations of mathematical expressions. At the planning stage of problem solving, the NEA uses verbal representations, namely by explaining during the interview. At the stage of implementing the plan, NEA uses visual representations and representations of mathematical expressions, namely drawing graphs and performing calculations. In the re-check stage, the NEA uses verbal representations, visuals, and mathematical expressions. This is in accordance with the opinion of (Dwi, 2017) which states that students with high spatial cognitive styles can state in visual representations, representations of written words / texts, and representations of mathematical expressions. The NEA explained during the interview how it redrawed the graph because there was an error in determining the set of solutions and providing conclusions. The NEA also performs calculations to correct whether the answers it finds are correct or wrong. Therefore, there are two graphic images presented by the NEA.

Of the 10 research indicators that have been assigned to 2 problem solving questions, NEA fulfills all of them. NEA uses 7 visual representations. Visual representations appear on IP1, IP5, IP6, and IP8 in question number 1 and on IP1, IP5, and IP6 in question number 2.

2. Students' Mathematical Representations in Solving Mathematical Problems in terms of Moderate Spatial Cognitive Style

Students with a moderate spatial cognitive style can solve mathematical problems in accordance with Polya (1973) problem solving stage. At the stage of understanding the problem, AZS uses visual representations and representations of mathematical expressions, but there is a sign writing error in the linear inequality. This is in accordance with the opinion of (Rangga, 2018) which revealed that there were students who were inaccurate in determining signs for linear inequalities. At the stage of planning problem solving, AZS uses verbal representations, AZS explained during the interview. At the stage of implementing the plan, AZS uses visual representations and representations of mathematical expressions, namely drawing graphs and performing calculations. However, on visual representations, AZS made some mistakes. In the re-examination stage, AZS uses verbal representations and mathematical expressions. AZS explained at the time of the interview the confusion he faced when describing the graph, so that at the stage of checking again, he realized that there was an error in the graph he was depicting, but AZS did not provide a conclusion from the answer he gave. AZS also performs calculations to find the answer it wants.

Of the 10 research indicators that have been assigned to 2 problem solving questions, AZS fulfills 9 research indicators, at IP9 AZS does not fulfill it. AZS uses 6 visual representations. Visual representations appear on IP1, IP5, and IP6 in question number 1 and on IP1, IP5, and IP6 in question number 2.

3. Students' Mathematical Representations in Solving Mathematical Problems in terms of Low Spatial Cognitive Style

Students with low spatial cognitive style can solve mathematical problems with 3 stages of problem solving Polya (1973), the re-checking stage is not carried out. At the stage of understanding the problem, LM uses visual representations and representations of mathematical expressions, but some errors occurred during the table creation. At the stage of planning problem solving, LM uses verbal representations, LM can explain in detail the steps to get the desired solution at the time of the interview. LM also explained that the problem with solving the problem is when making graphs. This is in accordance with the opinion of (Ariawan, 2015) who revealed the difficulties in linear programming problems, one of which is to graph the set of solutions for the linear inequality system from known constraints. At the stage of implementing the plan, LM which fulfilled these indicators used a representation of a mathematical expression in question number 1 and there were several errors. In question number 2 LM does not fulfill. This is in accordance with the opinion of (Dwi, 2017) which states that students with low spatial cognitive styles have not been able to apply mathematical expressions in solving problems. LM does not meet the research indicators at the reexamination stage.

Of the 10 research indicators that have been assigned to 2 problem solving problems, LM fulfills 3 research indicators, namely IP1, IP2, and IP3. LM uses 2 visual representations. The visual representation appears on IP1 in question number 1 and question number 2.

Based on the discussion of the analysis of students' mathematical representation in solving mathematical problems in terms of the spatial cognitive style of the three subjects, students with high and moderate spatial cognitive styles can complete problem solving problems, but have different representational tendencies. Students with high spatial cognitive style tend to use visual representations, while students with moderate social cognitive styles tend to use representations of mathematical expressions. Unlike the other two students, students with a low spatial cognitive style cannot solve problem solving problems. This can happen because students' cognitive styles do not always affect students with high mathematical abilities in solving math problems (according to the results of Ulya (2015), 61% is influenced by other factors besides cognitive style).

CLOSURE

Conclusion

Based on the results of research and discussion of student representation in solving mathematical problems in terms of spatial cognitive style, it is concluded that (1) Students with high spatial cognitive style understand the problem by presenting the information on problems with visual representations in the form of tables and mathematical expressions of mathematical inequalities. Planning problem solving using representations of words. Implement problem solving plans using representations of mathematical expressions in calculations and visual representations in graphical form. Re-check using representations of mathematical expressions, representations of words, and visual representations. (2) Students with a spatial cognitive style understand the problem by presenting the information on the problem with a visual representation in the form of tables and mathematical expressions of mathematical inequalities. Planning problem solving using representations of words. Implement problem solving plans using representations of mathematical expressions in calculations and visual representations in graphical form. Re-checking using representations of mathematical expressions, and verbal representations but have not been able to provide conclusions. (3) Students with low spatial cognitive style understand the problem by presenting some of the information on the problem with a visual representation in the form of tables and mathematical expressions of mathematical inequalities. Planning problem solving using representations of words. Carry out a problem solving plan with a representation of a mathematical expression. However, unable to re-check. Students with high and moderate spatial cognitive styles can solve problem solving problems, but have different representational tendencies, while students with low spatial cognitive styles cannot solve problem solving problems.

Recommendation

Based on the research results, the mathematical representation of each student in solving math problems is different. Students' mathematical representation can be trained by providing problem solving questions. Thus, the teacher should more often provide problem solving problems, so that it is hoped that it can train students' mathematical representations in solving mathematical problems. In addition, the spatial cognitive styles possessed by students also differ. Spatial cognitive style can be trained by giving questions or material in the form of pictures, because students with spatial cognitive styles acquire and process information with visual-spatial abilities. Therefore, the teacher should also pay attention to the students' spatial cognitive style in the learning process to make it easier for students to understand the material.

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