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Students' Cognitive Process to Solve Mathematics Problems Based on Learning Style

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ABSTRACT

The purpose of this study was to describe the cognitive processes of students in solving mathematical problems. This research is qualitative exploratory research. Researchers explore things that affect the occurrence of the subject's cognitive processes through in-depth interviews. Subjects were selected based on the results of the study of learning styles. The subject of this research is one student with visual, one auditory, one kinesthetic, and one tactile learning styles. Perceptual Learning Style elements are interpreted to investigate student learning styles. The stages of problem-solving in this research are to understand the problem, make a plan of completion, complete according to the plan, and look back. Mathematical problems from story problems and proof problems. Data from interviews and written work that has been valid were analyzed by examining how the subject's cognitive process toward the problem. The results showed differences in the cognitive processes of visual, auditory, kinesthetic, and tactile subjects in solving mathematical problems, both in story problems and in proof questions.

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1. INTRODUCTION

Problems are situations where goals are not achieved automatically through perception or recognition (Glass & Holyoak, 1986). Problem-solving is an individual's effort to build and choose a response to achieve the intended goal (Baron, 1995). Stanic & Kilpatrick (1988) argues that the problem is a condition in which the individual performs a task that has never been done before. Butts (1980) said that problems in mathematics are grouped into recognition exercises, algorithmic exercises, application problems, open-search problems, and problem situations. Johnson & Rising (1972) defines mathematical problem solving as a complex mental process that requires visualization, imagination, manipulation, analysis, abstraction, and equation of ideas.

Polya (1973) classifies the problems into two types, namely: a matter of looking, which is looking for, determining, or getting the value or object unknown in the matter and meeting the conditions or requirements following the issue, and a matter of proving that the procedure for determining whether a statement is accurate or not true.

According to Krulik & Rudnick (1995), there are five stages of the problem-solving process called heuristics. Polya (1973) describes problem-solving stages: as understanding the problem, making a problem-solving plan, solving the problem according to the plan, and checking the answers. Through this stage, the individual's cognitive structure is structured in solving mathematical problems.

The cognitive process is the process of forming thought associations. According to Carroll (1993), the cognitive process operates the content to obtain a response. Baron (1995) argues that cognitive processes are mental activities that include capturing, representing, storing, recalling, and using information. Suharnan (2005) & Widyastuti (2015) say that individual cognitive activities begin with recording information, transforming information, storing information in a memory warehouse, then extracting information stored in memory to be presented again in order to respond to a task. Jones (2006) argues that the cognitive process is a person's thought process which can be interpreted as information processing. Someren et al. (1994) also said that a person's cognitive process is information processing.

Based on Polya's problem-solving stages, researchers want to know how students solve problems in more detail, as shown in Table 1 below.

Table 1. Problem-solving steps and student methods

Troubleshooting Steps	Student Activities
Understand the problem	- The way students receive the information - How students explain the vital information that has been obtained.
Make a plan for the settlement of the problem	- How students devise solutions to problems. - How students check whether all the essential information has been used.
Implementing a problem-solving plan	- The way students make the steps for solving the problem correctly. - How students examine each step of completion.
Checking back answers	- The way students recheck the answers obtained. - The way students use the information to rework the problem differently.

If they are not suitable for students, mathematics learning methods can cause frustration for these students. Alternative efforts to provide good psychological learning techniques include observing the student's condition and learning style. According to Bennet (1995), learning style is the consistency of a person's behavior and performance patterns in the educational experience, which is a combination of cognitive, affective, and physiological behavior characteristics as a relatively stable indicator of how students feel, interact and respond to their learning environment. According to Prashnig (2001), learning style is the way individuals begin to concentrate, absorb, process, and accommodate new and complex information. Prashnig's expression refers to Dunn & Dunn's (1993) learning style model.

In their research, Dunn & Dunn (1993) found that triggering concentration and improving students' mathematics learning abilities and it can be done by providing teaching that pays attention to the power of perceptual learning styles. According to Dunn, Beaudry, & Klavas (1989), students with different learning styles will respond differently to the same teaching method, so the same teaching method will be effective for some students but not necessarily effective for others. Another definition of learning style, by Lee & Lodewijks (1995), is the tendency to use specific processing and regulatory activities when learning spontaneously.

Several other learning style models are the Visual - Auditory - Kinesthetic (VAK) model, the 4MAT system model, and the Gregorc/Butler. The VAK model, created in 1970, is widely used for counseling, teaching, and communication exercises (Prashnig, 1998). Bernice McCarthy (McCarthy, 1987)

developed the 4MAT system model in the early 1980s, which provides an understanding of how individuals first receive and process information. Another learning style was developed by Anthony F. Gregorc, called 'The Gregorc Model,' later refined by Butler (Gregorc & Butler, 1984). This model is used for teaching strategies to improve the quality of teaching in the classroom.

