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An Ability of Mathematical Connection in Trigonometric Problem- solving Viewed from The Tenth Grade Students' Mathematics Logical Intelligence

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Abstract. A Mathematical connection is students' ability in connecting various concepts, principles, and skills they have. An ability of mathematical connections enables them to do analytic and synthetic reasoning. The subjects of this study are the tenth grade students of SMA Negeri 2 Magetan who have different mathematics logical intelligence. The results of this study are as follows: (1) students with high mathematics logical intelligence work smoothly by using mathematical connections ability; (2) students with medium mathematics logical intelligence are working on problem-solving by making some errors in finding connections and relationships of various mathematical structures; and (3) students with low mathematics logical intelligence are unable to make connections and relationships between different mathematical structures.

Keywords: Mathematical connections, mathematical logical intelligence, trigonometric problem solving

INTRODUCTION

Mathematics in formal education becomes one of the very urgent learning activities for learners. Based on Permendiknas No. 22 Year 2006, the purpose of mathematics subjects are among others as follows: (1) understanding mathematical concepts, explaining inter-connections and applying concepts or algorithms flexibly, accurately, efficiently, and appropriately in problem- solving; (2) solving the problems that include the ability to understand problems, design mathematical models, solve models and interpret the solutions obtained. Krulik and Rudnick (in Carson, 7: 2007) states: Problem- solving as a tool or media so that an individual uses the knowledge, skills, and understanding acquired earlier to meet the needs of the new situation.

As an educator, it is important for a teacher to know the student's response in solving the problem. The teacher is able to determine the errors made by the students. Errors that have been observed can be used as a source of information to improve the students and teachers quality in learning activities. Related to mathematics learning, the trajectory of mathematical connection becomes an integral part in mathematical problem- solving. The mathematical connection expressed by the National Council of Teacher of Mathematics (NCTM) states that mathematical connections help students expand their perspective, view mathematics as an integrated part of topics, and recognize the relevance and application of both inside and outside the classroom.

Another factor that affects students' success in solving mathematics problems is their intelligence level. This is in accordance with the opinion of Charles and Lester in Jauhara (2010: 3) which states that there are 3 aspects that influence mathematical problem- solving, namely: (1) Cognitive aspect, including conceptual knowledge, understanding and strategies to apply the knowledge; (2) Affective aspect, an aspect that influences the student's tendency to solve problems; (3) Metacognitive aspect, including the ability to organize their own thoughts.

Gardner (2007: 3) states that intelligences are the ability to solve problems or create a product value in society. One of them is mathematics logical intelligence. Mathematics logical intelligence is the ability of a person to calculate, measure, use numbers, solve mathematical problems, think deductively and inductively, and create patterns and logical relationships in everyday life. Based on the results of the research, students' mathematical

connection ability still has some deficiencies. The existence of this study underlies the researcher to perform a preliminary study on the students of SMA Negeri 2 Magetan conducted on 8 to 9 January 2016 about how students' mathematical connection ability in solving trigonometric problem. Based on the results of written preliminary study on the subject of CTR obtained the results that students are able to make problem- solving steps, but they are still not able to relate various mathematical concepts in solving trigonometric problem. This study aims to know students' mathematical connections ability in solving trigonometric problems based on mathematics logical intelligence level.

RESEARCH METHODOLOGY

The type of research is qualitative descriptive research. This research was conducted on the even semester of the X-11 class of SMA Negeri 2 Magetan which consists of 30 students. Students were given 2 written tests. The first test was used to divide students into three categories base on mathematics logical intelligence, namely high, medium, and low mathematics logical intelligence. Each group was selected 2 students with good communication skills as the subject of the research. With good communication skills, they are expected to express what the research objectives are. Furthermore, the six subjects were given a second test in the form of trigonometric problems that are used as interview guidances to know mathematical connections ability in each category.

This research is divided into three stages, namely preparation stage, implementation stage, and analysis stage. In the preparation stage, the activities undertaken are preparing research instruments, agreement with the mathematics teachers relating to the research subjects and the time of the research. The instruments of this research are the main instrument in the form of mathematics logical intelligence test and supported instrument consisting of two instruments, namely trigonometric problem, and interview guidance.

The main instrument in this study is a mathematics logical intelligence test consisted of 40 items. This test is base on the blueprint of mathematics logical intelligence which is validated by the experts. The first and second supported instruments are trigonometric problems and interview guidances that are used to determine students mathematical connections ability in trigonometric problems. Interview guidances consist of questions outline that explores students mathematical connections ability in solving trigonometric problems.

