

STUDENTS' MATHEMATICS EDUCATIONAL VALUES IN PROBLEM-SOLVING AT SENIOR HIGH SCHOOL

Nyimas Aisyah^{1*}, Adelia Afissa², Scristia³, Jeri Araiku⁴

^{1,2,3,4} Universitas Sriwijaya, Jalan Raya Palembang-Prabumulih KM 32, Indralaya, South Sumatra, Indonesia

*Corresponding author. Pasar Skip Gang Pelita, No 8, Palembang, Indonesia.

E-mail: nyimas.aisyah@fkip.unsri.ac.id^{1*)}
adelia.afissa98@gmail.com²⁾
scristia@fkip.unsri.ac.id³⁾
jeriaraiku@fkip.unsri.ac.id⁴⁾

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Abstrak

Dalam matematika, kemampuan memahami, menalar, dan menghubungkan matematika termasuk dalam nilai pendidikan matematika. Fakta menunjukkan bahwa nilai-nilai pendidikan matematika belum sepenuhnya terintegrasi dalam pembelajaran matematika, sehingga mempengaruhi kualitas proses pembelajaran. Penelitian ini bertujuan untuk mendeskripsikan nilai-nilai pendidikan matematika siswa SMA pada pembelajaran berbasis sekolah. Jenis penelitian ini adalah deskriptif kualitatif. Subjek pada penelitian ini adalah siswa kelas X di SMA Negeri 1 Indralaya yang berjumlah 6 orang siswa. Pengumpulan data dilakukan melalui observasi, tes, dan wawancara untuk mengetahui aktivitas siswa saat menyelesaikan permasalahan matematika dan untuk mengkonfirmasi solusi siswa terhadap masalah tersebut. Berdasarkan analisis data dapat disimpulkan bahwa pemahaman relasional dan pengetahuan teoritis merupakan indikator yang terjadi pada semua subjek, sedangkan indikator penalaran kurang dominan. Untuk penelitian lebih lanjut, disarankan untuk menemukan korelasi antara semua nilai pendidikan matematika.

Kata kunci: nilai-nilai pendidikan matematika; pemecahan masalah

Abstract

In mathematics, the ability to understand, reason, and connect mathematics is included in the value of mathematics education. The fact shows that the values of mathematics education have not been fully integrated in mathematics learning, as a result, it affects the quality of the learning process. This study aimed to describe senior high school students' mathematical educational values on problem-solving tasks. It was a qualitative-descriptive study. The subjects were six students of Grade X of SMAN 1 Indralaya. The data were collected through observation, test and interview to perceive the students' activity while working on the mathematical problem, to determine the mathematic educational values, and to confirm the students' solutions toward the problem. The results of the study showed that the relational understanding and theoretical knowledge were the indicators that occurred in all subjects, whereas the reasoning indicator was less dominant. For further research, it is suggested to discover the correlation among all mathematical educational values.

Keywords: mathematics educational values; problem solving



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INTRODUCTION

The Indonesian national education purpose, as mentioned in the 2013

curriculum, is to prepare Indonesians to possess life skills in order to be a faithful, productive, creative, innovative

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and affective citizen, and also to enhance their capability to contribute towards the society, nation, state, and human civilization (Permendikbud, 2016). Mathematics learning is understood to have strong correlation with cognitive, psychomotor, as well as affective domains (Murrhiy, Bailey, & Roodenburg, 2017; Khalil, M, 2020; amora-Lobato, 2019).

During mathematics instruction, students are expected to not only obtain knowledge through learning materials, but also to understand the values contained (Clarkson, Seah, & Pang, 2019). The values described in mathematics classroom are general educational, mathematical, and the mathematic educational (Daher, 2021). The latter value focused on the gains related to its teaching (Aisyah, Saad, & Dollah, 2013; Aisyah, Saad, & Dollah, 2013). When students comprehend and appreciate value in mathematics, they will engage more in the learning process and hence, their mathematics achievements increase (Kalogeropoulos & Clarkson, 2019; Lam, 2012). Therefore, it shows the need for the educational system to highlight the internalization of values in mathematics education by providing significance (Aisyah, Saad, & Dollah, 2013; Aisyah, Saad, & Dollah, 2013).