Learning styles in this article are consistent with individuals' perceptual strength or senses when preceded concentrate, absorb, process, and receive new information on problem-solving. Perceptual tendencies are divided into four, namely: visual, auditory, kinesthetic, and tactile (Dunn & Dunn, 1993; Prashnig, 1998). Students classified as visual learners tend to describe something based on their appearance or presentation. They learn by reading or observing (Dunn & Dunn, 1993). They like things presented through visualizations, such as photos, diagrams, maps, and graphs (Prashnig, 1998).

The results of the research by Sitepu and Tanjung (2016) show differences in student learning outcomes between those with visual, auditory, and kinesthetic learning styles. Furthermore, the results of research by Aini, Haryani, and Suwanti (2020) show that students with different learning styles have different understandings of mathematical concepts. The research results by Nugroho, Juniati, and Siswono (2020) indicate that prospective mathematics teachers with different learning styles fulfill four aspects of learning independence at different levels, choices, and strategies.

Rofikoh, Rochmad & Kurniasih (2016) suggest research to analyze students' problem-solving abilities based on learning styles by using math problems that include all indicators of the stages of solving mathematical problems according to Polya.

Dunn & Dunn (1993)'s perceptual elements in the Learning Style Inventory (LSI) are presented in Table 2.

Table 2. Interpretation of Elements of Perceptual Learning Style Dunn & Dunn (1993)

Element	20-29	30-39	41-59	60-69	70-80
Visual	Often reads one page, comes to an end, thinks, 'I do not know what I have read,' then re-reads page by page.	Sometimes require re-read one page because although it has been read, almost meaningless what has been absorbed	If interested, you can keep most of what has been read and can continue reading by absorbing meaningful words.	Remembering most of what he had read.	Can concentrate on long readings, close eyes, 'see' open books, section pages, and paragraphs, focus on print, and remember what was read.
Auditory	Often sit on while studying and did not know what was being discussed. He has difficulty listening for long periods.	Sometimes sitting while studying and listen to songs. Must concentrate on 'sticking with' the speaker.	Interested can learn by listening if tired of not knowing what is next.	Find it easy to learn by listening.	Remembering something heard can concentrate and 'uncover' people's voices and reorganize what has been heard.

Kinesthetic	Prefers to drive than walk.	Not often involved in activities, action-oriented learning.	The level of student involvement in doing something is determined by what is done or by whom it is done.	Enjoy the activity and get involved.	Involved in lots of activities, and people say energetic.
Tactile	Never or rarely take notes. Also, not too much to do something with his hands.	Just taking notes for numeric data or something that cannot be remembered easily.	Whether or not students take notes during lectures depends on the difficulty/interest of the topic.	Often takes notes during lectures or while reading something new or complex that he wants to learn. Tactiles often draw or doodle to remember, and they enjoy hands-on learning.	If a student forgets a grocery list, he or she remembers the most things on the list. Students will have difficulty listening if their hands are not used during lectures (for note-taking, practice, cutting, or equivalent activities).

In this study, Table 2 will be used to prepare interview guidelines to investigate the subject's learning style. If the individual has a value of ≥ 60, it is said that the subject tends to certain perceptual or sensory powers.

The results of this study are helpful as reference material for educators to design their learning and can accommodate their students' different perceptual learning styles.

2. METHODS

This type of research is qualitative exploratory. Data were collected by observing subjects solving math problems, then digging deeper through interviews. The approach includes qualitative data mining is natural and deep, in the form of spoken words, gestures, facial expressions, expression, and written answers.

The research subjects were RK Budi Mulia Private High School students and SMAN 2 Pematangsiantar students. Subject selection is based on the results of the study of learning styles. Subject selection was carried out until four subjects were obtained: subjects with visual tendencies, subjects with auditory tendencies, subjects with kinesthetic tendencies, and subjects with tactile tendencies.

The research instrument was the researcher, guided by the question sheet instrument, interview guide, and a recording device in the form of a video camera. The Expert validates the instrument of the question sheet. The researcher, as an instrument, acts as an interviewer, with the nature of open and semi-structured interviews. The researcher as an instrument will make it easier to gather more information and provide prompting questions to the subject to reflect on the answers. So, interviews are needed to confirm whether the spoken data is inconsistent with the written data.

In addition to the researcher as the key instrument, the question sheet is also used as another instrument. When the interview has not been conducted, the subject is given a sheet of math problems in the form of story and trigonometry questions. The questions given to the respondents are: (1) A family has five children. The youngest child is half the age of the oldest child. Furthermore, the other three children are consecutively two years older than the youngest, four years older than the youngest, and three years younger than the oldest. If their average age is sixteen, how old are they? and (2) Show that $\frac{2\sin x + \sin 2x}{2\sin x - \sin 2x} = \text{ctg}^2 \frac{1}{2}x$

To collect data, it begins by giving mathematics questions to students individually. Researchers observed verbal and nonverbal expressions of research subjects. Then the verbal and nonverbal data were explored in depth through interviews. Interview questions are directed at what, why, and how. This process is repeated until the author believes each step of problem-solving is obtained until the data is saturated.

