Levels and competence in solving mathematical modelling problems: a case of preservice teachers

S. IRAWATI, MANUHARAWATI, ABADI

ABSTRACT

The problem and the aim of the study. Mathematical modelling has become an important topic in mathematics education. However, many students are not accustomed to dealing with mathematical modelling problems, which are characterized by reality relation, relevance, authenticity, openness, and the promoting sub-competencies. Students are more familiar with solving problems where all necessary data is clearly presented, despite the fact that real-life situations rarely provide complete information upfront. The ability of students to solve modelling problems is closely linked to their teachers' capabilities. In this article, we explore the modelling competencies of preservice teachers in solving mathematical modelling problems. The exploration is based on six levels of mathematical modelling competence and describes the process of solving these mathematical modelling problems through various sub-competencies.

Research methods. The research is descriptive and employs a qualitative approach. The subjects in this study were 34 preservice mathematics teachers. We used instruments in the form of mathematical modelling problems and interview guidelines. Based on the written responses and interview results, we categorized the subjects according to their modeling competency levels. The categorization of modelling competency levels is based on Ludwig and Xu's framework, while the process of solving the mathematical modelling problem is analyzed using the Blum and Leiß modeling cycle. The description of the process of solving the mathematical modelling problem was provided by a representative from each competency level who provided an insightful answer. The data was analyzed through the stages of condensation, display, and conclusion.

Results. According to our research findings, the distribution of subjects across competency levels is as follows: 5.88% are at level 5, 2.94% are at level 4, 5.88% are at level 3, 11.76% are at level 2, 64.71% are at level 1, and 8.82% are at level 0. We provide a detailed description of the process of solving the mathematical modelling problem based on their respective mathematical modelling sub-competencies of one subject from each level.

Conclusion. Based on the research results, the majority of preservice teachers are at level 1 (64.71%), indicating that they can understand the problem, but struggle to progress to the next stages. This is concerning because they believe they already have enough information to solve the problem, whereas solving the problem requires making assumptions. These findings reveal that the modelling competence of preservice teachers is relatively low, and it is important to focus on finding solutions to improve this. The difficulties encountered by the subjects include challenges in understanding the problem, difficulty organizing and simplifying the provided information, inability to differentiate between essential and non-essential elements, lack of algebraic skills, and limited use of various forms of representation.

KEYWORDS

competence, mathematical modelling, mathematical modelling competence levels, mathematical modelling problems, preservice teachers

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INTRODUCTION

Over the past few decades, mathematical modelling has become a prominent research topic within the international mathematics education community. It is widely recognized as a crucial component of mathematical literacy [1]. Mathematical modelling offers an alternative approach to addressing challenges in mathematics learning by involving the application of mathematics to real-world situations. UNESCO emphasizes that using mathematical contexts effectively conveys the message that mathematics is a valuable tool for sustainably meeting human physical needs, is relevant to the lives of students and others, and encourages students' engagement with mathematics as they work with information that directly relates to their experiences [2]. In Indonesia, the Ministry of Education, Culture, Research, and Technology has identified the development of problem-solving abilities through modelling as one of the six mathematics learning objectives. This objective aims to equip students with the skills needed to solve problems, which include understanding problems, designing mathematical models, solving these models, and interpreting the solutions (mathematical problem solving) [3]. This underscores the importance of mastering mathematical modelling skills for students.

Mathematical modelling is a two-way translation process between the real world and mathematics [4]. This process begins with a real situation and ends with a solution that meets the demands of the situation. It helps students comprehend mathematical concepts, recognize different representations, and apply them to interpret real-world phenomena. Through mathematical modelling, mathematics becomes more meaningful for students. Engaging in mathematical modelling allows, students deepen their understanding of mathematics, enhance their motivation, develop concept formation, and improve comprehension, while also cultivating a range of mathematical competencies. In essence, mathematical modelling bridges the gap between abstract mathematical concepts and their application in the real world context [4].