In the implementation stage, the researcher gives a mathematics logical intelligence test completed in 60 minutes. Problem-solving 1 and 2 are tested for 30 minutes done on different days. Each subject solved the problem does an interview to dig information relating to the mathematical connection ability in solving the given problem.

The results of the trigonometric problems solving test are analyzed using indicators set by the researcher. The analysis stage is done after obtaining the data collection from the written data and subjects interview. Validation used in this research is the time triangulation. According to Sugiyono (2008: 127), time triangulation is a technique of checking the validity of data by conducting an interview, observation, or other techniques in different times and conditions. The objectives of this study are to make problem-solving strategies by connecting different concepts/ topics, and students' skills in connecting various concepts as the implementation of a problem-solving stage. While for the step of interview analysis, there are three stages, namely data reduction, data presentation, and conclusion.

RESULTS and DISCUSSION

1. Analysis

According to the results of mathematics logical intelligence test, then the researcher choose the research subjects. The selected students as the research subjects are described in the following table.

TABLE 1. Research subject

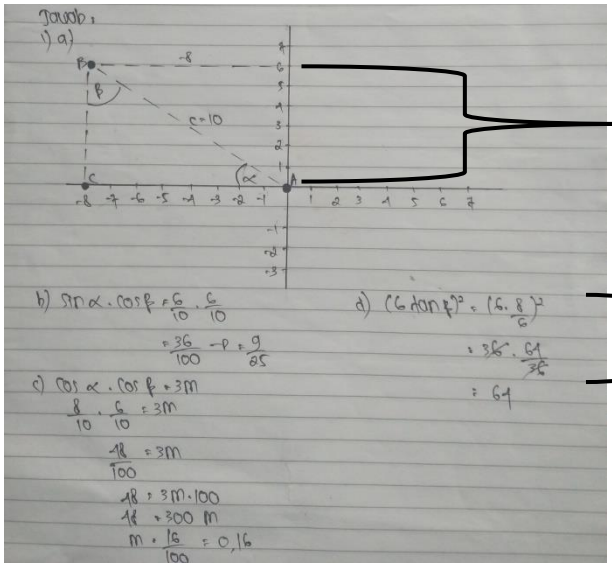
Student Initial	Score	Level	Subject Code
ARS	75	High	H1
MHD	72,5	High	H2
ASD	67,5	Medium	M1
ZPN	62,5	Medium	M2
SHL	42,5	Low	L1
AJN	35	Low	L2

After sampling, the researcher gives the trigonometric problem- solving test. The test used to know students' mathematical connection ability is examined into 2 parts. After the implementation of the trigonometric problem-solving test, the researcher conducts an interview with the subject. The first data was taken in the library of SMAN 2 Magetan and divided into three sessions. The first session, the collecting data were obtained by giving problem-solving items. Then, it was followed by a structured interview conducted on 21, 27, and 28 April 2016. The following is the result of the interview analysis on the first trigonometric problem- solving.

Subjects H1 and H2 understand the trigonometric problem- solving items and are able to explain well the information of the problem. Both subjects are able to plan the solution clearly and systematically. H1 solves the first problem by relating the Cartesian coordinate concept, Pythagoras theory, and the right triangular trigonometric comparison concept. Following is an excerpt of an interview with subject H1:

> Researcher: How do you plan the solutions based on the information and questions you know from the question?
>
> Subject H1: The first one is drawing, after the image is done , then we specify the oblique side of the triangle (elbow), and then determine the value of its sin, cos by using the formula.

The subject H1 does the calculation in solving the given problem correctly. The following is the result of the students' work by connecting some mathematical concepts in the trigonometric problem- solving:



Students are able to make the connection between the concept of coordinate system and Pythagoras theory in solving the problem.

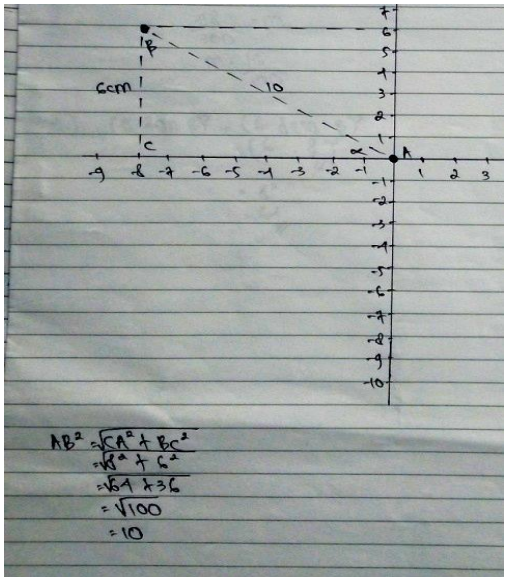
After finding all the required information, students are able to make mathematical connections between the triangle information (triangle edges, triangular corners) with the knowledge of the trigonometric comparison.