To increase the validity of the source, the same subject was given a similar question sheet, then interviewed to obtain data at each stage of the subject's problem-solving. Then, the results of the first and second data collection were triangulated. If the researcher still has doubts about the triangulated data, the researcher gives another similar question sheet to the subject and is then interviewed, and then triangulation is carried out again to see the tendency of problem-solving by the subject.

Furthermore, the valid data obtained were analyzed. Data analysis includes data reduction, display, conclusion drawing, and verification (Huberman & Miles, 1994).

3. RESULTS AND DISCUSSION

Results

The results of the learning style investigation of 80 students obtained four subjects who met the criteria, one visual subject was coded V, one auditory subject was coded A, one kinesthetic subject was coded K, and one tactile subject was coded T. The results of the investigation of learning styles are presented in Table 3.

Table 3. Results of Research on Learning Styles of Selected Subjects

No.	Research subject	School Origin	Value Each Element of Perceptual Learning Style			
			Visual	Auditory	Kinesthetic	Tactile
1.	Visual Subject	SMAN 2 Pematangsiantar	80	39	20	29
2.	Auditory Subject	RK Budi Mulia Private High School Pematangsiantar	39	80	20	39
3.	Kinesthetic Subject	SMAN 2 Pematangsiantar	39	39	80	59
4.	Tactile Subject	SMAN 2 Pematangsiantar	29	39	29	80

Analysis of cognitive processes carried out on the four subjects with different learning styles. The analysis was carried out on the results of written work and interviews. Students are given a math problem, and then for each step of solving the problem, an interview is carried out, explaining each step taken and what he thinks in solving the problem. From the results made by students, observations, and interviews with researchers (P), students' cognitive processes and attitudes are shown in Tables 4 to 11 below.

Table 4. Interviews and cognitive processes and attitudes of Visual Subjects (V) questions (1)

Troubleshooting Steps	Interview/Questioning Process	Cognitive processes and attitudes
Understand the problem	Q1: When faced with a question, what is your first step? V1: Reading Q2: For what? V2: Understand the problem, understand what is known, and understand what will be calculated *After reading question number 1, S1 writes down what is known,* P3: Then what is the purpose? V3: I want to calculate the age of each child. Q4: Already? V4: Yes. The goal is to calculate the age of each child	• The subject's appearance is calm, and focuses on the problem while reading the question without voicing it. After finishing reading, he looks at the question like thinking. • Subjects distinguish information into essential and less critical information. Important information is underlined in the questions and re-recorded. • The subject tries to make information relations by connecting with variables. • The researcher could explain the vital information obtained when interviewing the subject.
Make a plan	Q5: So, what is your plan? V5: Wait a minute, ma'am, I will count. Q6: Is the data in the problem sufficient to solve this problem? V6: Enough, ma'am.	• The subject makes a problem-solving plan by analyzing all the data to obtain a solution. • The subject considers what is known to be sufficient to solve the problem, based on a problem-solving plan, by analyzing all data in order to obtain a solution
Carry out the plan	*After counting, he got a number that was not an integer, thought for a moment, then V commented:* How is that weird? Q7: Anything weird? V7: In Mathematics, the numbers are weird usually not true Q8: What is the odd number? V8: This is ma'am. The numbers are not integers P9: Then, what would you do if thus? V9: Yes, check from the beginning. Their ages should be equal to 80 Q10: Where did you get the number 80 from? V10: It is known that their average age = 16, while the number of children = 5. So the sum of their ages is 80.	• The subject performs calculations and proves • The subject can choose and use formulas quickly and relate what is known to what will be obtained. Although he was less precise in his calculations, he eventually realized it immediately. • In realizing that there is something wrong with the calculation and you have to check it from the start • Realized how to evaluate his work by sorting from what is known, then what is asked, the relationship between variables and their calculations.

	After counting for a moment: How come it is not the same? Wow, that is wrong. Let me count again.	
Look back	*After counting again, then checking for correctness, I found that something was wrong* P11: Are you sure your answer is correct? V11: Find the total age equal to the mean times n = 80. The youngest is half of the oldest. If the oldest is A, the youngest is ½ A, and the others are 2 years older than the youngest, so it is true ½ A +2, then 4 years older than the youngest means ½ A + 4, then 3 years younger than the oldest, means A – 3. That is right. The sum is 80, which means….oh, this is wrong, adding up A. *Then he corrected the wrong count.* Found A = 22, *Then calculate the age of the other child and write it next to the known one.* Yes, ma'am, I am sure this is true P12: where did you get the numbers from? V12: the other age, the youngest ½ A = 11, the older brother is added by 2 = 13, then further added 4 = 15. The next one is 3 years younger than the oldest, so 22 – 3 = 19. The sum = 80. It is correct. P13: how can you be sure that it is true? V14: the number is 80, and the average is equal to 16	• The subject re-examined his work by sorting from what was known, what was asked, and the relationship between known variables and rechecking the truth. • To check his work, the subject, in addition to sorting his work, also by matching the results with what is known. • The subject knows there are other ways but can choose the right way.

