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The Quality of Mathematical Proficiency in Solving Geometry Problem: Difference Cognitive Independence and Motivation

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Abstract

Mathematical proficiency is essential to supporting students' success in learning mathematics. It is the ability to use conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition in problem-solving. Cognitive independence shows students' ability to process information. Meanwhile, motivation is related to things that encourage students to learn mathematics. This study aims to determine the effect of cognitive independence and motivation on mathematical proficiency. It involved 131 students and used a mixed method with Sequential Explanatory Design. The quantitative research part of the study was used to determine the effect of cognitive independence and motivation on mathematical proficiency using a multiple linear regression test. Furthermore, qualitative research was used to deeply scrutinize the effect by using in-depth interviews. The results showed that students with high cognitive independence could process the knowledge that has been possessed logically, while students with low cognitive independence did it illogically. Students with low motivation use trial and error strategies to maximize mathematical proficiency, while students with high motivation use analytical strategies.

Keywords: level of independence, level of motivation, mathematical proficiency.

Introduction

Students encounter different problems in their everyday life. Students need to be helped to develop their mindset by learning mathematics effectively and efficiently. Students' experience in using the mindset to overcome difficulties in learning mathematics will play an essential role in solving problems in their everyday life. Solving mathematical problems makes students use their thinking skills more actively to deal with new situations and focus on understanding mathematical ideas (Budayasa, 2019). Forming students' mindsets is important to the success of mathematical learning. Therefore, it is important to know the factors that influence the development of students' mindsets in learning mathematics.The mindset of students in learning mathematics can be developed by increasing their mathematical proficiency (Awofala, 2017). Mathematical proficiency is the ability of individuals to solve problems faced using understanding, computation, application, reasoning, and involvement (Groves, 2012). Mathematical proficiency has been studied for a long time, starting with the use of mathematical proficiency to determine the ability of elementary electronic school students to complete math tests (McCann, 1975). Furthermore, mathematical proficiency is the knowlwdge, skills, competencies, and facilities in using mathematics to solve problems (Kilpatrick, 2001). The aspect of mathematical proficiency used in this study is as described by Kilpatrick (2001) because it can fully explain students' mathematical proficiency in learning mathematics.

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solve problems (Kilpatrick, 2001). The aspect of mathematical proficiency used in this study is as described by Kilpatrick (2001) because it can fully explain students' mathematical proficiency in learning mathematics.

Mathematical proficiency consists of five strands which are interconnected with each other, namely conceptual understanding, procedural fluency, strategic competence, adaptive reasoning and productive dispositions (Kilpatrick, 2001). Conceptual understanding relates to the understanding of concepts, operations, and their relationships (Awofala, 2017). Procedural fluency is related to the skills possessed in implementing procedures flexibly, efficiently, and in accordance with the context (Awofala, 2017). Strategic competence is the ability to understand and formulate, determine, represent, and solve problems (Rahman et al., 2022). Adaptive reasoning is a mental activity connecting several concepts, facts, and procedures (Syukriani et al., 2017). Productive disposition is related to a positive attitude and the ability to realize mathematical values (Ramos et al., 2015). Success in learning mathematics can be demonstrated by the simultaneous use of these components.

The better students apply mathematical proficiency, the more problem-solving skills will increase (Ramos et al., 2015; Qiu & Wu, 2019; Awofala, 2017; Khalil & Alnatheer, 2020). Conversely, mathematical skills that are not well developed will be an obstacle to student success in learning because students can have difficulty thinking and have poor performance in school (Barham, 2020). The strategies that students use can determine their success in solving the problems encountered. Students who use strategies appropriately can understand concepts in mathematics and give concrete meaning to abstract mathematical statements (Juniati & Budayasa, 2017). Several researchers showed how to develop mathematical proficiency, such as using mathematical modeling tasks (Corrêa, 2021) and using innovative matrix strategy and the problem tree strategy (Jawad, 2021). However, it was still found that mathematical proficiency did not develop well. As in solving problems, only the ability of procedural fluency and productive disposition had a significant effect on other skills that had no impact (Awaji, 2021). Therefore, it is necessary to examine the description of factors that influence mathematical proficiency in solving mathematical problems.

One of the factors that can affect students' ability to solve problems is cognitive independence (Juniati, 2022). Cognitive independence is a method used in managing stimuli or information related to the process of remembering knowledge possessed to solve problems (Sudia & Lambertus, 2017). Moreover, cognitive independence affects the ability to solve mathematical problems (Son & Fatimah, 2020). Cognitive independence, on the other hand, is a characteristic of students in processing information to remember, think, and solve problems encountered. Individuals with high cognitive independence have more advanced analytical thinking skills (Liu, 2013)we use innovative full-text citation analysis along with supervised topic modeling and network-analysis algorithms to enhance classical bibliometric analysis and publication/author/venue ranking. By utilizing citation contexts extracted from a large number of full-text publications, each citation or publication is represented by a probability distribution over a set of predefined topics, where each topic is labeled by an author-contributed keyword. We then used publication/citation topic distribution to generate a citation graph with vertex prior and edge transitioning probability distributions. The publication importance score for each given topic is calculated by PageRank with edge and vertex prior distributions. To evaluate this work, we sampled 104 topics (labeled with keywords, while individuals with low cognitive independence can be more successful in the structured setting, which, guides them (Yuan et al., 2011). Differences in cognitive independence will show differences in cognitive strategies, namely more intuitive (low cognitive independence) or analytical (high cognitive independence) styles (Cuneo et al., 2018). Cognitive independence can provide differences in how to solve simple and complex problems (Juniati, 2022). Therefore, it is important to conduct research related to the effect of cognitive independence on mathematical proficiency in solving problems.