FIGURE 1. The results of the subject H1 answer on the first question.

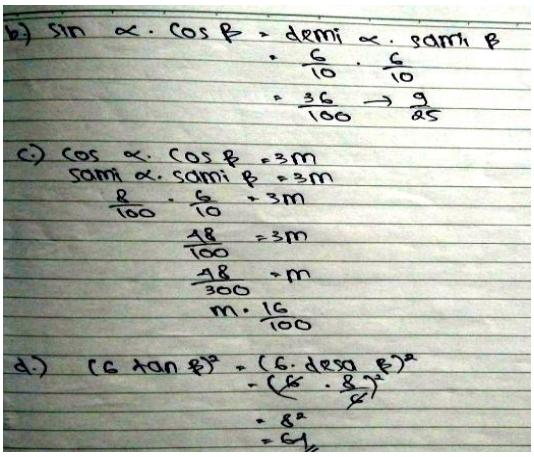
Subject H2 explains that to solve the problem, the information of coordinate points is used to create images. Then, it can determine the trigonometric comparison value. Following is an excerpt of an interview with subject H2:

> Researchers: Please explain the relationship of information contained in the item to the question given!
>
> Subject H2: These coordinate points are used for drawing, then after the drawing is complete, it can just take the next step.
>
> Researcher Explain how do you mean by that next step?
>
> Subject H2: After we get the triangle image, we find all sides, then used to find the value of sin, cos and tan (by formula).

Subject H2 does calculations correctly and precisely in solving the given problem. He is able to explain precisely the relationship of some concepts in the form of problem- solving. Here is the calculating result of the subject H2 in solving the first problem.



(a)

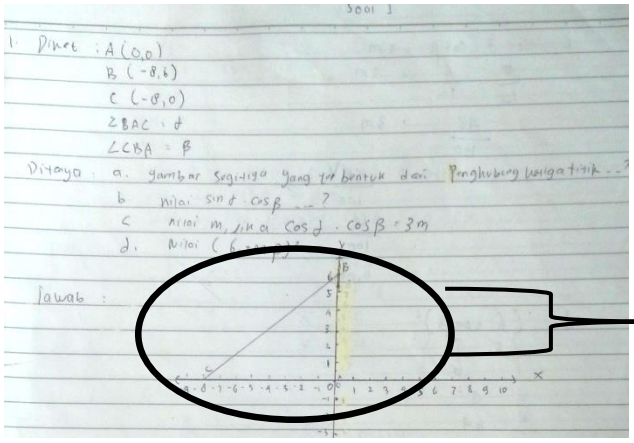


(b)

FIGURE 2. The results of subject H2 answer on the first question.

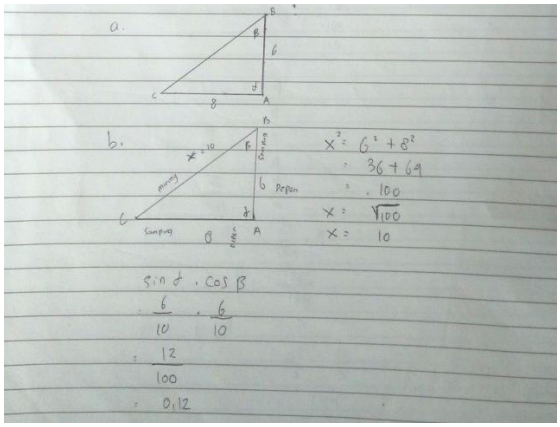
Based on Figure 2 (a), subject H2 is able to create a relationship between the image concept with the phytagoras formula to find the right triangle side skew. Furthermore, on figure (b) the H2 is able to use the trigonometric comparison formula and do algebra calculation appropriately.

The results of the interview with the subjects who have medium mathematics logical intelligence show that the subject M1 knows the supporting information and questions on the problem. He says that to solve the problem needs to connect the various knowledge. The required knowledge is the drawing concept on the Cartesian coordinates field, Phytagoras theory to find the side skew, then the formula of trigonometric comparison. In the problem- solving process, M1 makes an error in drawing on the Cartesian coordinates field. The following is the answer of the M1.