Mathematics educational values are classified into five complementary pairs: (1) formalistic versus activist view, (2) instrumental versus relational understanding, (3) relevance versus theoretical nature of mathematics in teaching and learning, (4) accessibility versus specialism of its knowledge, and (5) the utilization of this specific skill as part of a process, as opposed to a tool (Daher, 2021). The prior study shows that the dominant values provided by the teachers in mathematics classroom

activities are activist, relevance, theoretical, and reasoning, which were implemented and planned in the teaching process, while the instrumental and accessibility type were applied but not planned (Aisyah, Saad, & Dollah, 2013; Aisyah, Saad, & Dollah, 2013).

In order to gain mathematics educational values, a proper approach needs to be implemented in the instruction, one of which is through solving mathematical problem (Zhang, 2019). Furthermore, problem solving enhances students' training, in order to implement knowledge, and discover solutions, thus, producing meaningful comprehension (Anggo, 2011).

In mathematics, the ability to understand, reason, and connect mathematics is included in the value of mathematics education (Gaspard, Dicke, Flunger, Brisson, Hafner, & Trautwein, 2015). The fact shows that the values of mathematics education have not been fully integrated in mathematics learning, as a result, it affects the quality of the learning process (Aisyah, Saad, & Dollah, 2013). The researcher's initial observations in the implementation of mathematics learning in one of the schools carried out by prospective mathematics teachers, showed that prospective mathematics teachers had not applied the values of mathematics education in learning. Therefore we need a learning activity that can provide a stimulus so that the values of mathematics education can emerge.

Based on the description above, this study aimed to comprehend which mathematics educational values would occur during the learning process by utilizing problem-solving approach for high school students of SMAN 1 Indralaya.

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METHODS

This study was a qualitative-descriptive study aiming to describe mathematics educational values occurring when implementing the mathematics problem solving instruction. The study consisted of two phases, preliminary and field research as shown in Figure 1.

In order to control variability of the sample, the research subjects of this study were selected through three steps

of selection, namely above average academic competences, teacher's recommendation especially on student's behavior and cooperative manner, as well as student availability. There six students of class X IPA 3 SMAN 1 Indralaya that determined as sample. Two higher competent students are ER and SWN, two moderate competent students are AJ and KE, and two lower competent students are PW and AT.

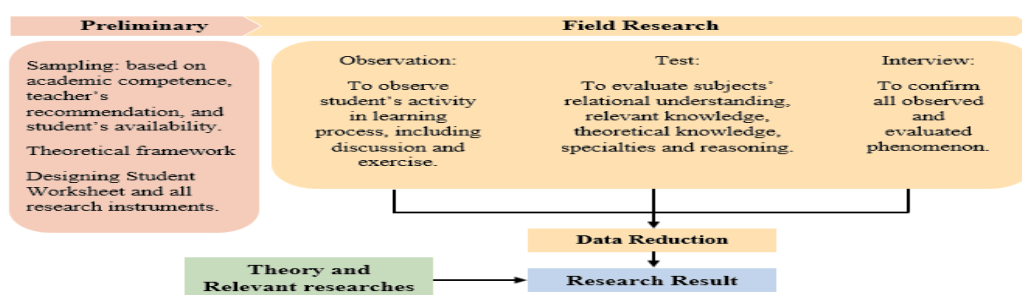


Figure 1. Research method

Table 1. The Indicators of mathematical education value in finishing the problem-solving exercise.

No	Indicator	Description
1	Activist	Involved energetically in finishing the exercise or discussion.
2	Relational Understanding	Being able to show the correlation between the concepts or principles of creating schemes or structures for use in the description of a more general problem.
3	Relevant Knowledge	The ability to apply the mathematical ideas and principles in solving daily challenges.
4	Theoretical Knowledge	The student was proficient in utilizing these concepts and philosophies to resolve problems.
5	Specialties	Being able to answer enrichment or non-routine questions.
6	Reasoning	The capability to create linkages with facts, in order to draw conclusions.