Another factor that affects students' ability to solve problems is motivation. Motivation is an impulse that arises from within students to provide readiness to achieve predetermined goals (Jawad, 2021). In increasing student learning motivation, strategies are needed in the process of learning mathematics. Motivation in learning can help students use the right strategies in applying known mathematical concepts to solve problems (Juniati & Budayasa, 2021). Motivation in learning is the summation of all impulses that come from within the students which cause the achievement of the desired goals (Bernardo, 2019). Likewise, motivation has a relationship with students' ability to solve problems (Cheung & Kwan, 2021). Therefore, it is important to conduct research related to the effect of motivation on mathematical proficiency in solving problems.

High school students aged 15-17 can be regarded as individuals who are prepared to face problems in their daily lives. Based on Piaget's theory, every child aged 13-17 years belongs to formal operational stage, namely children who can start thinking logically and abstractly (Babakr et al., 2019). Students within that age range are individuals who study in high school. Furthermore, mathematical proficiency is abstract thinking skills that can be developed in high school students.

One of the materials in mathematics at the high school level that needs attention is geometry. Solving geometric problems may be a difficult task for students, and they often feel that way in learning mathematics (Yeo, 2009). The forms of difficulty are understanding the problem, choosing the right strategy in solving the problem, modeling the problem situation, and applying calculations based on the formula that is chosen correctly (Haviger & Vojkůvková, 2014). Problem-solving using drawing strategies can help students in solving geometry problems (Juniati & Budayasa, 2022). The differences in the strategies used affect students' ability to represent answers to the questions given (Suliani et al., 2022). In addition, the difficulty is to relate the basic concepts of geometry that are already known to the problem situation (Alghadari et al., 2020).

Research on the effect of cognitive independence on mathematical proficiency is still not numerous. Still, some have been done, such as qualitative research related to the effect of cognitive independence on strategic competence (Son & Fatimah, 2020) as well as the ability of strategic competence and productive disposition (Rahman et al., 2022). Student motivation has an influence on students' ability to solve problems (Mailizar et al., 2020). However, research on the effect of motivation on mathematical proficiency has never been done before. Therefore, this study deals with the effect of cognitive independence and motivation factors on mathematical proficiency. Cognitive independence is related to how to select and process information, while motivation is related to students' drive to learn mathematics.

Mathematical proficiency is important for students to use in solving mathematical problems as students will learn how to use effective and efficient strategies in formulating problem situations, in choosing the right concepts and formulas to solve problems correctly, and in justifying them logically and know their usefulness in everyday life. Therefore, the mathematical proficiency indicator in this study refers to these aspects. Based on the results of research related to cognitive independence and motivation, most of them have an effect on problem-solving and only a few examine their influence on mathematical proficiency. Based on the results of research related to geometry, a question has been raised whether or not the problem applies to all of high school students. Therefore, this study aims to determine the effect of cognitive independence and motivation on students' mathematical proficiency in solving geometry problems. This research is hoped to contribute to the teaching of mathematics. Furthermore, teachers can seek learning activities that support students who have low cognitive independence and low motivation to achieve better success in mathematics.

Method

Research Design

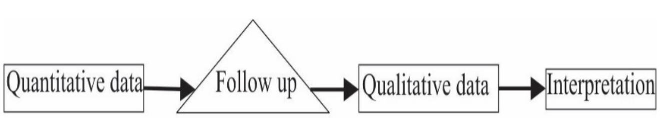


Fig. 1: Explanatory sequential design

The research method used was a mixed method, while the design is Sequential Explanatory Design. Mixed methods relate to the methods used for the collection, analysis, and presentation of quantitative and qualitative data (Creswell, 2009). Sequential Explanatory Design is carried out by collecting and analyzing quantitative data based on the results obtained, then collecting and analyzing data and explaining the results obtained qualitatively (Creswell, 2009). This research was carried out in two stages: first, quantitative data collection was carried out with the aim of determining the effect of cognitive independence and motivation on students' mathematical proficiency. After being analyzed by a multiple linear regression test, the second data collection was carried out qualitatively to explain in more detail the mathematical proficiency of students in solving problems with different cognitive independence and motivation using semi-structured interviews.

Participants

The sample selection in this study used a random sampling cluster technique, which groups all students based on age, namely aged 15 years old, 16 years old, and one student aged 17 years old. Then 131 students were selected from each cluster using simple random sampling. To deeply explore the effect of cognitive independence and motivation on mathematical proficiency of the subjects, qualitative research was conducted, and the subjects were selected using purposive sampling, which considered the ability of students to communicate and willingness to be interviewed. Four different subjects were selected for their level of cognitive independence and motivation. One subject has high cognitive independence and motivation (SHIM), another with high cognitive independence and low motivation (SILM), another with low cognitive independence and high motivation (SDHM), and the other subject with low cognitive independence and low motivation (SDML).

Data Collection Tools

The Group Embedded Figure Test (GEFT) is used to see the level of students' cognitive independence. GEFT can be used to examine students' ability to focus on finding simple shapes in complex drawings. The GEFT in this study was adapted from (Juniati, 2022). GEFT, in this study, consisted of 3 parts. The first part had seven questions to be answered in 2 minutes. The second part consisted of 9 questions to be answered in 5 minutes. Finally, the third part had nine questions to be finished in 5 minutes. Students who obtained a score of 0-9 were grouped on low cognitive independence, while students with a score of 10-18 were grouped on high cognitive independence. Based on the results of the agreement of three people consisting of experts in the fields of mathematics education, language, and psychology as well as the results of the trial, GEFT can be declared valid and reliable with a Cronbach alpha value of 0.912. Therefore, it is feasible to use.