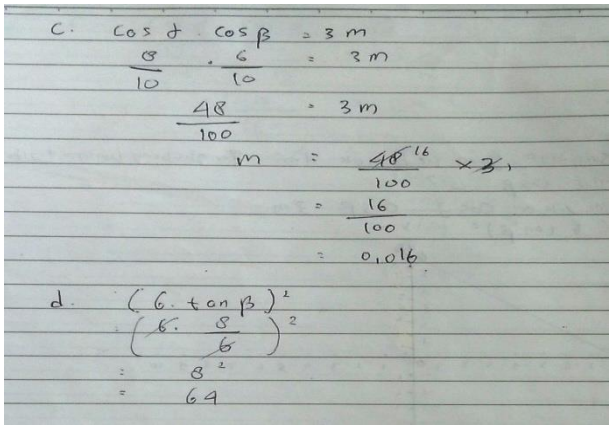


(a)

Subject M1 made a drawing error on the Cartesian coordinate field. Based on the work of the M1 subject, it shows that he is fluent in relating the various mathematical concepts to the plan, but the final outcome is less appropriate.



(b)

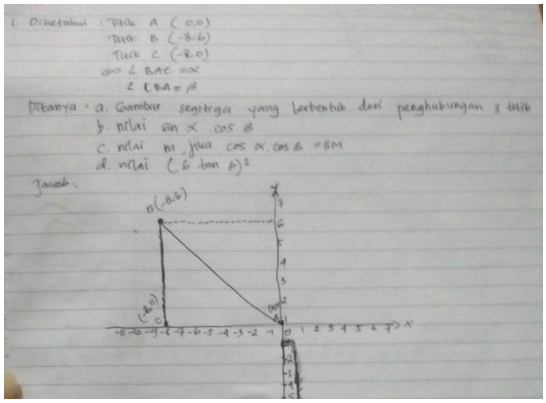


(c)

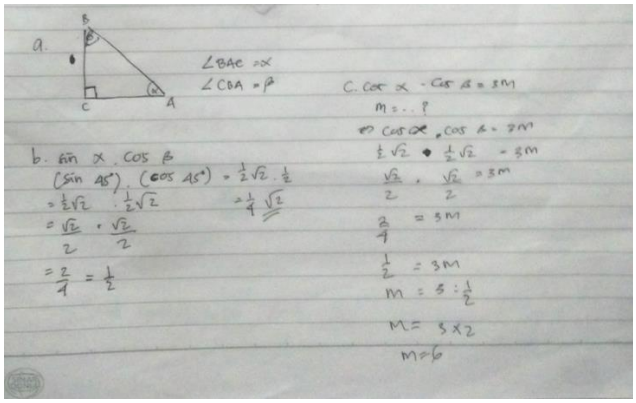
FIGURE 3. The result of the M1 answer on the first question.

Based on images (b) and (c), the subject shows a calculation to find the side skew of the right triangle, then he relates the triangle concept with the trigonometric comparison concept.

Subject M2 understands and plans the problem by mentioning the supporting information and focusing on the question. At the problem- solving stage, subject M2 draws in the coordinate field precisely, but after the image is drawn, he can not relate the knowledge of right triangle with the trigonometric comparison concept of right triangle. He does not know that the next step is to look for the oblique side of the right triangle. Furthermore, subject M2 uses the trigonometric comparison concept of the special angle because he finds difficulty in determining the formula used to solve the given problem. Following is the result of the student's work:



(a)



(b)

FIGURE 4. The result of the M2 answer on the first question.

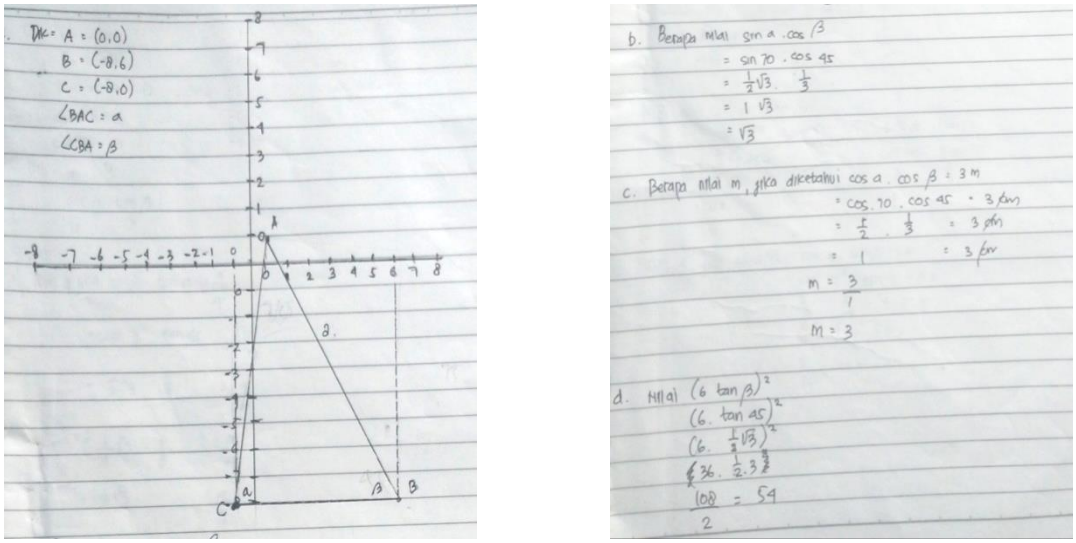
Based on the figure (a), M2 subject is able to make the relationship between the information in the problem and the drawing concept on the coordinate field. In figure (b), M2 subject shows a calculation to find the length of the AB side of the ABC triangle. However, he makes an error concept to determine the trigonometric comparison value in the question.