It is important to note that not all students are familiar with solving mathematical modelling problems. Students are typically accustomed to solving problems where all the necessary data is provided, but in real-life situation, not all the data is given upfront. Mathematical modeling problems are problems that cannot be solved with known algorithms but require a strategy to solve them [5]. Mathematical modelling problems are essentially non-standard word problems with ambiguous conditions [6]. Solutions to these problems are obtained through a complex process that involves making realistic assumptions, using different mathematical models, employing various solution methods, and yielding different results [7; 8]. Siller and Greefrath [9], as well as Wess and Greefrath [10] explain several characteristics typical of these problems, such as reality relations, relevance, authenticity, openness, and promoting sub-competencies. The following table is an explanation of each of these characteristics:

Table 1

Catalog of Criteria for Modelling Problems

Criterion	Specifications
Reality relations	The factual reference in the problem definition is not mathematical.
Relevance	Students find the problem definition intriguing, pertinent, or directly related to their everyday experiences.
Authenticity	The problem definition is genuine in terms of the non-mathematical aspects.
Openness	The definition of the problem allows for different solutions and multiple methods.
Promoting sub-competencies	The formulation of the problem encourages cognitive components in the shape of partial mathematical modelling competencies.

Blum and Leiß [11] developed a modelling cycle to help students in solving mathematical modelling problems. As shown in Figure 1, the process consists of seven steps: understanding, simplifying/structuring, mathematizing, working mathematically, interpreting, validating, and exposing.

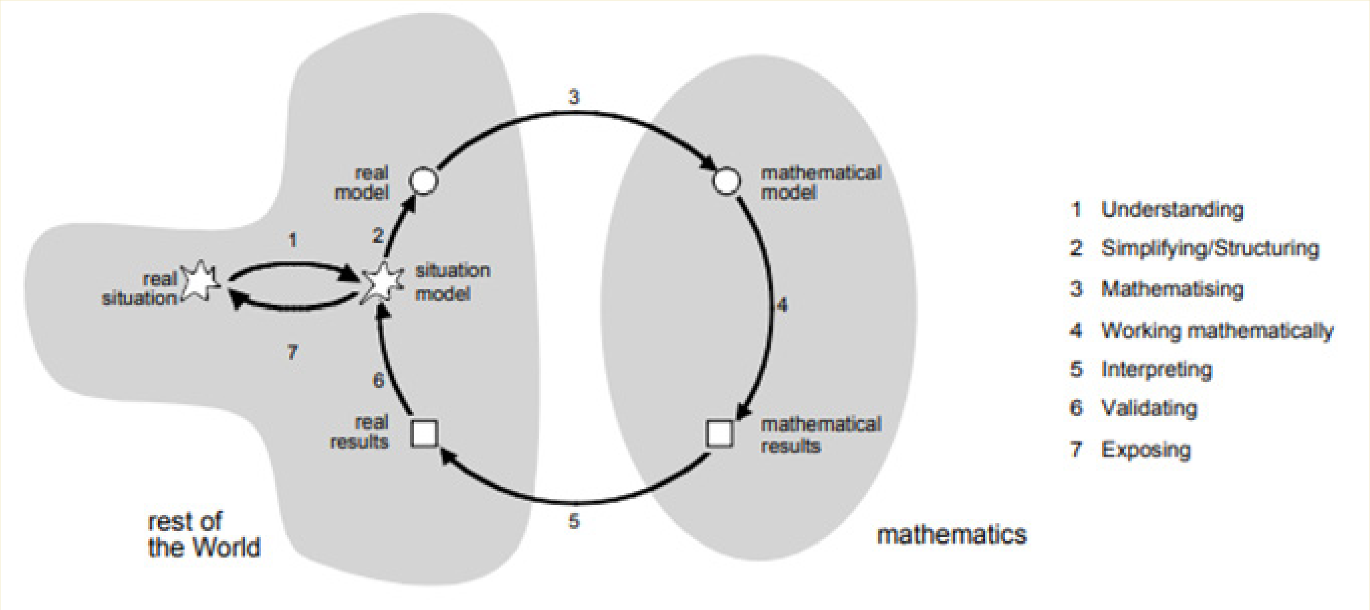


Figure 1 Modelling Cycle From Blum and Leiß [11]

The term modelling competence refers to the ability to perform all aspects of mathematical modelling in a comprehensive manner [12]. This encompasses the skills and capabilities required to conduct the modelling process with accurately and with purpose [13]. Specifically, modelling competence involves identifying relevant variables and relationships in a real-world situation, translating them into mathematical notation, interpreting mathematical results to make them applicable to the real-world context, and verifying the applicability of the model to the situation. Additionally, It involves the ability to validate the given model. This means that every stage of the modelling process is connected to various competencies and sub-competencies in modelling [14].