Table 5. Interviews and cognitive processes and attitudes of Visual Subjects (V) questions (2)

Troubleshooting Steps	Interview/Questioning Process	Cognitive processes and attitudes of the subject
Understand the problem	P1: What do you know about this question? V1: It will be proved that ctg^2x is equal to $\frac{\cos^2 \frac{1}{2}x}{\sin^2 \frac{1}{2}x}$	• The subject's appearance is calm, and focuses on the problem while reading the question without voicing it. After finishing reading, he looks at the question like thinking. • Realizing that this problem will prove the trigonometric formula • Choose the formula that will be used

		• Understanding the direction to go
Make a plan	P2: How do you plan to prove this formula? V2: with ctg^2x, which means equal to $\frac{\cos^2 \frac{1}{2}x}{\sin^2 \frac{1}{2}x}$ Then Sin 2x is described, and it turns out that there are the same elements, 2 Sin x, removed, then crossed out.	• Knowing the direction to be taken, planning well
Carry out the plan	*Then do the proof as follows:* P3: Why is 2 sin x crossed out? V3: Because it is the same. P4: If it is crossed out like that, what operation do you use? V4: divided, ma'am P5: Why did you change the numerator and the denominator to such? Even though the quantifier and denominator both contain cos x V5: Because I want to prove the same as $\frac{\cos^2 \frac{1}{2}x}{\sin^2 \frac{1}{2}x}$, P6: Why is that? V6: Because $ctg^2 \frac{1}{2}x = \frac{\cos^2 \frac{1}{2}x}{\sin^2 \frac{1}{2}x}$ cos x in the numerator is replaced $2\cos^2 \frac{1}{2}x - 1$ while in the denominator is replaced, $1 - 2\sin^2 \frac{1}{2}x$ It is done, ma'am.	• Doing the proof as planned • perform formula simplification, and perform correct operations • Can you remember the required formula • Can choose the most appropriate formula
Look back	P7:When you are done, what do you do? V7: If it is a test, immediately do something else; when it is all finished, it is still time to re-examine it. P8:Are you sure it is true? V8: Yes, ma'am, it has been proven	• Re-examine his work by sorting from what is known, what is being asked, the relationship between known variables, and rechecking the truth.

Table 6. Interviews and cognitive processes and attitudes of Auditory Subjects (A) questions (1)

Troubleshooting Steps	Interview/Questioning Process	Cognitive processes and attitudes of the subject
Understand the problem	P1: When faced with a question, what is your first step? A1: Read first to understand the question P2: What do you mean by understanding the question? A2: Understanding the question so that you understand what is known and understand what is being asked *Read carefully, then write what is known as follows:* P3: Why did you write that? A3: Of all ages, there are variables related to the youngest. Suppose the youngest is x, and the others follow the rules that the youngest half of the oldest means the oldest is 2x, the other child is 2 years older than the youngest, so it is true that x+2, then 4 years older than the youngest means x+ 4, then 3 years younger than the oldest means 2x – 3. Known: average = 16 so sum of their ages = 16 x 5 = 80 P4: Then what is the goal? A4: To calculate the age of each child.	• The subject's appearance is calm while reading the question by voicing it. • Realize that to solve this problem, and one must understand what is known and what is asked by reading • Feel important to write what is known and asked • Understand the relationship between known data • Understand the required formula • Understanding data completeness • Reviewing the truth of the relationship between existing data
Make a plan	P5: How do you calculate the age of each child? A5: Children's ages add up, equal to 80	• add up the existing variables. • Do good planning
Carry out the plan	Then count.	• Perform calculations carefully according to the plan • linking between variables adjusted to what is known
Look back	*After checking again, the result is correct* P6: How to check it? A6: The ages of all children are added up, and it turns out to be true = 80 P7: Already? Sure it is, right? A7: Already, ma'am	• Re-examine the work by relating the known variables to recheck the truth.

Table 7. Interviews and cognitive processes and attitudes of Auditory Subjects (A) question (2)