The subjects with low ability, L1 and L2 are able to know the supporting information and focus on problem-solving given. However, subject L1 has difficulty in planning problem- solving. He does not know what mathematical concepts and topics used after drawing in the field of Cartesian coordinates. Subject L1 states that after finishing drawing on the field, the next step is to find a large angle. The interview of L1 is as follow:

Researcher: What is the relationship of the information on the problem to the question in that problem?
Subject L1: Firstly, we are told to draw based on this coordinate point,
Researcher: Then what next?
Subject L1: After drawing, then determining the angle
Researcher: The point is to determine how big the angle is?
Subject L1: From the image formed we determine the angle to answer questions 1b, 1c, and 1d.

In the problem- solving step, the subject makes an error in drawing on the coordinate field. He is not able to make the relationship of various mathematical knowledge to solve the trigonometric problem. Subject L1 states

that in solving the problem, he only guesses it in determining the completion formula. Here are the results of the L1 subject's work:



(a) (b)

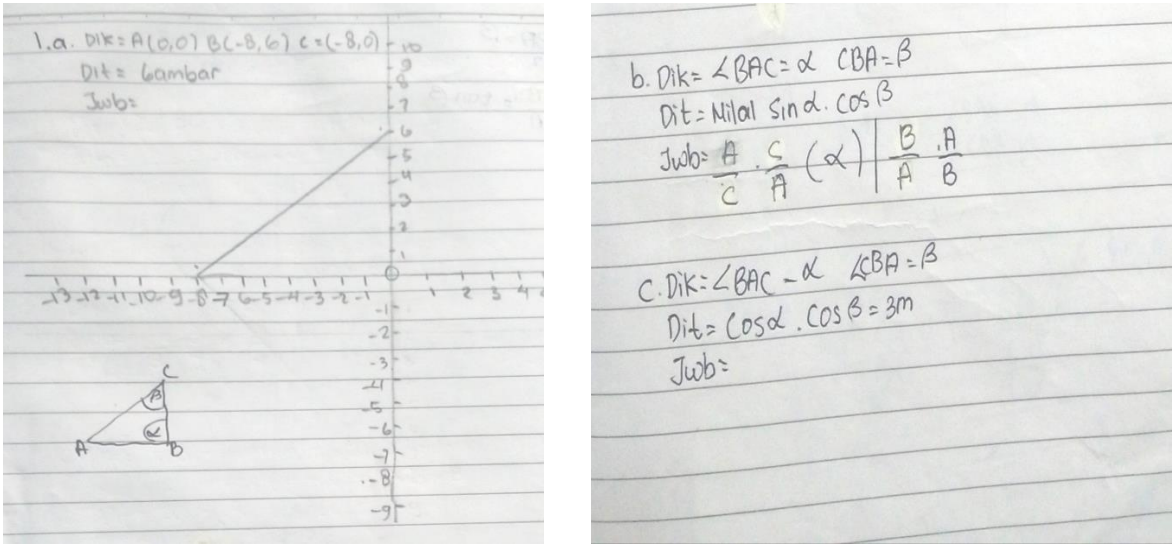
FIGURE 5. Results of the L1 Subject answer on the first question.

Based on the image (a), it shows that L1 does not know the relationship between the supporting information and the questions presented in the problem. While in the image (b) the subject makes an error in using the concept to answer the question.

Subject L2 makes many errors in solving the problems. He can not create images in the Cartesian coordinates appropriately. He also can not make the relation of various mathematical concepts to solve the problem. Subject L2 does not know what concept will be used to solve the given problem. The following is the result of the interview with the subject L2.