The sub-competencies of modelling are related in a way detailed by Greefrath and Vorhölter [15] as follows:

Table 2

Sub-competencies of Mathematical Modelling

Sub-competencies	Description
Understanding	By creating their own mental models for a specific problem situation, students are able to comprehend the question.
Simplifying	Students distinguish between relevant and irrelevant details regarding a real situation.
Mathematizing	Students convert sufficiently simplified real situations into mathematical models (e.g., terms, equations, figures, diagrams, functions).
Working Mathematically	To answer the mathematical issue, students use heuristic techniques and mathematical understanding.
Interpreting	By applying the outcomes from the model to the real situation, the students attain authentic outcomes.
Validating	Students assess the suitability of the real outcomes in relation to the situation model.
Exposing	Students respond to the question by applying the answers from the situation model to the real context.

The lack of sub-competencies can create barriers during the process of finding solutions. Galbraith and Stillman [16] have pointed out the obstacles faced by learners when transitioning between modelling phases and how the absence of certain sub-competencies impacts the modelling process. Therefore, in this article, we aim to analyze students' mathematical modelling competency when solving mathematical modelling problems based on their level of mathematical modelling competency. While Ludwig and Xu [17] have evaluated students' modelling competencies, they did not connect their findings to the stages of the modelling cycle. Consequently, we propose to modify Ludwig and Xu's competency evaluation to align it with the modelling cycle stages proposed by Blum and Leiß [11]. This adjustment will make it easier to align competency evaluation with the stages of the modelling cycle, thereby identifying the obstacles faced by students.

M. Ludwig and B. Xu [17] categorizes mathematical modelling competencies into six different levels sequentially presented as follows:

Table 3

Indicators of Mathematical Modelling Competency Level

Level	Indicator
Level 0	Students still need to understand the situation and are unable to sketch or write something concrete about the problem.
Level 1	Students understand only the real situation given but are unable to organize and simplify it or find connections to clear and precise mathematical ideas.
Level 2	After investigating a given real situation, the learner finds a real model through structuring and simplification but does not know how to translate it into a mathematical problem (the learner creates a kind of word problem about a real situation).
Level 3	Learners can find real models and translate them into precise mathematical problems, but they struggle to work clearly with them in mathematics.
Level 4	Students can derive mathematical problems from real situations, work with these mathematical problems within the world of mathematics, and obtain mathematical results.
Level 5	Students are able to engage in the process of mathematical modelling and validate solutions to mathematical problems in a given situation.

It is crucial to remember that students' skills in mathematical modelling are closely linked to the role of teachers in school. Teachers play a significant part in enhancing students' problem-solving abilities through mathematical modelling, ultimately preparing them for real-life experiences. Therefore, it is essential to train competent preservice teachers who are capable of making mathematics learning interesting, enjoyable, and meaningful.

This research focused on preservice teachers because their involvement in mathematical modelling can enhance their understanding of the characteristics of mathematical modelling [18; 19] as well as their competencies in this area [20; 5]. This knowledge and competence enable them to recognize students' challenges when solving mathematical modelling problems [21]. and can better equip them to guide students during modelling activities. The findings of this study are expected to contribute to the professional development of preservice mathematics teachers, particularly in Indonesia.

RESEARCH METHODS

This research was of the descriptive type, using a qualitative approach. In this research we discussed the modelling competence of preservice teachers in solving mathematical modelling problems, based on six levels of mathematical modelling competence and described the process of solving the mathematical modelling problem based on mathematical modelling sub-competencies. We also analyzed students' challenges in transitioning, which refers to changing from one stage of the modeling cycle to another.

The subject selection technique in this research was purposive sampling, namely, preservice mathematics teachers in the sixth semester follow the linear programming course for as many as 34 students in one of Indonesia’s mathematics education study programs. To get research data about the mathematical modelling competence of preservice mathematics teachers, we use an instrument in the form of a mathematical modelling problems, namely the problem of filling up with petrol, and interviews protocol. Both instruments have been validated by experts regarding their content, construct, and language.

The research procedure involved asking participants to solve mathematical modeling problems and then interviewing them based on their results. This was done for two main purposes: to assess the participants' modeling skills and to observe their problem-solving process. The categorization of modeling competency levels was based on Ludwig and Xu's framework [17], while the problem-solving process was based on the Blum and Leiß modeling cycle [11], which includes stages such as understanding, simplifying, mathematizing, working mathematically, interpreting, validating, and exposing. Next, the data was analyzed through data condensation, data display, and conclusion [22].