Motivation questionnaires were used to find out students' motivation on learning and solving mathematical problems. The motivation questionnaire was used to group the samples into two groups, namely high motivation and low motivation. The low motivation group was students who incurred an average value of mathematics anxiety from 1 to 2,6 while the high motivation group consisted of students who had an average value of motivation incurred more than 2,6 (Juniati, 2022). The questionnaire uses closed questions totaling to 10 items with a Likert scale to show how students are motivated with a score of 1 for never, a score of 2 for rarely, a score of 3 for often, and a score of 4 for always and used was an instrument adapted from (Abramovich et al., 2019). This questionnaire has ten items consisting of four items related to encouragement from within students, four items of encouragement from parents, and two items of encouragement from the environment. Based on the results of experts' approval and the trial, motivation questionnaires can be declared valid and reliable with a Cronbach alpha value of 0,891. The motivation questionnaires in this study are shown in table 1.

The mathematical proficiency test used was a test consisting of 10 questions about geometry and based on a nationally standardized curriculum. The materials used are trigonometric ratios, the principles of a plane and spatial figures relating to distances and angles between points, lines, and planes, the concept of the equation of a circle, and the nature of the tangent to a circle. Here, the students' mathematical proficiency is looked up on the aspects of understanding the problem in order to choose the suitable concept, representing the problem to choose the right procedure, solving the problem to apply the procedure correctly, justifying problem-solving, and having a good attitude in problem-solving. The score that the students would get was based on the ability to fulfill these aspects. When students were not able, they were given a score of 0. If students were less able then they were given a score of 1. Lastly, when students are able, they were given a score of 2. Based on the results of experts' approval and the trial, the mathematical proficiency test can be declared valid and reliable with a Cronbach alpha value of 0,788. Therefore, it is feasible to use.

The mathematical problem used in this study was a problem that contained geometric material arranged by adding information that could interfere with students' ability to solve the problem. The subjects were given two problems, which are: a bottle has a circular base with an acute angle on top and contains water but is not full and when the acute angle is above, the distance from the surface of the water is 10 cm, and when the circle is above, the distance from the surface of the water is 6 cm. The problem in question is to know the height of the bottle. Based on the results of experts' approval and the trial, mathematical problem solving can be declared valid and reliable with a Cronbach alpha value of 0,612. Therefore, it is feasible to use.

Mathematical proficiency questionnaires were used to determine students' attitudes towards learning and solving mathematical problems. The mathematical proficiency questionnaire used close-ended questions totaling 16 items with a Likert scale to show how often students have mathematical proficiency, with a score of 1 for never, a score of 2 for rarely, a score of 3 for often, and a score of 4 for always and adapted from the research of (Cerbito, 2020). Each questionnaire consisted of 4 items to determine the self-confidence of students in solving problems, mathematical usefulness, perseverance possessed by students and enjoyment in learning mathematics. Based on the results of experts' approval and the trial, mathematical proficiency questionnaires can be declared valid and reliable with a Cronbach alpha value of 0,859. Therefore, it is feasible to use.

Data Collection

All participants were given a mathematical proficiency test and then grouped into two groups based on the GEFT score and filling out a motivational questionnaire. Then the scores obtained by participants in these groups are sorted from high

Table 1: The motivation questionnaires

Aspect	*Sub Aspect*	*question items*
Intrinsic motivation	Reaching dreams	• I believe I can achieve my dream by studying geometry
	Getting math test scores	• I study geometry to get good grades
	mathematics usefulness	• I stop trying when I have difficulty solving geometry problems • I'm not interested in learning geometry because it's just memorizing formulas
Extrinsic motivation	Parents	• I am supported by my parents to learn geometry • I was provided with facilities by my parents to learn geometry • I have parents who don't care about the facilities for learning geometry • Parents don't care about the results I get in studying geometry
	Neighborhood	• The neighborhood where I live provides a comfortable atmosphere for learning geometry • The people around where I live are too noisy when it's time to study geometry

to low. Participants who will be interviewed are selected based on the results of the sequence, namely high and low levels of cognitive independence and high and low motivation levels.

Data Analysis

The quantitative data obtained were analyzed using a multiple linear regression test to determine the effect of cognitive independence and motivation on mathematical proficiency. Multiple linear regression testing shall explain the effect jointly between cognitive independence and motivation on mathematical proficiency. Multiple linear regression is a regression model that involves more than one independent variable. After that, qualitative data was obtained based on interview transcripts, the results of solving mathematical problems, and the results of filling out mathematical proficiency questionnaires. The steps taken for the qualitative analysis are data categorization, data reduction, data presentation, and drawing conclusions (Miles, 2018). The indicators of mathematical proficiency in this study are shown in table 2.

Table 2: Indicators of mathematical proficiency

Aspect	*Sub-aspect*
Conceptual understanding	• Strategy of choosing a concept that is appropriate to the problem situation • Understanding the characteristics of a concept that appropriate the problem situation
Procedural fluency	• Strategy of choosing the right formula • Applying the calculation correctly
Strategic competence	• Strategy of understanding the problem situation • Strategy of representing the problem • Strategy of solving the problem
Adaptive reasoning	• Justifying the reasons for choosing the strategy used
Productive dispositions	• Self confidence of Learning Mathematics • Enjoyment of learning mathematics • Usefulness of learning mathematics in daily life • Diligence of learning mathematics

Table 3: Descriptive Statistics on Mathematical Proficiency, Cognitive Independence and Motivation

Variable	*Minimum*	*Maximum*	*Mean*	*Std. Deviation*
Cognitive Independence (X1)	2	18	7,52	2,26
Motivation (X2)	10	39	3,01	0,17
Mathematical Proficiency (Y)	20	100	49,21	12,26

Findings

The Effect Of Cognitive Independence And Motivation On Mathematical Proficiency

The quantitative research part of the study was used to determine the effect of cognitive independence and motivation on mathematical proficiency. The results obtained by the participants can be seen in table 3.

