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Research Article

EXPLORATION OF SOCIAL JUSTICE ORIENTED MATHEMATICAL PROBLEM MODELING RELATED TO THE SINGARAJA-MENGWITANI SHORTCUT PROJECT

*** I Gusti Putu Suharta and I Made Ardana**

Mathematics Education, Universitas Pendidikan Ganesha, Bali-Indonesia.

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ABSTRACT

In connection with the Singaraja-Mengwitani Sortcut Project, many real life problems can be raised whose substance is related to mathematical concepts. The aim of this research is to describe the social justice oriented mathematical modeling related to the Singaraja-Mengwitani Shortcut Project for prospective elementary school teachers. The type of research used is qualitative with a case study design. The subjects of this research are Elementary School Teacher Education (PGSD) Universitas Pendidikan Ganesha students who in 2023 will carry out Field Experience Practices. The number of research subjects was determined by 6 people consisting of 3 men and 3 women. The instruments used were tests and interview guides, while data collection techniques used tests and interviews. The data analysis used is descriptive qualitative. This research shows that: (1) the ability to construct and simplify in modelling is categorized as very good, in mathematization it is categorized as fair, in interpreting and validating it is categorized as very poor, while in exposing it is categorized as not good; (2) judging from sex differences, the ability to construct and simplify is the same in the very good category, the ability to interpret and validate is the same in the very poor category, while the ability in mathematization is different, men are classified as good and women are categorized as enough; and (3) the logical reasons or additional information provided are very realistic and relate to real life and are oriented towards social justice. For example, compensation for land acquisition profits given takes into consideration the trees or buildings on the acquired land. Shortcut project profits do not only consider financial profits, but also non-material assets and wider impacts.

Keywords: mathematical problems, problem solving, situation models, mathematical models.

INTRODUCTION

According to Julia M. Aguirre, at all (2023) the two main challenges in mathematics teacher education are developing teachers' understanding of (a) culturally responsive, social justice-oriented mathematics pedagogy and (b) mathematical modeling as a standard for mathematical content and practice. In accordance with this opinion, the implementation of mathematics teacher education which will produce graduates as mathematics teachers needs to place more emphasis on ensuring that graduates can understand mathematics pedagogy and apply mathematics in real life. Solving real life problems by students not only provides opportunities for students to carry out language processes, mathematical processes, and reasoning about situations, but also provides opportunities for students to think critically relating problems or their answers to real situations or conditions in everyday life. Problem solving is the essence of learning mathematics. The research results show that students are still weak in solving real life problems and providing realistic reasons (Suharta, 2016; Parwati and Suharta, 2020; Suharta and Parwati (2020). Weak students' abilities can be caused because students are not yet accustomed to solving real life problems. Wrong one key aspect in solving real life problems is mathematical modeling which is based on situation models. Differences in assumptions have implications for differences in modeling and differences in modeling have implications for differences in solutions.

The Singaraja-Mengwitasi Shortcut Project is essentially a project that reduces the number of corners so that if people go to Denpasar from Singaraja, the travel time will be faster, more comfortable and safer.

***Corresponding Author: I Gusti Putu Suharta,**
Mathematics Education, Universitas Pendidikan Ganesha, Bali-Indonesia.

Figure 01 : The Singaraja-Mengwitasi Shortcut Project

(**Source :** https://www.detik.com/bali/berita/d-6557112/proyek-shortcut-singaraja-mengwitani-titik-7d-7e-dilelang-tahun-ini)

In connection with this project, many real life problems can be raised whose substance is related to mathematical concepts such as volume of geometric shapes, addition and multiplication, etc. Changing the land that is used as a shortcut and the trees on it are of course oriented towards social justice. With certain assumptions, situation models, mathematical models and their solutions can be made. It is understood that student learning outcomes are influenced by student performance, student performance is influenced by teacher performance, and teacher performance is influenced by previous experience (including experience during college). A teacher will be able to develop mathematical modeling if the teacher himself has good mathematical modeling skills. Exploring and describing the modeling and solving of mathematical problems carried out by Primary School Teacher Candidates has a positive contribution to the planning and implementation of mathematics lectures. The profile of a graduate of the Undiksha Elementary School Teacher Education Study Program (PGSD) is to become an elementary school teacher.