Troubleshooting Steps	Interview/Questioning Process	Cognitive processes and attitudes of the subject
Understand the problem	P1: From this question, what information did you get? A1: Asked to prove	• The subject's appearance is calm while reading the question by voicing it. • understand what is known and asked by reading and voicing • Understand the relationship between known data and what will be proven
Make a plan	P2: What steps will be taken? A2: Sin 2x changed; there is a sin x in each term, removed, then crossed out.	• Choose the required formula • Realizing the direction to be taken, • do good planning
Carry out the plan	*After going through the steps, it comes to changing the numerator and denominator* P3: Why was it changed to this A3: To be a tan, the numerator must be a sine and the denominator a cosine. $tg^2 \frac{1}{2}x = \frac{\sin^2 \frac{1}{2}x}{\cos^2 \frac{1}{2}x}$ So that it is made so that the top one becomes a sine form and the bottom one becomes a cosine form P4: How? A4: cos x equal to $2\cos^2 ½ x - 1$ Equal to $1- 2\sin^2 ½x$ P5: Why so? A5 : Because $1 = \sin^2 ½ x + \cos^2 ½ x$ *Write this formula above, then continue the proof*	• Perform calculations carefully according to the plan • evaluate his work by connecting between variables adjusted to what is known
Look back	P6: It is finished? Sure it, right? A6: Already, ma'am. P7: Have you ever come across a problem like this? A7: I did, but I forgot. P8: Is there any other method? A8: Yes, but longer. This is what I remember, and it seems to be the shortest.	• Re-examine his work by relating the known variables to recheck the truth.

Table 8. Interviews and cognitive processes and attitudes of Kinesthetic Subjects (K) questions (1)

Troubleshooting Steps	Interview/Questioning Process	Cognitive processes and attitudes of the subject
Understand the problem	P1: When faced with a question, what is the first thing you do? K1: reading, ma'am P2: What for? K2: To know what is known and what will be counted *Read and write what is known* P3: Why write like that? K3: Yes. To make it easier to understand. For example, the children A, B, C, D, and E. Let us say that the oldest is x, the youngest half means ½ x, The brother is 2 years older, which means ½ x+ 2, the other brother 4 years older than the younger, means ½ x +4, then 3 years younger than the older means x - 3 *Then read again*	• The subject looked restless in a sitting position that could not be still, looked bored, and looked at the questions. • Subjects prefer to point to sentences containing important information using a ballpoint pen and read them many times, then try to make connections between them. • The subject linked to the information in the question and could explain it again when interviewed by the researcher. • understand what is known and what is not asked by reading and then writing it down • write down what is known • Aware of the link between data known. • Realized that he had to research again from the beginning for the correctness of the data • Looking back on the truth of the relationship between existing data
Make a plan	P4: What is your plan to solve this problem? K4: By using the average formula P5: How? K5: by adding up all divided by 5.	• Calculate the average by adding the existing variables and then dividing by the number of variables. • Planning well by connecting between variables adjusted to what is known
Carry out the plan	P6: How can you add and then divide by 5? K6: The average is the total divided by the number of data. So the known ages are added up and then divided by the number of children. So, 5 must be equal to what is known, that is =16	• Perform calculations according to the plan until the age of each is obtained
Look back	*After checking again, the result is correct* P7: After you are done, what are you doing? K7: Usually, I will check it out when it is all done. P8: How to examine it?	• Re-examine the work by looking at the relationship between known variables to check the truth by connecting the calculations one by one

K8: By sorting the calculation one by one, whether it is correct or not
P9: How about this one?
K9: Already correct, ma'am

Table 9. Interviews and cognitive processes and attitudes of kinesthetic subjects (K) question (2)

Troubleshooting Steps	Interview/Questioning Process	Cognitive processes and attitudes of the subject
Understand the problem	P1: From the following question, what do you know? K1: This question must prove the formula	• The subject looked restless in a sitting position that could not stay still and looked at the problem. • By reading, S3 knows that this problem is related to trigonometry, that is proving the formula
Make a plan	P2: How to do it? K2: By deciphering sin 2x first, then the same issue. Then divided by the same.	• Realizing the direction to be taken, the method is by deciphering sin 2x first, and then the same is issued. Then divided by the same.
Carry out the plan	*Then do as follows:* P3: Why was it crossed out? K3: Wrong, ma'am. It will not quickly lead to a tangent P4: Why did you replace it with $\sin^2 ½ x$ for the numerator and $\cos^2 1/2x$ for the denominator? K4: This, ma'am, the formula for cos 2x can be changed to something like this	• Remembering the formulas related to the known • Doing the proof as planned • Apply the necessary formulas • Can choose the most appropriate and fast way
Look back	P5: Are you sure it is right? K5: It is true, ma'am P6: Is there any other way to prove the truth? K6: There is, ma'am. But this is the shortest	• Convinced that the work is correct • Realize that there are other ways, but this one is the fastest

Table 10. Interviews and cognitive processes and attitudes of tactile subjects (T) questions (1)

Troubleshooting Steps	Interview/Questioning Process	Cognitive processes and attitudes of the subject
Understand the problem	P1: What is the first thing you do when faced with a problem? T1: reading, ma'am P2: for what? T2: To know what is known and what will be counted *After reading, immediately write down what is known by linking existing data.*	• The subject's appearance is relaxed while reading silently with moving lips, relaxed gaze, sitting position, and pointing to sentences or information considered essential. • The subject can know all necessary information on the