Based on table 3, it is obtained that the average mathematical proficiency is 49,21 with a maximum score of 100, and thus it is classified as fairly high, with the lowest value being 20 and the standard deviation which shows an average deviation of 12,26. The result of the cognitive independence obtained has the lowest value of 2 and the standard deviation of 2.26. In addition, the average value of cognitive independence is 7,52, with a maximum score of 18. Therefore, it can be said that the average participant is classified as having a low level of cognitive independence. The result of motivation obtained has the lowest value of 10 and a standard deviation of 0,17. The average value of anxiety is 3,01. Therefore, it shows that the students often use their motivation to support learning mathematics and working on mathematical problems.

Multiple linear regression analysis was used to determine the effect of the independent variable, namely cognitive independence and motivation, on the dependent variable, namely mathematical proficiency. The following are shown the results of multiple linear regression analysis using SPSS 20.

Table 4 shows the effect of independent variables (cognitive independence and motivation) on dependent variables (mathematical proficiency). The simultaneous relationship between cognitive independence (X1) and motivation (X2) to mathematical proficiency (Y) is shown by the regression model Y = 18,979 + 2,483X1 + 0,405X2. This indicates that when cognitive independence and motivation are zero, the student's estimated mathematical proficiency is 18,979.

Table 4: The Results of Multiple Linear Regression Coefficient Analysis of Cognitive Independence and Motivation on Mathematical Proficiency

Model		*Unstandardized Coefficients*		*Standardized Coefficients*		
B		*Std. Error*	*Beta*		*T*	*Sig.*
1	(Constant)	18,979	4,886		3,885	0.000
	Cognitive independence (X1)	2,483	0,457	0,458	5,434	0.000
	Motivation (X2)	0,405	0,193	0,177	2,095	0.038

a. Dependent Variable: mathematical proficiency (Y)

The cognitive independence variable (X1) that has a calculated T value of 2,434 and a significant value of 0,000 smaller than the significant level of 0,05 means that the cognitive independence variable (X1) has an influence on mathematical proficiency. The regression coefficient for cognitive independence (X1) is 2,785 and the regression model for mathematical proficiency (Y) is 18,979 + 2,483X1 with a 95% confidence level. The regression model found that mathematical proficiency is positively and significantly influenced by the cognitive independence, meaning that the increasing cognitive independence of students also increases mathematical proficiency.

The motivation variable (X2) has a calculated T value of 2,095 and a smaller significant value than the significant level, meaning that the motivation variable (X2) influences mathematical proficiency. The regression coefficient for motivation (X2) is 3.567, and the regression model for mathematical proficiency (Y) is 18,979 + 0,405X2 with a 95% confidence level. In the regression model, it was found that motivation affected mathematical proficiency positively and significantly. This indicates that the motivation of students also increases mathematical proficiency.

Based on table 6, the value of multiple R is 0,568 and in table 5, it is obtained a value smaller than its significant level of 0.000 so that it can be concluded that cognitive independence and motivation simultaneously affect mathematical proficiency. In table 6, the R square value is 0,323, which shows that 32,3% of cognitive independence and motivation simultaneously affect mathematical proficiency while 67,7% explain other things.

To ensure the validity, the data must be normally distributed and experience symptoms of homoscedasticity and analyzed using multiple linear regression. The normal probability plot graph is used to determine normal-distributed data, which can be seen in the figure 2.

Figure 2 shows that the distribution plot of mathematical proficiency values is around the normal line. Therefore, it can be concluded that mathematical proficiency data is normally distributed. Homoscedasticity is used to determine whether the residuals related from one observation to another are fixed. The scatter graph plots mathematical proficiency data can be seen in Figure 3 below.

Figure 3 shows that there is no special pattern, and the points are evenly distributed above and below zero on the X axis as well as left and right on the Y axis. It can be concluded that there is homoscedasticity between independent variables (cognitive independence and motivation) in the regression model. Based on figures 1 and 2, it is obtained that the mathematical proficiency data is normally distributed and evenly distributed so that the regression model is feasible to use.

Table 5: Analysis of variance Based on Multiple Regression Analysis of Cognitive Independence and Motivation on Mathematical Proficiency

Model		*Sum of Squares*	*Df*	*Mean Square*	*F*	*Sig.*
1	Regression	6299.998	2	3149.999	30.467	0.000b
	Residual	13234.017	128	103.391		
	Total	19534.015	130			

a. Dependent Variable: mathematical proficiency (Y)

b. Predictors: (Constant), cognitive independence (X1), motivation (X2)

Table 6: The Results of Multiple Linear Regression Coefficient Analysis of Cognitive Independence and Motivation on Mathematical Proficiency