Researchers: Do you think this triangle image is right?
Subject L2: Hehe .. yes (subject looks hesitant with the answer)
Researchers: In addition to drawing this triangle, what other concepts do you use in solving this problem?
Subject L2: Hehhe ... .. (Subject L2 shakes his head / indicates his ignorance)
Researcher: Do not know huh? Then how can you do this?
Subject L2: Logic mr (only alleged subject L2 that the concept used is ordinary multiplication)

Here is the result of student work in solving the problem.



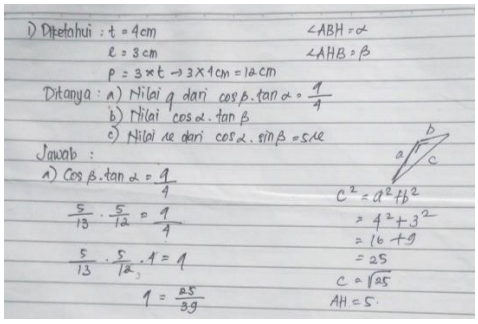
(a) (b)

FIGURE 6. The results of the H1 answer on the first question.

Figure (a) shows that student can not understand the concept of drawing on the Cartesian coordinates field. While the image (b) shows that the student is working on the given problem by doing algebra multiplication without the final result.

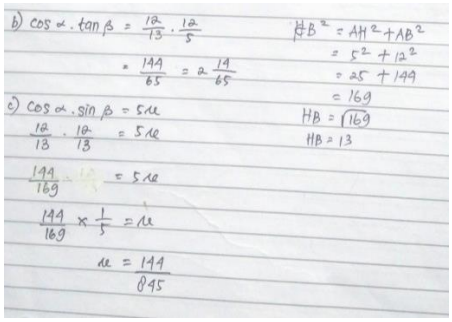
Furthermore, in the second part, the researcher gives the second problem of the trigonometric comparison test to each research subject. This is done to obtain valid data with time triangulation. The subject is asked to work on the second trigonometric comparison problem which is isomorphic with the previous problem. The second data collection by giving problem- solving items is followed by the interview conducted in Classroom XII IPS 3 SMAN 2 Magetan. This data collection was conducted on 4, 12, and 18 May 2016. The data collection steps on solving this second trigonometric problem are the same as the first steps. The following is the result of the interview analysis with the subject on the second trigonometric problem- solving.

Subjects H1 and H2 are able to understand, explain information and know the focus of questions in the second trigonometric problem. Both subjects were able to plan the solution clearly and systematically. H1 solves a second problem- solving by using a bound mathematical connection ability. He connects the diagonal knowledge of the field and the diagonal of the space with the trigonometry knowledge and subsequently shows the mathematics calculation correctly. Here are the results of the H1's work on the second question:



(a)

Subject H1 shows AH side length calculations using pythagoras theory. Subject H1 understand diagonal concept in the field, so subject H1 can seek length side of AH.



(b)

After obtaining length of AH, in figure (b) this subject searches the length of HB which is the diagonal of space from ABCD beam. EFGH by using Pythagoras theory concept. Then he links the knowledge about the sides and angles of the triangle ABH to determine the value of the trigonometric comparison.

FIGURE 7. The results of the H1 answer on the second question

Subject H2 solves the second problem- solving well. Just like subject H1, subject H2 connects the diagonal concept of the field, and the space diagonal to find the sides of the triangle ABH. He explains that the steps to solve the problem are by connecting knowledge of the diagonal field with Pythagoras theory, as well as looking for the length of the BH side which is one of the diagonal spaces of the beam. Based on the calculation, H2 uses the comparison formula of right triangle trigonometry. Having obtained *sin*, *cos*, and *tan* values from α and β angles, then the subject performs an appropriate algebra operation.

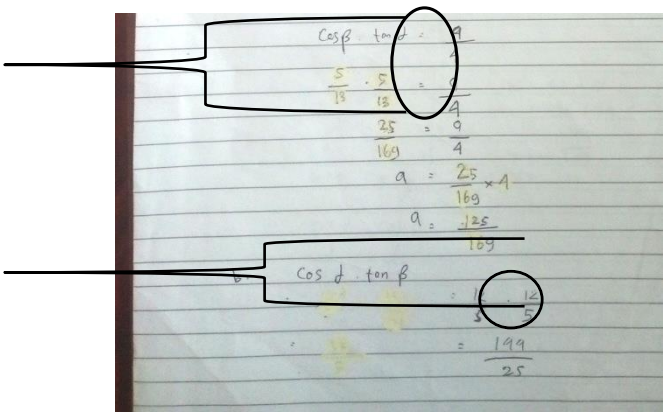
The result of the interview with the subject M1 related to the second question indicates that the subject M1 uses the information of the problem. M1 relates knowledge of the diagonal field and the diagonal of space to find the lengths of the AH, and BH side of the triangle ABH appropriately. Then, he connects the information from the triangle ABH with the concept of right triangular trigonometric comparison. However, he makes an error in determining the value of *tan α* and *cos α*, as a result it causes miscalculation of problems 1a, and 1b. The student's error is shown in figure (a) below:

The subject error in determining the trigonometric comparison value of tan α. It should be a value of

$$\tan\alpha = \frac{5}{12}$$

Similarly, the value of cos α should be

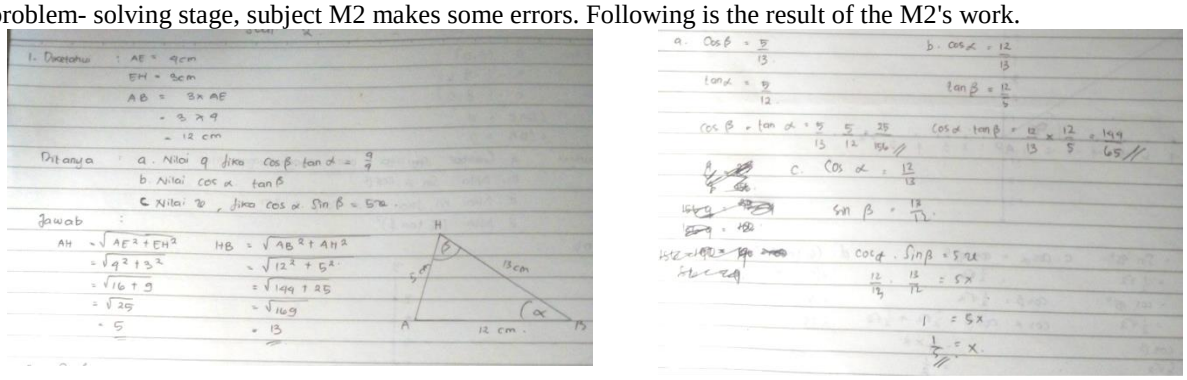
$$\cos\alpha = \frac{12}{13}$$



(a)

FIGURE 8. The result of the M1 answer on the second question

Basically, subject M2 understands and plots the problem by mentioning supporting information on the trigonometric problems. M2 says that in planning he must use various mathematical concepts. The concepts he used are the diagonal concept of the beam, the Pythagoras formula, as well as the trigonometry concept. However, when solving the problem, he is careless in doing the calculation, so the final answer is not appropriate. At the problem- solving stage, subject M2 makes some errors. Following is the result of the M2's work.



(a) (b)

FIGURE 9. The result of the M2 answer on the second question

From the image (a), the subject of M2 shows the triangle side ABH calculation by using the information on the ABCD.EFGH beam correctly, whereas in image (b) subject M2 makes error calculation because it is not complete in writing item 1a.

The subject writes item 1a with, $\cos\beta.\tan\alpha =$

It should be, $\cos\beta.\tan\alpha = \frac{q}{4}$

The second error made by the subject is in answering question 1c. M2 makes an error in the count operation.

The answer result of the subject with low mathematics logical intelligence on the second problem indicates that the subjects L1 and L2 can understand the information of the problem well. L1 in the problem- solving stage, finds difficulty to solve the problem because it can not make the connection between the knowledge in the problem and the question. L1 says that in solving this second problem, he only uses trigonometry material , and the subject also does not understand the material. Subject L1 solves this second problem by using the concept of special angular trigonometry. Here is an excerpt of an interview with the subject.

Researchers: Do you think the information on this question is enough to answer the question?

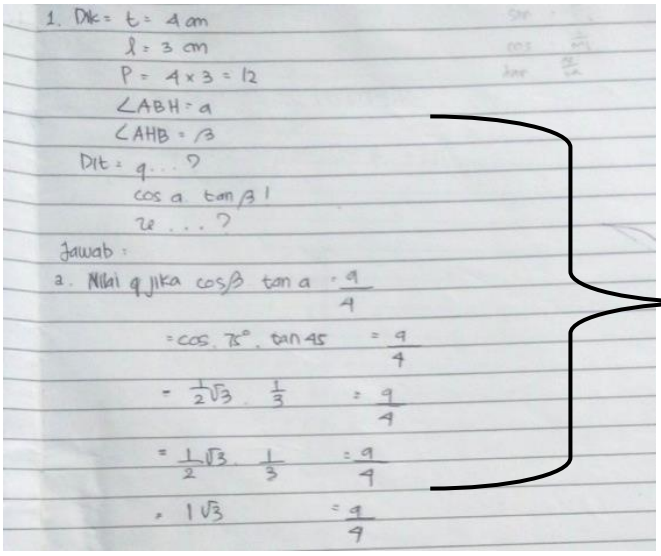
Subject L1: Not yet (not enough)
Researcher: Not yet, why is that? Please explain!
Subject L1: Because I do not know *sin*, *cos* and *tan* formula
Researcher: If you do not know, how can you solve this problem?