	The oldest age is 2 times the age of the youngest, so the oldest is A = 2E, then B = 4 + E, then C = 3 + E, then D = 2 + E, and the youngest E. P3: what will you look for? T3: each child's age	question after being given a provocation question, • Realize that to solve this problem, and one must understand what is known and what is asked by reading • Feel important to write what is known • Be aware of relationships between known data. But due to haste, what was written was wrong • Realizing that he had to research again from the beginning for the correctness of the data • Looking back at the truth of the relationship between the data and correcting the incorrect one
Make a plan	*Then started counting, but then he stopped. Moreover, cross out the calculations.* P4: Why stop? Why was it crossed out? T4: Looks like it is wrong *Reading again from the beginning and interpreting again, it turns out the previous example is wrong. Then write again what is known next to it.* P5: How do you calculate the age of each child? T5: Children's ages add up, equal to 80	• add up the existing variables. • Linking between variables adjusted to what is known.
Carry out the plan	Then count P6: Why was it crossed out? T6: Miscalculated, ma'am. This is the wrong number of E.	• Perform calculations according to the plan but are not thorough, so they feel that their work is wrong
Look back	*After checking again, the result is correct* P7: how to check? T7: The ages of all the children are added up and divided by 5 = $\frac{80}{5} = 16$ P8: Finished? Sure it is, right? T8: It has done, ma'am	• Re-examine the work by looking at the relationship between known variables to check the truth by connecting with the known

Table 11. Interviews and cognitive processes and attitudes of tactile subjects (T) questions (2)

Troubleshooting Steps	Interview/Questioning Process	The thought process and attitude of the subject
Understand the problem	P1: What do you think to understand this question? T1: Oh, ma'am, for trigonometry, I have not been able to do it, ma'am, because the first time I was explained about trigonometry, I was not admitted because I was sick. So until now, I do not understand, so when I look at trigonometry, I am already confused. P2: So what if you are confused? Want to do it tomorrow? T2: Okay, I will do it now	• The subject's appearance is relaxed while reading silently with moving lips, relaxed gaze, sitting position, and underlining sentences or information considered essential. • Realizing that this problem is a trigonometry problem • Feeling unsure of his ability to solve trigonometric problems
Make a plan	P3: Why was it crossed out? P4: wrong ma'am, it should be in $2x = 2 \sin x.\cos x$ Wait a minute, ma'am. I will try to remember the formula first *Then write down the formulas he remembers, which may be related to the problem, which can help him solve the problem*	• Realizing that in order to solve this problem, he must remember the formulas that may be related • Consciously write down the formulas used • plan well by relating what is known to a formula that may be useful.
Carry out the plan	P5: Why did you suddenly write like that? T5: $\cos x = 1 - 2\cos^2 ½ x$	• Doing calculations according to the plan but not being thorough, so actually, the work is still not quite right
Look back	P6: Are you sure it is true? T6: sure, ma'am.	• Since he was sure he was right, he did not re-examine

Table 12 summarizes the results of interviews and analysis of subjects with visual, auditory, kinesthetic, and tactile learning styles.

Table 12. Summary of Interview Results and Subject Analysis

Steps	Subjects with Learning Style			
	Visual	**Auditory**	**Kinesthetic**	**Tactile**
Understand the problem	The subject's appearance is calm, and focuses on the problem while reading the question without voicing it. After finishing reading, he	The subject's appearance is calm while reading the question by voicing it. Subjects prefer to point to sentences in the questions they read.	The subject looked restless in a sitting position that could not stay still and looked at the problem. He prefers to point to sentences containing important information using	The subject's appearance is relaxed while reading silently with moving lips, relaxed gaze, sitting position, and pointing to sentences or information considered

	looks at the question like thinking. Subjects distinguish between necessary and unnecessary information. Important information is underlined and rewritten. The subject tries to make information relations by connecting with variables. When the researcher interviewed the subject, the subject could retell important information obtained.	The subject sorts the information into meaningful and unimportant information. The subject underlines essential information on the question but does not re-record it. The subject tries to make connections between the existing information by connecting with arrows When the researcher interviewed the subject, the subject could re-explain the vital information obtained.	a ballpoint pen, read it many times, then try to make connections between the information. Subjects make links to the information contained in the questions and can explain again when interviewed by the researcher.	necessary. The subject prefers playing with his left hand with the eraser and pencil. After being given a provocation question, the subject can know all the essential information.
Make a plan	The subject's appearance is calm and focuses their attention on the question sheet. The subject makes a problem-solving plan by analyzing all the data to obtain a solution. The subject considers what is known to be sufficient to solve the problem, based	The subject's appearance is calm, focusing on the problem while thinking by talking, then writing the solution step by step. The subject makes the steps to be implemented. Subjects choose the required formula and can choose the most appropriate formula.	The subject's appearance could not be calm, especially the sitting position changing intermittently, looking at the questions, and holding the paper while thinking. He often played with a ballpoint batted against the table and wiggled his legs back and forth. The subject makes a problem-solving plan by focusing on what is asked	The subject's appearance is relaxed, immediately writes the solution while playing with a pencil, and gives a unique mark to the problem. The subject makes the steps to be done, Important information is written. Subjects write down formulas that may be useful.