The focus of this research was on the six mathematical education values that dominantly occur in mathematics classroom, which are activist, relational understanding, relevant knowledge, theoretical knowledge, specialties and reasoning. At the preliminary stage, the researchers construct theoretical framework to be implemented in field

research. This construction produces Indicators of Mathematics Educational Values in Finishing the Problem-Solving Exercise as shown in Table 1.

Lastly on the preliminary stage, the researchers designed student worksheet and all instruments needed to collect the data. The worksheet was designed based on the problem-solving

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steps, consisting of understanding the problem, making plan to solve the problem, carrying out the plan, and looking back (Mollah Mesbahuddin Ahmed, 2016). Other research instruments were observation sheet, mathematics test, and interview guidelines. All the data collected from these processes were then analyzed through the data reduction and then compared to the existing theory and prior relevant research in order to derive

complete, deeper, and meaningful conclusion.

RESULTS AND DISCUSSION

This research analyzed the occurrence of mathematic educational values during the mathematics instruction, utilizing problem-solving approaches for student of Grade X IPA 3, of SMAN 1 Indralaya, illustrated by an exercise, consisting of two tests.

Table 2. Occurrence of mathematical education values.

Indicator \ Name	ER	SWN	AJ	KE	PW	MSY
Activist	√	√	√	√	×	×
Relational Understanding	√	√	√	√	√	√
Relevant Knowledge	√	√	√	√	×	×
Theoretical Knowledge	√	√	√	√	√	√
Specialties	√	√	√	√	×	×
Reasoning	√	√	×	×	×	√

Remarks:

√ : indicator occurred

× : indicator did not occur

Activist

The activist indicator occurs when a subject actively engages during the learning process (Hui Nong & Adnan, 2017; Aisyah, Saad, & Dollah, 2013; Daher, 2021). The occurrence was determined by the observation conducted by the observer. Table 2 shows, that 4 of 6 students were identified as active students. Based on the observation (Figure 2), the subject ER was the most active participant in the group discussion due to the response administered towards the questions of others that did not understand the point of the discussion. Furthermore, this subject was not afraid of asking the teacher about the difficulties or things that were not clearly understood.

The occurrence of active indicators was shown on a dialogue

between the participants while performing the exercises in the LKPD below:

- Student 1* : What about this one?
Student 2 : So this is the ?
ER : Write the example by Bu Mega first, suppose this is the x and to show the types
Student 1 : How do we obtain this?
ER : Bu Mega completed it asand Desti was . Hence, the result counted by both were, = as it was finished during seven days.

From the dialogue above, it shows that the subject was actively involved in the group discussion,

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through the response provided to the question given by the other participants and also the help made available to others that found difficulties in problem-solving. Conditioning students in class discussions and stimulating

students to be actively involved in each other's discussions to solve problems can lead to social norms in mathematics classrooms (Putri, Dolk, & Zulkardi, 2015; Zulkardi, Putri, & Wijaya, 2020).

School name : SMAN 1 Sungailiat
Student's name: Widia Utami
Subject : Mathematics
Class : X IPA 2
Day/Date : Wednesday, October 24, 2018
Time : 09.00 - finish
Material : Three-variable linear equation system

No	Problem solving step	Observed Indicator	Indicator Appearance	
			Yes	No
1	Understanding Problem	The student is answering question(s) from their friends which haven't understood.	√	
		The student is asking teacher about things they haven't understand.	√	

Figure 2. The description of ER's activeness

Furthermore, from Table 2 we can see that subject PW and MSY did not show any significant engagement in the classroom activity, which seems to affect their performances in relevant knowledge and specialized values. Students who are actively participated in a variety of mathematics learning activities scored higher mathematics achievements (Fung, Tan, & Chen, 2018). Students may have incentive to overcome learning challenges, and at the same time have interest and enjoy the given tasks (Bazelais, Lemay, & Tenzin, 2016; Orsini C, 2015). On the other hand, sometimes being not active in a class discussion doesn't necessarily mean that the student is lack of mathematical understanding (Kiwanuka, Damme, Noortgate, & Reynolds, 2020). As a counter example, the subjects AJ and KE showed

significant engagement in the class activity, but failed to perform in reasoning. Hence, further research needs to be conducted in response to this phenomenon.