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.568a	0.323	0.312	10.16812

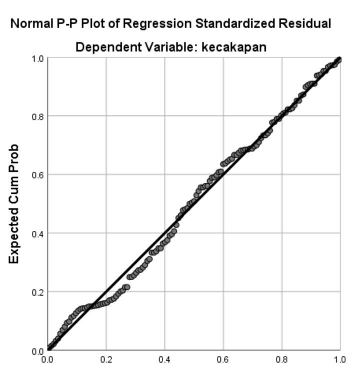


Fig. 2: Normal Distribution Plot

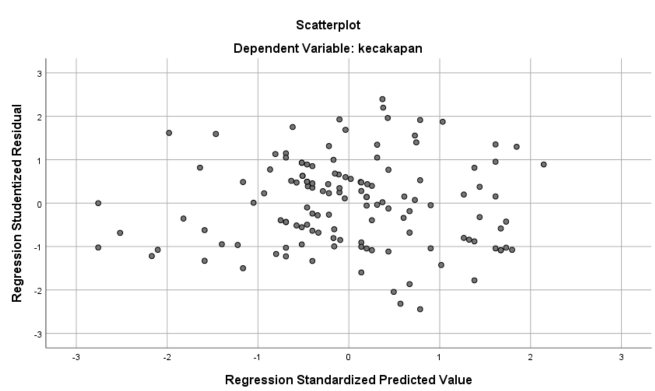


Fig. 3: Residual Scatter Plot Graph

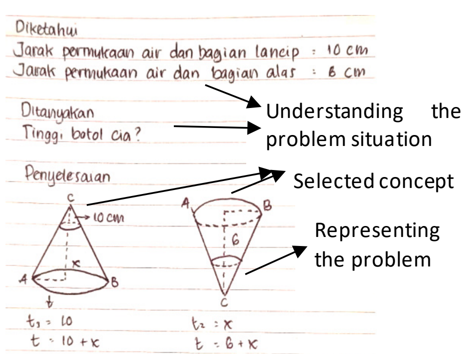
Based on several descriptions that have been explained, it can be concluded that there is a significant influence between cognitive independence and motivation on mathematical proficiency. If the higher the value of cognitive independence and the score of motivation is obtained, the mathematical proficiency used in solving the problem will increase.

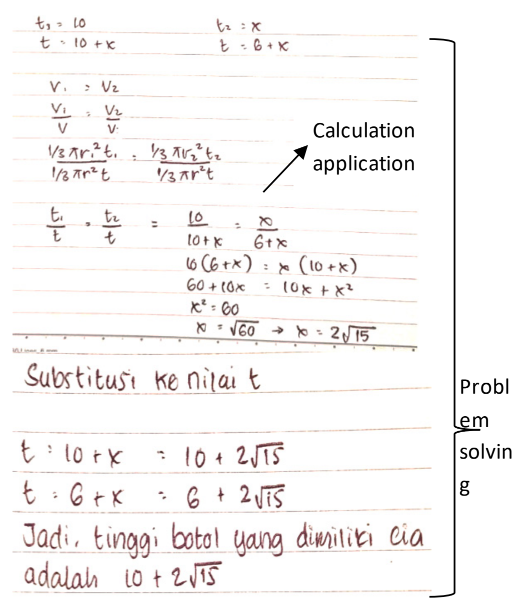
Description of The Effect of Cognitive Independence and Motivation on Mathematical Proficiency

Data collection was carried out by providing a mathematical question about strategies for the move from one point on the ground to a diagonal point through interviews with the subjects based on the results of solving questions on mathematical proficiency questionnaires.

Student who has high levels of cognitive independence and motivation (SHIM)

SHIM often uses mathematical proficiency in solving problems but has not used them fully in dealing with the problem of solid shapes geometry. SHIM can fully understand the problem situation with the strategy of reading and imagining the contents of the problem, namely the distance between water and the peak point in the first position is 10 cm, the distance between water and the pedestal part in the second position is 6 cm, and the problem in question is to know the height of the bottle. SHIM can justify logically that the strategy is appropriate because of the way it is always used. SHIM chose the concept of a cone by imagining the information contained in the complete problem situation, namely the bottle pedestal is circular and has a peak point. SHIM justified logically that the strategy has been used frequently. SHIM justified logically that the characteristics of the cone obtained are in accordance with the knowledge possessed, namely having a circular pedestal, having a cylinder, a point, the diameter of the pedestal, the radius of the pedestal, and the height of the line. SHIM represented the problem situation with an incomplete image that did not obtain an appropriate cone comparison. SHIM justified the strategy because it has been done often. SHIM imagined the relationship between concepts and known information, and it was obtained the cone volume and similarity. SHIM justified logically that the strategy is in accordance with the knowledge possessed. SHIM solved the problem analytically but incompletely by drawing two cones with the same side length comparison and then comparing the volume. Therefore, the comparison of height in the first position is the same as that in the second position. SHIM applied calculations to the formula, namely by compiling the volume and density formulas, $\frac{v}{v_1}=\frac{v}{v_2}$ with v is the volume of the cone, v1 is the volume of the cone that is not filled with water in position 1, v2 is the volume of the cone that is not filled with water in position 2. Therefore, the value of height in the first position is $10+2\sqrt{15}$ and in the second position is $6+2\sqrt{15}$. SHIM justified logically that the strategy is in accordance with the knowledge possessed. SHIM concluded that the height of the bottle is $10+2\sqrt{15}$ cm. SHIM justified that the solving strategy is in accordance with the knowledge possessed. SHIM's mathematical proficiency process can be shown in the following figure 4.