	on a problem-solving plan, by analyzing all data to obtain a solution.		through the relevant data. The subject considers what is known to be sufficient to solve the problem based on searching the relevant data.	
Carry out the plan	The subject's appearance is calm and focuses their attention on the question sheet. The subject performs calculations and proves The subject can choose and use the formula correctly and relate what is known to what is asked; although he was less precise in his calculations, he eventually realized it immediately.	The subject's appearance is calm while thinking by paying attention to the problem and speaking in a voice, then looking up and at the question alternately with blinking eyes. The subject performs calculations/pro ofs carefully so that there are no miscalculations or proof errors	The subject's appearance, primarily his feet and hands, cannot be silent. The subject writes down the solution gradually. Subjects make steps to be implemented, Moreover, it checks the plan because it turns out the information written is wrong, and the subject does the calculations.	The subject's appearance is relaxed and immediately writes down the solution. To perform calculations, he prefers to knead the eraser with his left hand or play with it. The subject performs calculations/prov es
Look back	The appearance of the subject is calm and focuses attention on the question. He prefers to use the index finger of his left hand to point to information on the problem. The subject re-examined his work by writing in order from what was known, what was asked, and the relationship	The subject is calm while paying attention to the problem and talking, looking up and at the question alternately, with blinking eyes; the subject is thinking about the solution for a while, then writes down the solution. The subject re-examined his work by writing in order from	The subject's appearance can not be still while holding the paper and paying attention to the problem. Subjects prefer to write solutions without performing accurate calculations. The subject re-examines what is done by checking its accuracy. The subject understands that	The subject's appearance is relaxed while reading silently, lips moving, pausing as if thinking, then writing down the solution step by step. Subjects review their work by checking their accuracy by rechecking their correctness. The subject understands that to check the

between known variables and rechecked the truth. To check his work, the subject, in addition to sorting his work, also by matching the results with what is known. The subject knows other ways but can choose the right way.	what was known, what was asked, and the relationship between known variables and rechecked the truth. The subject knows that to check his work is to match the results with what is known.	to check the results of his work is to adjust the results with known information.	results of his work is to adjust the results with what is known. For the question of proof, the subject did not evaluate or re-examine because he was sure he was right.

Discussion

From the summary of the results of interviews and analysis obtained, it can be seen that subjects with different learning styles will respond differently. The visual appearance of the subject is calm and focuses on the problem while reading the question without voicing it. After finishing reading, he looks at the question as if thinking.

Visual subjects distinguish information into needed and unneeded information in understanding the problem. Important information is underlined and rewritten. This follows the opinion of Dunn & Dunn (1993) that when solving problems, students' visual path is to read information and make notes about any problems or obstacles they face.

Planning problem solving, visual subjects make plans by analyzing all data in order to obtain solutions. This finding is in line with the statement of De Porter (2000: 85). Subjects who have a visual learning style require an integrated description and purpose and capture in detail, remembering what is seen.

In the problem-solving plan, visual subjects can choose and use formulas appropriately and relate what is known to what will be obtained. This finding is in line with the statement of Dunn & Griggs (1988), which said that visual subjects very often understand what to say, even though they are not good at conveying through words.

In re-examining the answers obtained, the visual subject re-examines their work by writing sequentially what is known, what is being asked, the relationship between known variables, and rechecking its accuracy. This finding is in line with Dunn & Dunn's (1993) statement that students with visual learning styles tend to be neat and orderly and not affected by the existing noise. However, they have difficulty receiving verbal instructions and following the results of Hidayah, Kusumaningsih & Prasetyowati's (2020) research that the critical thinking ability of visual subjects is better than auditory subjects.

This is also in line with Radiusman & Simanjuntak's (2020) research that subjects with a visual learning style can carry out problem-solving steps better than auditory and kinesthetic subjects. Turmuji, Kurniati & Azmi (2021) say that the highest scores for the ability to understand mathematical concepts were obtained on visual and auditory subjects. Gunawan, Harjono & Imran (2016) conclude the results of their research that mastery of subject concepts is influenced by learning styles; visual students have higher conceptual mastery than students with other learning styles.

Furthermore, the appearance of the auditory subject is calm while reading the question by voicing it. In understanding the problem, the subject can explain the critical information that has been obtained.

This is in line with Dunn & Dunn (1993) that the auditory subject can re-explain important information obtained and likes to discuss and explain everything at length.

In making a problem-solving plan, the auditory subject can choose the formula needed and the most appropriate formula. This is in line with Dunn & Dunn's (1993) statement that auditory subjects can learn faster through verbal discussion and listening to what the teacher says, and also following Laamena's opinion (2019) that auditory subjects will pay attention to the problem again, recalling what has been learned after the teacher's explanation.

In the problem-solving plan, the auditory subject carefully carries out calculations/evidence so there are no miscalculations or errors of proof. This is in line with the opinion of DePorter & Hernacki (2016) that auditory students can remember the material discussed in groups or classes well.