The Relational Understanding Values

The indicator of relational understanding occurs when students are able to show the correlation between the concepts or principles of creating schemes or structures for use in the description of a more general problem (Şahin & Özpınar, 2020; Aisyah, Saad, & Dollah, 2013; Daher, 2021). The result showed that all subjects were able to exhibit this value. For example, the subject AJ. When AJ's answers the question number 2, the subject was able to make an example, using variable x, y, and z. The subject subsequently created an equation from the information gained

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from the question. However, during the process, the answer was searched for by performing trial and error, and a correct answer was selected. Meanwhile, the

following was the content of the subject's answer sheet as shown in Figure 3.

<p>Motor = x Mobil = y Minivan = z</p> $\begin{array}{r} \rightarrow 3y - z = x \\ \quad \quad z = 5x \\ \hline 3y = 6x \end{array}$ <p>1 mobil = 5 motor 3 mobil = 1 motor + 1 minivan 3 mobil ← 1 minivan = 1 motor 3 mobil = 6 motor</p> <p>Banyak kendaraan di parkir berjumlah 200</p> $\rightarrow 200 = 1x + 2y + 4z \rightarrow \text{karena } 1 \text{ motor} = 2 \text{ mobil, dan } 1 \text{ mobil} = 2 \text{ minivan}$	<p>Persamaan:</p> $z = 5x \quad \dots (1)$ $3y = x + z \rightarrow 3y - z = x \quad \dots (2)$ <p>motor : minivan 5 : 1 mobil : motor 1 : 2</p> <p>10 motor = 2 minivan 5 mobil = 10 motor Jadi, 2 minivan = 1 mobil</p>
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Figure 3. Answer sheet of number 2 by subject AJ

From Figure 3, the attempt to solve problems through the use of three-variable linear equation system principle was observed. However, this was seen to be difficult during the process. Therefore, a trial and error technique was adopted to solve the problem (Keleş & Yazgan, 2021). Furthermore, the previous steps were used involving making an equation which was detected to be correct, although the equation was not yet completed, hence, causing the subject to be confused in making the required substitutions and eliminations (Shinariko, Saputri, Hartono, & Araiku, 2020). Meanwhile, during the interview, the subject was confused to provide a description, as shown in the transcript of the dialogue below:

AJ : I don't understand the third equation, Mam.
Teacher : How come? The first and the second were correct.

AJ : I'm confused, because if the $x + y + z = 200$, is it possible to complete it this way?

This showed the difficulties faced by the subject while making the third equation, thus the solution was sought by performing trial and error or logics. In addition, the following admission was made by the subject during the interview.

Teacher : So, what about this logics?
AJ : This...five motorcycles is the same as a car. It means motorcycles: car was 5:1. Hence, the car and van... (confused)
Teacher : Look at this one, why the car is one and the motorcycle is two? How is this possible?
AJ : Nah, the equation of $3y = 6x$ compared to 1, Mom. This logics (point the answer) was incorrect, Mom. This one is correct (point the right answer).

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This was because the subject was confused through the process of creating the third equation. Hence, a trial and error was conducted (Keleş & Yazgan, 2021).

Relevant Knowledge

In answering the written test, relevant knowledge appears when a subject is able to apply the mathematical ideas and principles in solving daily challenges (Aisyah &

Dollah, 2014; Aisyah N., 2016; Bishop A., 2008; Dollah, 2007), for example, the subject KE in solving mathematical problem. This involved the elimination and substitution of previous result through the use of a mathematical model personally created to enhance the ease of calculation. In addition, the subject made an example of motorcycle, car, and van as variables of x , y , and z , as seen in the Figure 4..

The figure shows a handwritten solution for a system of linear equations with three variables. The equations are:

$$\begin{aligned} \text{Motor} &= a \\ \text{Mobil} &= b \\ \text{Mini Van} &= c \end{aligned}$$

The subject made an example by using variables.