RESEARCH RESULTS

Based on the written answers and results of the interview of 34 students, we further grouped them into competency level modelling mathematics. There were 2 students in level 5 (5.88%), 1 student in level 4 (2.94%), 2 students in level 3 (5.88%), 4 students in level 2 (11.76%), 22 students in level 1 (64.71%), and 3 students in level 0 (8.82%).

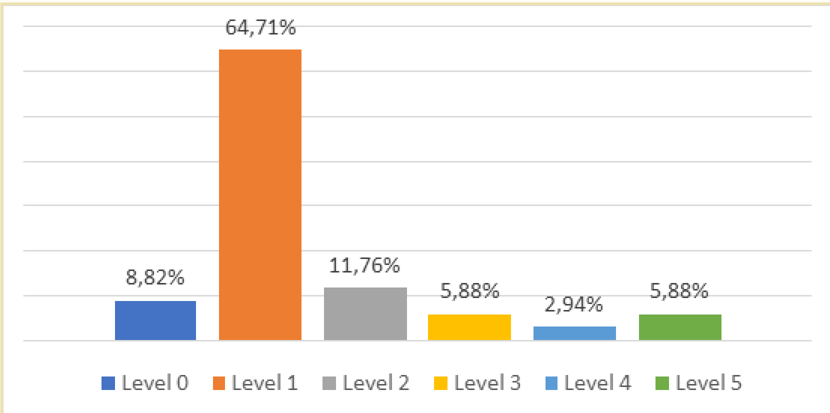
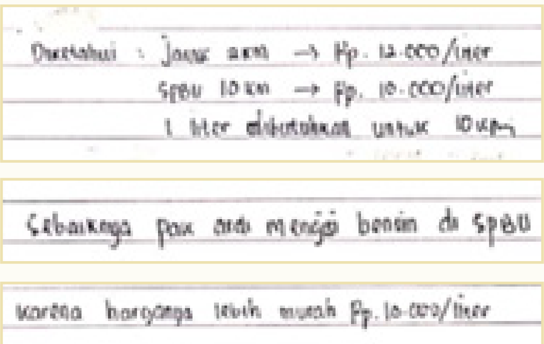


Figure 2 The percentage of mathematical modelling competence of preservice teachers

The following describes the process of solving mathematical modelling problems by representatives from each level, whose answers are interesting based on the sub-competency of mathematical modelling:

1. Mathematical Modelling Competence of Preservice Teacher Level 0 (L0):

Level 0 subjects are individuals who were unable to express or write specific information about the given problem and did not fully comprehend the given problem. A response provided by a subject at level 0 was as follows:



Distance 2 km = Rp.12,000/liter
distance 10 km = Rp.10,000/liter
1 liter is needed for a distance of 10 km
Mr. Ardi should fill up at a petrol station 10 km away because the price is lower at Rp.10,000/liter

Figure 3 Level 0 subjects' answers

Based on the results, the written response provided by the L0 subject indicates that the subject mentioned two different petrol prices. It seems that the subject wrote that 1 liter of petrol is needed for every 10 km. To gain a deeper understanding of the subject's response, the researcher conducted an interview. The following is an excerpt from the researcher's interview with the L0 subject.

R : Do you understand the problem in the question?

L0 : I'm having trouble understanding. I don't understand the use of ½ liter mentioned in the question.

R : What does it mean that 1 liter is needed for 10 km?

L0 : I'm not sure; I'm just guessing

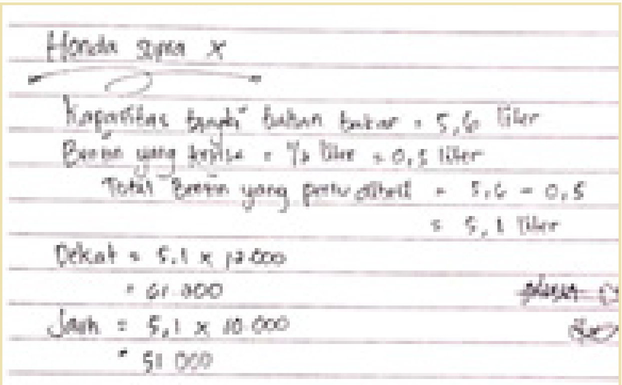
R : Is the data in the question enough to answer the problem?