Translation :
Known :
distance between the water surface and the taper = 10 cm
distance between the water surface and the base = 6 cm
Asked :
Cia bottle height = … ?
Solving :
substitution to value t
Thus, the height of the bottle that Cia has is
$10+2\sqrt{15}cm$

Fig. 4: SHIM's Mathematical Proficiency Process in Solving Problem

Student who has high independence and low motivation (SILM)

SILM rarely uses mathematical proficiency in solving problems. The subject had not used mathematical proficiency to the maximum in dealing with the problem of solid-shaped geometry. In the process of solving the problem of solid-shaped geometry, SILM understood the problem situation completely by reading, imagining, and describing the problem situation related to the distance of the water surface with the peak, the distance between the water and the pedestal, and the height of the bottle. SILM could justify logically that the strategy is already often used. SILM chose the appropriate concept by fully imagining the shape of the bottle, namely the cone. SILM justified logically that the strategy has been used frequently. SILM justified the problem logically but incompletely based on the knowledge possessed that the characteristic of the cone is a circular pedestal, has a peak point, a height, and a pedestal diameter. SILM represented the concept and problem situation by describing it incompletely because it is not related to the volume of the cone. Logic justification of the strategy used can facilitate the process of solving the problem. SILM chose the Pythagoras formula using the strategy of imagining the shape of the cone looking like the shape of the isosceles triangle in an incomplete way. SILM justified logically that the strategy is in accordance with the knowledge possessed. SILM did an incomplete calculation by equalizing the cone sides in the first and second positions. SILM could not justify logically that the given strategy provides appropriate results. SILM solved the problem intuitively by trying several formulas that can be used so that the bottle's height is 11 centimeters. SILM justified that the strategy in solving the problem is in accordance with the knowledge possessed. SILM's mathematical proficiency process can be shown in the figure 5.

Student who has low independence and high motivation (SDHM)

SDHM often uses mathematical proficiency in solving problems but has not used them fully in dealing with the problem of solid shapes geometry. SDHM fully understood the problem situation by reading, imagining, and describing the problem situation related to the shape of the pedestal of the bottle, the distance between the apex point and the surface of the water, the distance between the pedestal and the surface of the water, and then the problem in question was the height of the bottle. SDHM could justify logically that the strategy is already often used. SDHM fully described the problem situation so that the subject was able to choose the appropriate concept, namely the cone. SDHM justified logically that the strategy has been used frequently. SDHM also justified the problem logically but not completely based on the subject's knowledge that the characteristic of cones is to have the radius of the pedestal, height, pedestal diameter, and apex point.

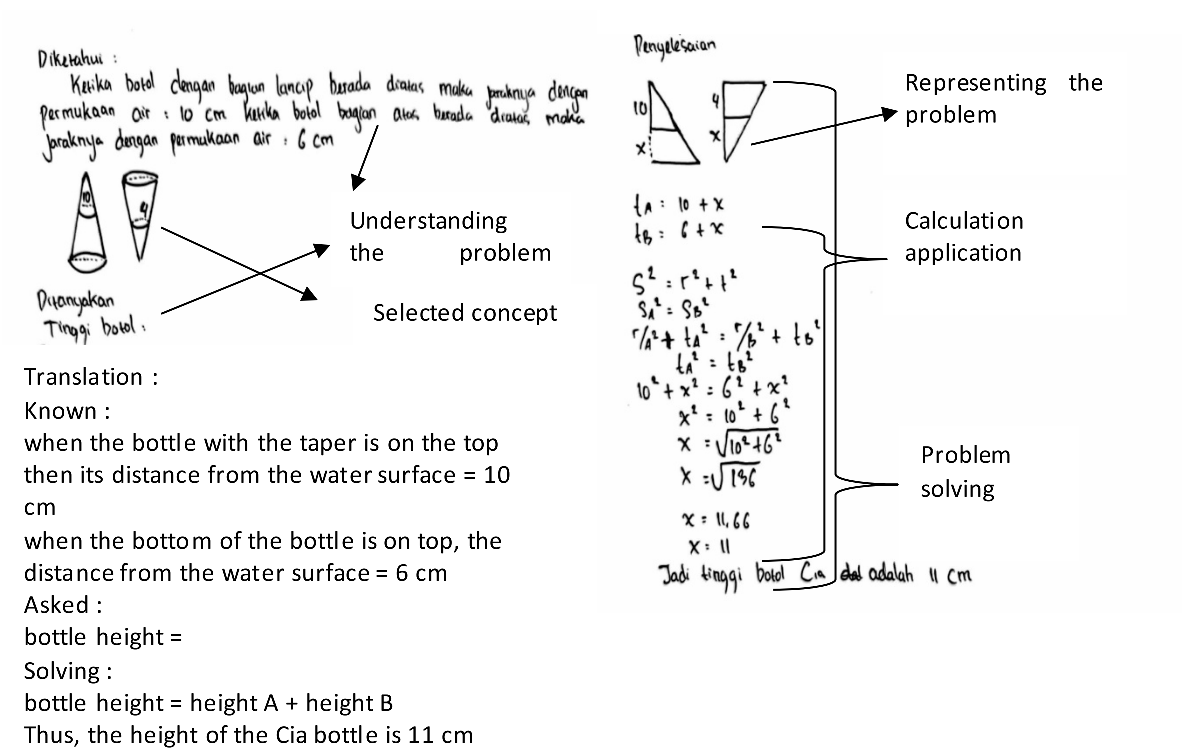
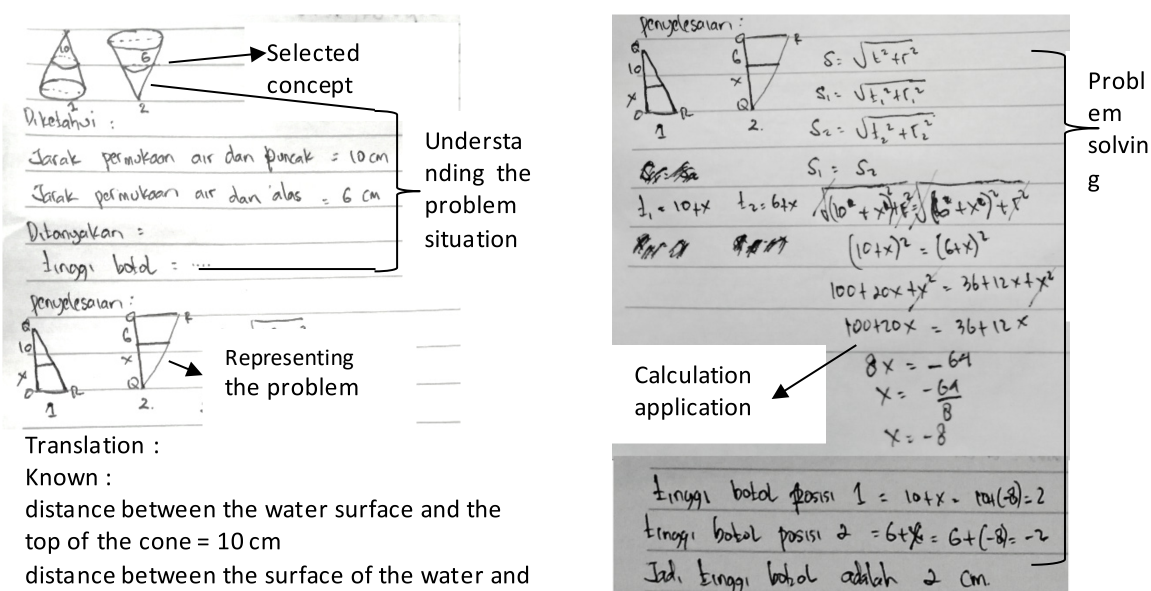