The courses given at PGSD include Mathematics, Mathematics Education I, Mathematics Education II, Mathematics Education III. In general, the focus of mathematics courses or mathematics education for PGSD students is mathematics in elementary school and its learning. Some relevant concepts such as probability theory and geometric shapes are given, but not in depth. There does not appear to be any study of material that develops mathematical thinking skills, so that students are competent strong mathematics, specifically strong in mathematics and elementary school mathematics learning but not accompanied by the ability to reason, solve problems, or reflect (Suharta and Suarjana, 2018). It is important for PGSD students as prospective elementary school teachers to have mathematical modeling abilities in an effort to develop real-life problem-solving abilities, especially social justice-oriented problems, to provide very important experience. The experience gained while studying will influence your performance when you become a teacher.

Based on the description above, it is necessary to carry out a fundamental study of the ability of prospective elementary school teachers in making mathematical modeling. The results of this study have the potential to be used as a further basis for developing learning as an effort to increase students' real problem solving abilities and awareness related to social justice. Many mathematical concepts are extracted from real life and these concepts are developed so that they can be used to solve real problems. According to Novotna (2000) there are five reasons for solving real life problems or story problems in mathematics learning, namely: formative reasons, critical competency reasons , reasons for benefits , reasons for the characteristics of mathematics, reasons for introducing mathematics.

In connection with the project, many real life problems can arise, for example how much land was taken/removed to build the road, how much land the residents acquired, how much money the land owner received in exchange for the freed land, how much the plants on the land were valued. that, etc.

Problem solving involves organizing knowledge, previous experience, intuition, attitudes, beliefs and cognitive abilities (Mi Kyung Cho, Min Kyeong Kim. 2020). Not all math problems are a problem. A problem whose solution procedure is known to students is a routine problem or not a problem. A problem is a problem (non-routine problem) if the solution procedure is not yet known, and there is an interest in solving it (Megan Che, Elaine Wiegert, Karen Threlkeld..2012). Real life mathematical problems are mathematical problems in the form of stories with a real life context, and their solutions require arguments or considerations based on real life. The connection between real life and mathematics is very close. Mathematics is used in real life and mathematics is developed to solve problems in real life. Mathematical modeling is a mental process for converting real life problems into mathematical statements. According to Gilbert Greefrath and Katrin Vorhölter (2016) there are 6 (six) competencies in mathematical modeling namely construction, simplification, mathematization, interpretation validation, and exposure, and describe mathematical modeling as a cycle, as in the following figure.

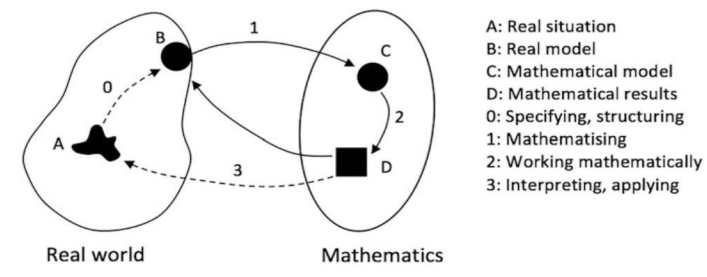

Figure 02. Modeling as a Cycle

METHODS

This research is to reveal in depth about modeling and solving mathematical problems. Therefore, the type of research used is qualitative with a case study design (Black, J and D, J Champion, 1999). The subjects of this research are Elementary School Teacher Education (PGSD) Universitas Pendidikan Ganesha students who in 2023 will carry out Field Experience Practices. The number of research subjects was set at 6 people consisting of 3 men and 3 women. The instruments used were tests and interview guidelines, while data collection techniques used tests and interviews. The data analysis used is descriptive qualitative. Mathematical modeling abilities are classified into very good, good, fair, not good, very bad, with conversion guidelines using absolute norms as follows.

If X ≥ 85% then very good
If 70% ≤ X < 85% then good
If 55% ≤ X < 70% then sufficient
If 42% ≤ X < 55% then it is not good
If X < 42% then it is very not good

The research procedure is as follows.

a. Introducing or showing images of the Singaraja Shortcut project-Mengwitani
b. Checking the research subject's understanding of the Singaraja-Shortcut project Mengwitani
c. Provides real life problems related to the Singaraja- Mengwitani Shortcut project.
d. Asking provoking questions to encourage research subjects can model the situation.
e. Encourage research subjects to construct situation models based on the assumptions provided.
f. Encouraging research subjects to add assumptions with realistic and social justice-oriented arguments and reasons.
g. Create mathematical modeling.
h. Perform a qualitative descriptive analysis of the modeling and realistic arguments provided.

RESULTS AND DISCUSSION

By using mathematical modeling competency indicators as previously described, mathematical modeling competency can be presented as follows.