L0 : Yes, it's sufficient

The subjects were unable to understand the problem completely. They did not understand the usefulness of the information on the remaining ½ liters of petrol, and they thought that the information in the question was sufficient to solve the problem. However, to answer the problem, several additional information or assumptions were required. Based on the results of the interviews conducted, it was found that the subjects were unable to achieve the sub-competency of understanding.

2. Mathematical Modelling Competence of Preservice Teacher Level 1 (L1):

Subjects at level 1 were able to comprehend a given situation in its entirety and provide a concrete description or explanation of the problem. For example, the distances from home to two petrol stations are 2 km and 10 km, with a price difference of 2000. The response provided by a subject at level 1 was as follows:


Honda supra X
Kapasitas tangki bahan bakar = 5,6 liter
Bensin yang tersisa = ½ liter = 0,5 liter
Total Bensin yang perlu diisi = 5,6 − 0,5
= 5,1 liter
Dekat = 5,1 x 12.000
= 61.200
Jauh = 5,1 x 10.000
= 51.000

Honda Supra X
Fuel tank capacity = 5.6 liters
Remaining petrol = ½ liter = 0.5 liters
Petrol to be filled = 5.6 – 0.5 = 5.1 liters
Near = 5.1 × 12,000 = 61,200
Far = 5.1 × 10,000 = 51,000
Mr. Ardi should buy petrol at a place 10 km away because the price is lower

Figure 4 Level 1 subjects' answers

Here are the results of the interview with the subject at level 1:

R : Try to tell me how you solve this problem

L1 : Based on my understanding, it seems like the motorcycle in question is a Honda Supra X. After researching the internet, I found that its tank capacity is 5.6 liters. Since there are still 0.5 liters of petrol left, Mr. Adi only needs to buy 5.1 liters. When I calculated the purchase price, it was 61,200 in a nearby place and 51,000 in a faraway place. Therefore, it is more affordable to buy from the faraway place.

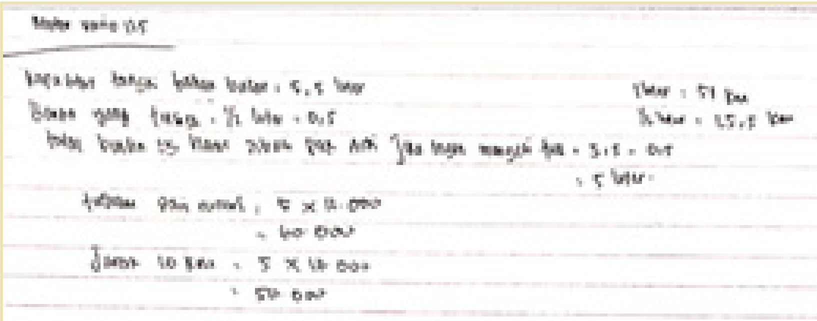
R : Even though the distance is farther at 10 km, is it still acceptable?

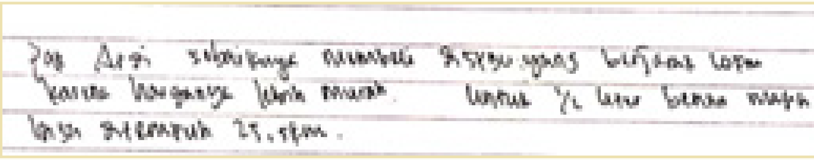
L1 : Yes, it is okay

Based on the interview and written work results, it is evident that the L1 subject defined the best price as the lowest or cheapest price. The subject believes that the data provided in the question could help solve the problem. However, the subject only made an assumption about the fuel tank capacity, which is used to fill the motorcycle's full tank. While the subject acknowledges the importance of the ½ liter information in the question, they were unsure if ½ liter is sufficient to reach a petrol station that is 10 km away. Consequently, the subject suggested buying at the nearest petrol station out of concern that ½ liter might not be enough to reach a distant petrol station. The subject only considered the price as a determining factor and overlooked distance as another important factor. Based on these findings, it can be concluded that L1 subject has only reached the understanding sub-competency stage.