Fig. 5: SILM's Mathematical Proficiency Process in Solving Problem

SDHM represented the problem situation with an incomplete drawing strategy because it did not relate to the information that the bottle contained water. SDHM justified the approach logically that the reason for using the strategy was to facilitate the process of solving the problem. The SDHM selected the Pythagoras formula based on an incomplete representation of the problem situation. SDHM justified logically that the strategy is in accordance with the subject's knowledge that the shape of the right triangle is part of a cone shape. SDHM determined the height of the bottle by performing analytical calculations. The subject equated between the length of the first and second conical painter lines. SDHM justified that only such strategies are known to implement calculations. SDHM solved the problem intuitively by trying several formulas that can be used so that the bottle's height is 2 centimeters. However, SDHM ilogically justified that the strategy in solving problems is in accordance with the knowledge possessed. SDHM's mathematical proficiency process can be shown in the following figure 6.

Students who have low independence and low motivation (SDML)

SDML rarely uses mathematical proficiency in solving problems. The subject had not used mathematical proficiency to the maximum in dealing with the problem of solid-shaped geometry. SDML could fully understand the problem situation with strategies of reading, imagining, and describing the shape of the bottle, the distance between the surface and the apex point, the distance of the water surface with the pedestal, and the height of the bottle. SDML could justify logically that the strategy has been often used. SDML fully described the problem situation so that the subject was able to choose the appropriate concept, namely the cone. SDML justified logically that the strategy has been used frequently. SDML also justified the problem logically but not completely based on the subject's knowledge that one of the features of the cone is to have a round-shaped pedestal and an apex point. SDML represented the problem situation with an incomplete drawing strategy because it did not relate to the characteristics of the cone. SDML justified that the reason for using the strategy was to facilitate the process of solving the problem. SDML selected the summation formula based on an incomplete representation of the problem situation. The subject also justified illogically that the strategy suddenly comes to mind. SDML determined the height of the bottle by performing analytical calculations but not intact as it only summed the distance of the water surface on both of the cones. SDML justified that only such strategies are known to implement calculations. SDML resolved the problem intuitively by following hunches in choosing the formula so that the subject could not provide



Translation :
Known :
distance between the water surface and the top of the cone = 10 cm
distance between the surface of the water and the base of the cone = 6 cm
Asked :
bottle height = ... ?
Solving :
bottle height position 1 = 10 + x
bottle height position 2 = 6 + x
Thus, the height of the bottle is 2 cm