Subject L1: This uses the cos sin formula in physics lessons

Researcher: What is a special angular trigonometric formula ?, then how can you set cos 75º with half root three?

Subject L1: I just guessed the answer (inconsequential).

The following figure (a) is the answer of subject L1 in solving the second problem of trigonometry:

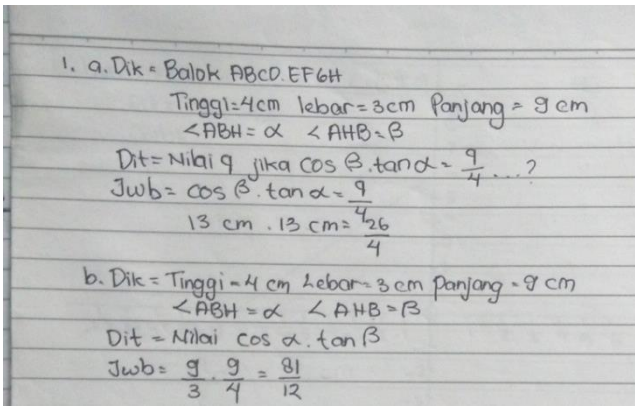


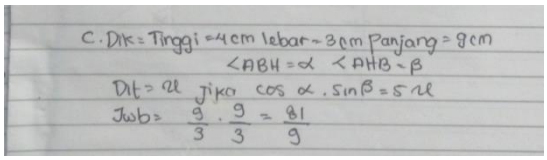
Subject L1 can not relate the existing knowledge to the problem with other mathematical concepts. L1 uses the knowledge he recalls only, that is, about the concept of special angular trigonometry.

(a)

FIGURE 10. The result of the L1 answer on the second question

Subject L2 makes an error in determining the concept used to solve the second problem. He can not determine what concepts related to the existing questions. In completing the second problem, L2 says using the length, width and hight of the beam to determine the final result. He does not understand the proper completion step. Here are the results of the L2's work in solving the second trigonometric problem:





(a) (b)

FIGURE 11. The result of the L2 Subject answer on the second question

Figure (a) shows that subject L2 can not make the exact completion step. He uses the information about the length, width, and height of the beam to determine the *sin, cos,* and *tan* values of α and β angles. L2 says if the solution remembered is using a comparison, he forgets which formula to use. Figure (b) also shows the same steps by the L2 subject in solving the second trigonometric problem.

2. Discussion

From the results of the research above, subjects with high category do mathematical connections from the information contained in the matter with other mathematical knowledge. Subjects in the medium category, at the first step, they connect with various mathematical concepts well, but they make errors in the process of coordinate

concepts and calculation of algebra. Subjects with low categories can not make mathematical connections, they are false in determining the concepts used to solve problem- solving. In addition the low category subjects do not seem to understand the concept of trigonometric comparison correctly. In the low category, it is in accordance with a research conducted by N.K. sari, Budiyono, T. Wibowo who stated that students have not been able to make connections between mathematical concepts correctly. While to improve mathematical connections ability is choosing the right method of learning as the research result from D.K. Zaenab (2010) who states that students mathematical connection ability with contextual learning will be better than conventional.

CONCLUSION

This research has one problem formulation, that is to know mathematical connection ability in trigonometric problem viewed from 3 categories of mathematics logical intelligence. After the research, the discussions are completed, the researchers give conclusions. The conclusions are:

Of the two trigonometric problems given, students with high categories are able to create connections or relationships of various mathematical concepts. They can plan and do problem- solving appropriately. Then, the students in the medium category are able to make relationships of various mathematical concepts. However, they do some errors in the calculations and understanding the concept. At least not the last, subjects with low categories, they do not understand the concepts used to solve the problem. They also can not make connections from various mathematical concepts in solving trigonometric problems.

It becomes very important for teachers to use appropriate learning methods according to the mathematical problems faced by the students. Like doing exercises about trigonometric problem- solving on a regular basis. By doing a lot of practices, the students will get used to understanding the concept and making connections between related concepts in solving trigonometric problem.

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