Table 01: Competency of Mathematical Modeling

Competency indicators	Mathematical modeling (%)			Average (%)	Category
	Problem 1	Problem 2	Problem 3		
Constructing	100	100	100	100	Very good
Simplify	100	100	100	100	Very good
Mathematization	50.00	100	66.67	68.89	Sufficient
Interpretation	33.33	33.33	33.33	33.33	Very not good
Validate	33.33	33.33	33.33	33.33	Very not good
Expose	50.00	66.67	33.33	50.00	Not good

Mathematical modeling competency seen from gender differences can be presented as follows

Table 02: Competency of Mathematical Modeling in Terms of Sex

Competency indicators	Mathematics modeling (%)						Average (%)	
	Problem 1		Problem 2		Problem 3			
	Man	Women	Man	Woman	Man	Woman	Man	Woman
Constructing	100	100	100	100	100	100	100	100
Simplify	100	100	100	100	100	100	100	100
Mathematization	66.67	33.33	100	100	66.67	66.67	77.78	66.67
Interpret	33.33	33.33	33.33	33.33	33.33	33.33	33.33	33.33
Validate	33.33	33.33	33.33	33.33	33.33	33.33	33.33	33.33
Expose	66.67	33.33	66.67	66.67	33.33	33.33	55.56	44.44

In general, the ability to construct and simplify in modeling is categorized as very good, in mathematization it is categorized as sufficient, in interpreting and validating it is categorized as very poor, while in exposing it is categorized as not good. Based on sex differences, the ability to construct and simplify is the same in the very good category, the ability to interpret and validate is the same in the very bad category, while the ability to mathematize is different, the male gender is in the good category and the female is in the moderate category.

The reasons given by research subjects can be stated based on their answers. An example answer is presented in the following image.

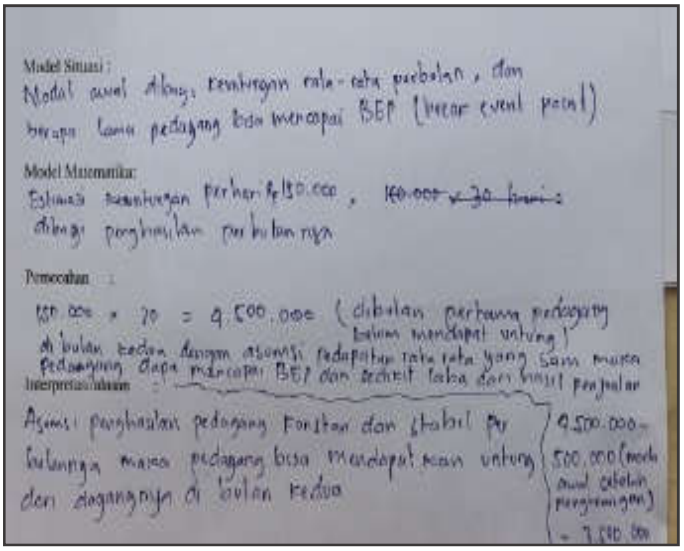

Figure 04 : An example answer

Situation model:
Initial capital divided by the average profit change, and how long it takes the trader to reach the BEP (break even point)

Mathematical models:
estimated profit per day Rp. 150,000 divided by monthly income

Solution:
150,000 x 30 = 4,500,000 (in the first month, traders have not made a profit)
In the second month, assuming the same average income, traders can achieve BEP and a small profit from sales of 4,500,000 - 500,000 (initial capital after deduction) = 3,500,000

Interpretation :
Assuming the trader's income is constant and stable per month, the trader can make a profit from his trading in the second month.

This is supported by the results of interviews with S2, S4, and S6 subjects as follows.

R: In the case of Pak Wayan's land acquisition, how is the compensation calculated in order to provide justice to Pak Wayan?
S2: calculated the area of the land, and everything on the land?
R : For example, if there are mango trees on the land and buildings, how do you count them?
S2 : Mango trees usually don't have a very long productive life, so it can only be calculated as 2 years
R: how to calculate the building?
S2: assume the building is old, so it can be calculated equal to the value when building
R: what about the tools in the building?
S2 : all become the owner of the building
R: related to problem number 2, how to determine the BEP?
S4 : The BEP can be calculated from the savings per day for cars and two wheels
R: Anything else...
S4: ..e..e..there are other advantages for the local government.....usually also on Saturdays and Sundays there are far more cars and motorcycles that pass
R: For example, what are the benefits for the local government?
S4 : tourists are increasing
R: regarding question no. 3, does the policy benefit traders?
S6 : Look at the trader's profit every day.....every day for 150,000 and 4,500,000 a month. In the dry season, tourist visits can double so that traders are more profitable
R: How about the setup fee?
S6: the cost of setting up is quickly fixed, so that traders are still profitable. The conclusion of the shot cut policy is profitable for traders.