Fig. 6: SDHM's Mathematical Proficiency Process in Solving Problem

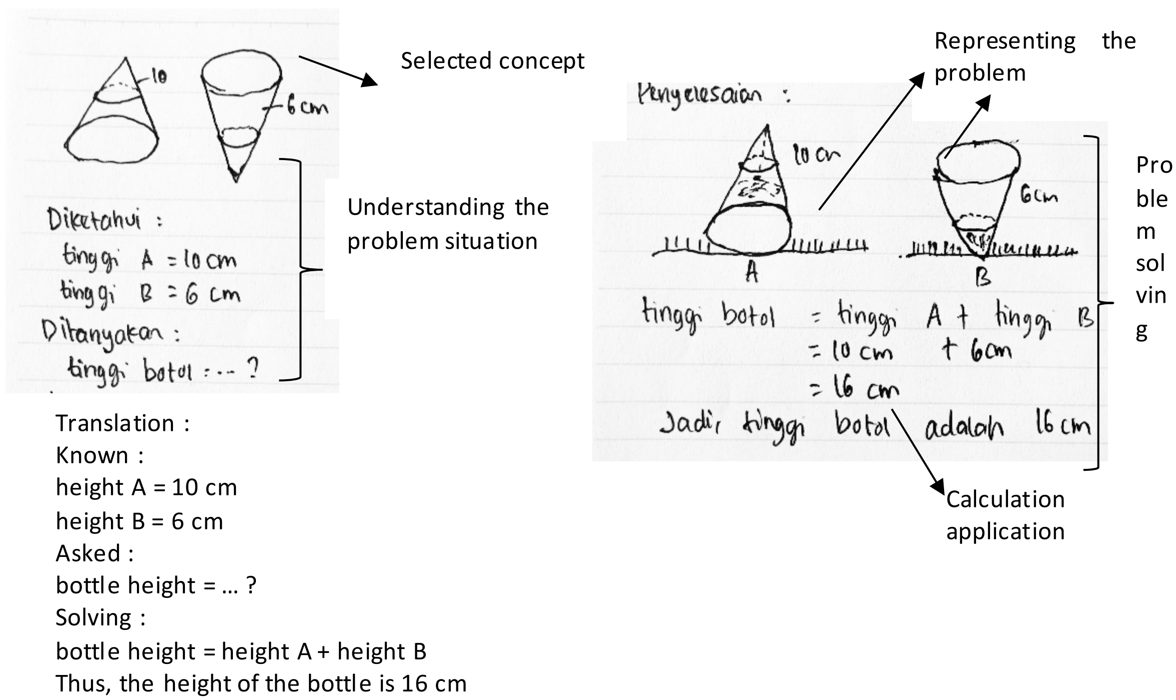


Fig. 7: SDML's Mathematical Proficiency Process in Solving Problem

a suitable conclusion, which is the height of the bottle was 16 centimeters. However, SDML justified that the strategy in solving problems is in accordance with the knowledge possessed. SDML's mathematical proficiency process can be shown in the following figure 7.

Discussion

Based on the results obtained, it can be seen that cognitive independence has a significant and positive effect on students' mathematical proficiency in solving geometry problems. Therefore, the higher the students' cognitive independence, the higher the use of mathematical proficiency in solving problems. Students with a high level of independence have a positive tendency to use analytical, effective, and efficient strategies in managing the complete and whole information related to problem situations, as well as the knowledge possessed about concepts, formulas, and their application in solving problems. Students with a low level of independence have a negative view of mathematics that translates toward using strategies that tend to be intuitive and inefficient in managing the information related to understanding the problem situation and managing incomplete knowledge, and hence, providing inaccurate conclusions. However, they chose the correct concepts and formulas appropriate to the problem situation. The ability of students to manage information independently cause students to view mathematics positively. Therefore, the students can apply the strategies analytically and logically using the concepts and formulas appropriate to problem situations. The results of this study are in line with (Zolkower et al., 2020) that students with field independent can recognize their experience capacity in elaborating information on problems in depth and also with the study that found that student field independent tends to be independent and confident in solving problems (Son & Fatimah, 2020). Then, the ability of students to manage information in a dependent manner can make students tend to use strategies intuitively and illogically in processing the knowledge that has been possessed related to concepts and formulas and in relating to the problem situations so that appropriate solutions cannot be obtained. This result is also in line with the study that found field-dependent students are more likely to look for help from others to solve problems (Abrams & Z. Belgrave, 2013) and with the study that found field-dependent cognitive independence experience difficulty in processing information and lack of knowledge restructuring (Onwumere & Reid, 2014).

Motivation influences students' mathematical proficiency positively and significantly. The higher the motivation of students, the more maximum mathematical proficiency is used in solving problems. Students with high motivation have a positive attitude in supporting the ability to use appropriate strategies in understanding and representing problem situations to obtain appropriate concepts and formulas to solve problems analytically, can justify logically related reasons using the selected strategies, and can apply calculations in accordance with the selected formulas so as to provide the correct conclusions. Furthermore, students with high mathematical anxiety have attitudes that tend to be negative in supporting their ability to solve problems, namely choosing the appropriate concept intuitively as information that suddenly appears in their mind, describing the relationship of concepts and situations incompletely but can choose the right formula, solving problems with trial and error strategies but cannot provide the correct conclusions and cannot explain the reasons for selecting strategies logically. Increased anxiety can hinder students' ability to view learning mathematics positively and use logical strategies in choosing concepts and formulas appropriate for the problem in solving it. This study's results align with students with low motivation cannot solve the given problem because they perceive that mathematics is a difficult lesson but believe that learning more diligently can improve their abilities (Liu & Lin, 2010) and with motivation, students can solve mathematical problems (Mazana et al., 2018).

Conclusion

The level of cognitive independence positively affects mathematical proficiency. Students who have a high level of cognitive independence tend to be able to process their own knowledge to choose strategies to solve problems analytically and logically, while students who have a low level of independence tend to use problem-solving strategies intuitively and not logically. The level of motivation of students in learning and completing mathematical tasks has a significant and positive effect on mathematical proficiency. High motivation in learning and completing mathematical tasks can provide knowledge related to choosing strategies logically in understanding problem situations, and choosing and applying concepts and formulas so that mathematical proficiency can be used maximally.

Suggestion

The results of this study support previous research that cognitive independence and motivation play a role in students' mathematical proficiency. In planning the learning process, teachers should consider the characteristics of students with high or low motivation who can process information independently or with the help of others. In addition, teachers can strive for learning activities that support students with low cognitive independence levels and low motivation to achieve success in learning better mathematics.

Limitation

This research is limited to knowing the general view of the effect of different cognitive independence and motivation on the mathematical proficiency of high school students. Further research is needed to explore students' difficulties, especially low levels of independence, cognitive and low motivation, to find ways to overcome this.

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