The subject made a mathematical model:

$$\begin{aligned} \text{Mini van} &= 5 \cdot \text{Motor} \rightarrow c = 5a \\ \text{Motor} + \text{Mini van} &= 3 \text{ Mobil} \rightarrow a + c = 3b \end{aligned}$$

The subject used the elimination and substitution to get the score of x , y , and z :

$$\begin{aligned} \text{Motor} + \text{Mobil} + \text{Mini Van} &= 200 \\ a + b + c &= 200 \\ 3b + b &= 200 & a + c &= 3(50) \\ 4b &= 200 & a + c &= 150 \\ b &= 50 & a + (50) &= 150 \\ & & 6a &= 150 \\ & & a &= 25 \end{aligned}$$

Then:

$$\begin{aligned} c &= 5a \\ c &= 5(25) \\ c &= 125 \end{aligned}$$

Jadi, Motor = 25, mobil = 50, mini van = 125.

Figure 4. The answer sheet of question number 2 conducted by KE

Based on Figure 4, the substitution and elimination were used to determine the score. Previously, the variables of motorcycle, car, and van were changed into x , y , and z , followed by the creation of the mathematical model. The following is a part of the interview with the subject is as follows:

Teacher : And then?
KE : I substituted it to create the fourth equation, therefore, where the first was $z=5x$, So, I substituted it into the

third, hence, $6x+y=200$

Based on the interview, the subject was capable of describing the way of answering the questions correctly; therefore, the subject understood how to solve the problem using mathematical concepts and principles in real contexts (Shinariko, Saputri, Hartono, & Araiku, 2020). Problems that require students to connect mathematical knowledge and real word problem have an effect on students' problem solving abilities

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(Novita, Zulkardi, & Hartono, 2012). Moreover, it is a clear strategy that has been made by the student to make it easier to solve the problem (Araiku, Parta, & Rahardjo, 2019).

Theoretical Knowledge

The indicator of theoretical knowledge occurs when students are proficient in utilizing all concepts and

philosophies needed to resolve problems (Aisyah, Saad, & Dollah, 2013; Daher, 2021; Hui Nong & Adnan, 2017). For example, in the answer sheet of question number 2, the subject MSY answered the question through the creation of an example and the remodeling of previous equation, using prior information. Figure 5 shows the answer sheet of the subject.

Diketahui :

- motor = x
- mobil = y
- minivan = z
- $5x = 2$
- $3y = x + 2$
- Jumlah kendaraan = 200

Ditanya : Berapakah banyak kendaraan diparkiran ?

Jawab :

- $5x = 2$
- $3y = x + 2$
- $3y = 6x$
- $y = 3x$
- $x + y + z = 200$

Dari pernyataan diatas, maka didapatkan

- Banyak motor = 100
- Banyak mobil = 75
- Banyak minivan = 75

Figure 5. The answer sheet of question number 2 by AT

Based on Figure 5, the subject provided an example which was changed into variables of x , y , and z followed by the creation of a mathematical model from the information obtained in the question. However, in finishing the equation, the data were supported by the result of the equation, although the answers were wrong and the substitution was not yet possible. The following is the part of the interview with the subject as follows:

- Teacher : When you look at this estion, what will you do st? (Question nunumber
- MSY : Mm... make an example, m.
- Teacher : After that?
- MSY : Make the mathematical model similar to this (point at the answer). Hence, it was easier to substitute and eliminate.

Based on the dialogue, the subject reported that, during the process of completing this example, the strategy

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of the subject was making a simpler alternative equation in order to enhance the ease of substitution or elimination in order to obtain the right answer (López, Férez, & López, 2021). In obtaining the solutions to the problems, sometimes students have different strategies, one of which is by simplifying the calculation process, but still getting logical answers (Yansen, Putri, Zulkardi, & Fatimmah, 2019).

Specialties

The specialties occur when students are able to answer enrichment or non-routine questions (Aisyah, Saad, & Dollah, 2013; Hui Nong & Adnan, 2017). The instance that this indicator occurred in the answer sheet of the subject SWN was shown in Figure 6, indicating the ability to answer questions in a real context, utilizing the appropriate steps, and obtaining the right answer. This was conducted with thorough and precise calculation in order to enable the subject to solve the problem.