Note: R = researcher, Si = subject i

Based on the answers and interview results mentioned above, the reasons given by the research subjects can be presented in the following table.

Table 03 : the reasons given by the subjects

Problems	Reasons
The land belongs to Pak Wayan. subject to 300 meters of clearance. If the price of land there is Rp. 50,000,000 per 100 M2, how much should Mr Wayan get in exchange for profits in order to provide justice for Mr Wayan?	1. The productive period of mangoes is not long, only 2 years, so that the replacement of trees is only 10,000,000. Building replacement amounting to Rp. 300,000,000 because all the contents were given to Pak Wayan.

	2. The compensation for Pak Wayan's profit is the price of land, mango trees, and buildings
The shortcut project cost 1 trillion rupiah. With this shortcut, the Singaraja Denpasar trip will be about 30 minutes faster, and on average it will save Rp. 40,000/four-wheeled vehicle and Rp. 1,000 for motorbikes. If 1000 four-wheeled vehicles and 450 motorbikes pass by in a day, how long will it take for the costs incurred to be covered (break event point) to be reached?	1. Calculation of BEP will be achieved by considering fuel savings for both cars and motorbikes. 2. Profits have not considered immaterial, namely income for local governments due to tourist visits. 3. Savings per day (1000 x 40,000) + (450 x 1000) = 40,450,000. The survey results show an increase of 5 x (Saturday and Sunday) so that the savings are 5 x 40,450,000 x 2 = 404,500,000.
At the shortcut point 4, the old road is still functioning in one direction with the consideration that there is the Candi Kuning market so that the economy remains good There is an opinion that before the existence of the shortcut (one-way enforcement) the average income/profit of traders was Rp. 100,000 per day. Another opinion says that with the shortcut, the number of domestic tourists who come to Singaraja via the shortcut is very large, and those who stop by at Candi Kuning Market also increase so that traders' sales increase and the traders' profits average Rp. 150,000 per day, but traders have to organize their wares. For this arrangement, a fund of Rp. 5,000,000. Does this policy benefit traders?	1. Weekly savings = 5 x 40,405,000 + 404,500,000 = 606,750,000 and monthly savings are 606,750,000 x 4 = 2,427,000,000 2. BEP = 1 T/2,427,000,000 = 413 months = 35 years 3. With the short cut, traders get a net profit of Rp. 1,500,000/month. Policies favor merchants, and profits may increase due to increased tourists. 4. Assuming the first month the trader gets a constant profit 5. In the dry season there is a 2-fold increase in tourists, resulting in an increase in traders' profits. 6. To find out the profitable policies of traders, consider the cost of setting up their merchandise and the average profit earned by traders. 7. Trader profits 50,000/day, so for a year 50,000 x 360 = 18,000,000. The setup fee is 5,000,000, so the net profit is 13,000,000

In terms of solving real life problems, it starts with creating a model of the situation. At this stage, build an understanding of the problem by determining what is known and what is not known and identifying existing information on the problem. This ability is of course influenced by understanding the context of the problem and relating it to everyday life. The context of the problem is related to shortcuts that he already knows or is related to everyday life. Add information that is oriented towards social justice so that land owners feel they have benefited from the project. Translating real situations and translating into symbols, mathematical concepts has not been done optimally. Likewise, after creating a mathematical model, it does not connect it to a real situation and does not make an assessment. The modeling ability between male and female subjects is relatively the same because the problem context is both close to everyday life (it is very well known), so it can change problems from everyday sentences to mathematical sentences.

CONCLUSIONS

Based on the description above, it can be concluded as follows.

1) The ability to construct and simplify in modeling is categorized as very good, in mathematization it is categorized as fair, in interpreting and validating it is categorized as very poor, while in exposing it is categorized as not good.
2) Based on gender differences, the ability to construct and simplify is the same in the very good category, the ability to interpret and validate is the same in the very poor category, while the ability in mathematization is different, men are categorized as good and women are categorized as fair.
3) The logical and realistic reasons given are oriented towards social justice. For example, the compensation given takes into consideration the trees or buildings on the acquired land. The benefits of the shortcut project do not only consider financial benefits, but also from non-material assets and wider impacts.

Based on these conclusions, it is important for pupils or students to be given mathematics problems that are oriented towards social life, so that they know directly the benefits of mathematics in everyday life as well as to motivate pupils or students to learn.

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