To re-examine the results obtained, the auditory subject re-examines the results of his work by writing sequentially from what is known, what is asked, and the relationship between known variables and re-examines its accuracy by voicing it. Auditory subjects know that to check the results of their work is to adjust the results with what is known. This is in line with DePorter & Hernacki's (2016) opinion that written information sometimes has minimal meaning for auditory subjects. This is also in line with the research results of Afnia & Setyawan (2021) that auditory students can achieve two steps of critical thinking correctly and precisely, the step of developing basic skills and the conclusion step, while kinesthetic students can work only at the stage of basic skills in solving mathematical problems.

Furthermore, the appearance of the kinesthetic subject looks restless in a sitting position that cannot be still, looks bored, looks at the problem, and holds objects around him. In understanding the problem, the kinesthetic subject reads the question many times, makes connections to the information in the question, and can explain it again when the researcher interviews. This follows the opinion of Dunn & Dunn (1993) that kinesthetic subjects need much practice and learning by requiring all the five senses: eyes, feelings, tongue, nose, ears, and much use of the laboratory, and is also following the results of Saija's research (2020) which says that kinesthetic subjects learn more effectively by using their bodies as a whole.

Kinesthetic subjects make a problem-solving plan by focusing on what is asked through relevant data. The kinesthetic subject makes the steps to be carried out and checks the plan. If it turns out that the information written is wrong, then the subject does the calculations. Kinesthetic subjects re-examined the results obtained by re-examining their accuracy. This is in line with the results of Nurjannah's research (2019), which concluded that kinesthetic subjects answered questions very coherently and full of explanations, so the answers were long.

The appearance of the tactile subject looks relaxed, often wringing his stationery, ballpoint, pencil, and eraser. This follows the opinion of Dunn & Dunn (1993) that tactile-style learners can learn better if they use their fine motor skills to take notes by making their writing style (notes) so that what they write is easier to remember. In understanding the problem, the tactile subject records essential information, but the tactile subject can know all necessary information on the problem after being asked about a provocation. In planning problem-solving, tactile subjects write formulas that may be useful. Carry out problem-solving plans, and tactile subjects carry out calculations. Tactile subjects re-examine their work by re-reading the truth.

4. CONCLUSION

The cognitive process of students solving mathematical problems differs between students with visual, auditory, kinesthetic, and tactile learning styles.

Visual students calm down, understand the problem by reading the problem without voicing it, underlining and re-recording important information, making a problem-solving plan by analyzing all data to obtain a solution, implementing a problem-solving plan by selecting and using formulas appropriately, and able to relate what is known with what is being asked, re-examine the results obtained by re-examining the results of their work by sorting from what is known, what is being asked, the relationship between known variables and rechecking the truth.

Auditory students are calm, understand the problem by reading the question and voicing it, can re-explain important information that has been obtained, make a problem-solving plan by choosing the required formula and be able to choose the most appropriate formula, carry out the problem-solving plan by doing calculations/evidence carefully, so that there are no miscalculations, or proving errors.

Kinesthetic students cannot calm down, look like they are bored, understand the problem by reading the question many times and making connections to the information in the problem and can explain it again when interviewed by the researcher, make a problem-solving plan centered on what is asked through relevant data, planning problem solving by taking steps to be carried out, checking the planning, if it turns out that the information written is wrong, then the subject performs calculations, re-examines the answers obtained by re-examining his work by rechecking its correctness.

Tactile students look relaxed, often wring their writing utensils, ballpoints, pencils, and erasers, and understand problems by recording important information. However, all vital information on questions can be known after being given provocation questions, planning problem-solving, writing formulas that may be necessary, implementing the problem-solving plan, doing calculations, and re-examining his work by re-reading his work.

Based on the results of research showing differences in students' cognitive problem-solving processes, it is recommended that teachers pay attention to these findings as input for developing learning models that accommodate differences in students' perceptual learning styles so that students find it easier to learn and solve problems.

For visual students, it is recommended that teachers use visual materials such as pictures, diagrams, maps, and colors to underline essential things, invite students to read illustrated books, use multimedia, and illustrate their ideas in pictures.

For auditory students, it is recommended that teachers invite students to participate in discussions both in class and in the family, encourage students to read the subject matter aloud, discuss ideas with students verbally, let children record the subject matter, and encourage students to listen to it again.

For kinesthetic students, it is suggested that the teacher not force students to study too long, invite students to learn while exploring their environment, and increase field practice.

For tactile students, it is recommended that teachers allow students to learn while touching or holding objects they want, do demonstrations or simulations of a process, create models or illustrations, and multiply simulations and role-playing.

The thing that has not been considered in this study is students' ability because it is difficult to find students who are strong in one aspect of perceptual learning styles. Therefore, it is recommended that further research be conducted on the relationship between students' mathematical abilities and their learning styles. This study also recommends further research into making learning tools based on student learning styles.

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