Figure 6 shows that despite of minor error in writing some letters, the subject was capable of solving the problem correctly, using the steps of three-variable linear equation system learned previously, by connecting the available information (Araiku, Parta, & Rahardjo, 2019). This was initiated by writing out the information, creating example by making some variables followed with a mathematical model, and conducting elimination and substitution. This was also supported by the result of the interview, in which the adopted method while answering the question from the beginning to the end was described without any confusion.

SWN : *Because for this could be included into four hours, therefore, to find time of each person, Robi and his father $4 + 4 = 1$ and then both sections were divided into four. Hence, the result is , which is the first equation, making Robi and his uncle same.*

Based on the interview, the subject tried to describe the origin of the equation derived in order to answer the question. Subsequently, the steps taken were also described.

SWN : *When the first and second equation are excluded (write the answer), eliminate x and z , then substitute it (write the answer).*

The part of the dialogue shows that the subject eliminated and then substituted the score obtained in answering the question in the exercise. Finding out the relevant information from the problem and then determining the variables to be able to make a mathematical model correctly is important to find solutions to the questions (Saputri & Zulkardi, 2020).

Reasoning

The last mathematics educational value is reasoning (Aisyah, Saad, & Dollah, 2013). Reasoning appears when students are able to create linkages with facts in order to draw conclusions. For example, the subject AJ's solution on problem number 1 as shown in Figure 7 below.

The final answer offered by the subject was correct although the calculation was incorrect during the substitution. Hence, the reasoning is considered done incorrectly (Araiku,

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Parta, & Rahardjo, 2019). Meanwhile, during the interview, the following

conclusion was made:

misal :
 x = jumlah minivan
 y = jumlah motor
 z = jumlah mobil

Diketahui:
 $x = 5y \quad \dots (1)$
 $x + y = 3z \quad \dots (2)$
 $x + y + z = 200 \quad \dots (3)$

substitusikan pers. 2 ke pers. 3
 $x + y + z = 200$
 $3z + z = 200$
 $4z = 200$
 $z = 50$

Substitusi $z = 50$ dan pers. 1 ke pers. 2.
 $x + y = 3z$
 $5y + y = 3(50)$
 $6y = 150$
 $y = 25$

substitusi $y = 25$ ke pers. 1
 $x = 5y$
 $x = 5 \cdot 25$
 $= 125$

Jadi, jumlah minivan adalah 125
 jumlah motor adalah 25
 jumlah mobil adalah 50

2). Diketahui:
 $\frac{1}{R} + \frac{1}{A} = \frac{1}{4} \quad \dots (1)$
 $\frac{1}{R} + \frac{1}{P} = \frac{1}{1.5} \quad \dots (2)$
 $\frac{1}{A} + \frac{1}{P} = \frac{1}{7.2} \quad \dots (3)$

$2 \frac{1}{R} + 2 \frac{1}{A} + 2 \frac{1}{P} = \frac{1}{2} + \frac{1}{1.5} + \frac{1}{3.2}$
 $2(\frac{1}{R} + \frac{1}{A} + \frac{1}{P}) = \frac{4.5 + 9 + 7.5}{18}$
 $2(\frac{1}{R} + \frac{1}{A} + \frac{1}{P}) = \frac{11}{18}$
 $\frac{1}{R} + \frac{1}{A} + \frac{1}{P} = \frac{11}{36} \cdot \frac{1}{2}$
 $= \frac{11}{72}$

Jadi, Ayah, ibu, dan paman dapat menyelesaikan pekerjaan dalam waktu $\frac{36}{11} = 3.27$ jam

Figure 6. The answer sheet of the question number 1 by SWN

AJ : Yes, Mom. I miscalculated it, but I recalled the final answer in the book when I studied at home last night.

Teacher : Oh, so you remembered the answer from the book?

AJ : Yes, Mom

Based on the interview, the subject realized the mistake made and only recollected the answer learned previously.

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