3. Mathematical Modelling Competence of Preservice Teacher Level 2

Level 2 subjects were able to make accurate assumptions about the capacity of the petrol tank and the rate of petrol consumption. Additionally, they determined the best price as the cheapest option considering both price and distance. Although the subject can create a mathematical model, it is only based on either price or distance considerations, rather than combining the two factors. The subject were able to find a real model through simplification, but were unsure of how to translate it into a mathematical problem. The response provided by a subject at level 2 was as follows:





Honda Vario 125
Tank capacity = 5.5
1 liter = 51 km
½ liter = 25.5 km
Remaining petrol = ½ liter
Petrol purchased = 5.5 – 0.5 = 5 liters
Petrol price at the nearest petrol station = 5 × 12,000 = 60,000
Price at a place 10 km away = 5 × 10,000 = 50,000
So Mr. Ardi should buy at a place 10 km away because the price is lower. than 2 km, and ½ liter of petrol can travel 25.5 km

Figure 5 Level 2 subjects' answers

Here are the results of the interview with subject at level 2:

R : Tell me how you solve this problem

L2 : To solve this problem, I assumed that the motorcycle used is a Vario 125. Based on information from the internet, the tank capacity is 5.5 liters, and it can cover a distance of 51 km with 1 liter of petrol. If the remaining petrol is ½ liter, it can cover the distance to the far away petrol station. I then compared the price of petrol. If Mr. Ardi fills up near his house, the price is 60,000. If he fills up at a petrol station that is far away, the price is 50,000. Therefore, it's better for Mr. Ardi to fill up at the petrol station 10 km away because the price is cheaper.

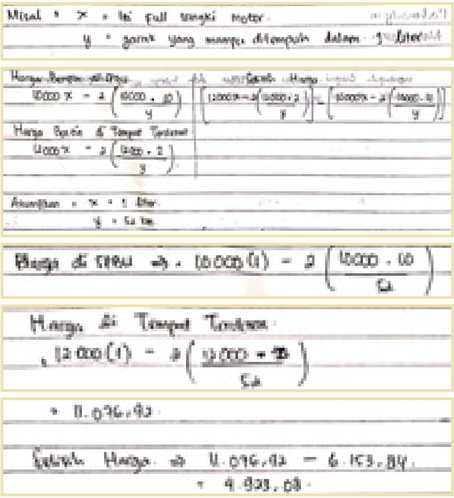
R : How about the long distance

L2 : I think it's okay as long as it's cheaper

Based on the interviews and assessments of the L2 subject's written work, it is evident that the subject was capable of making accurate assumptions about the petrol tank's capacity and the rate of petrol consumption. The subject could calculate the amount of petrol required to reach a distant petrol station, taking into account the rate of petrol consumption. Additionally, the subject based their purchasing decisions solely on price, disregarding the distance factor. While the subject was able to create a mathematical model, it is purely numerical in nature. Furthermore, the subject only calculated the cost of filling up the entire petrol tank, even though it is possible to purchase less than the tank's capacity, such as 1 liter. The recommendation to purchase from a farther petrol station due to lower prices indicated that the subject was at the simplifying sub-competency stage based on these findings.

4. Mathematical Modelling Competence of Preservice Teacher Level 3

Level 3 subjects were individuals who could develop mathematical models to determine the optimal price based on price and distance. The mathematical model created may take the form of a specific equation, possibly involving variables. The response provided by a subject at level 3 was as follows:



x = full tank of motorcycle
y = distance travelled by 1 liter
Price of petrol in faraway place = 10,000x – 2(10,000×10/y)
Price of petrol in near place = 12,000x – 2(12,000×2/y)
Price difference = [12,000x – 2(12,000×2/y)] - [10,000x – 2(10,000×10/y)]
Assumption : x = 1 liter and y = 52 km
Price in faraway place = 6,153.84
Price in near place = 11,076.92
Difference = 4,923.08

Figure 6 Level 3 subjects' answers

Here are the results of the interview with the subject at level 3:

R : What is the next step after making an assumption?

L3 : I have developed a mathematical model to calculate the cost of filling up at a gas station located 2 km and 10 km away. When filling up at a gas station 10 km away, the cost is represented by the equation 10,000 multiplied by the amount of gas needed, minus the travel cost. Since it's a round trip, I've multiplied the total cost by two to be 10,000x – 2(10,000×10/y). The same method applies to a gas station that is 2 km away, so we get 12,000x – 2(12,000×2/y).

R : Why is the travel cost reduced?

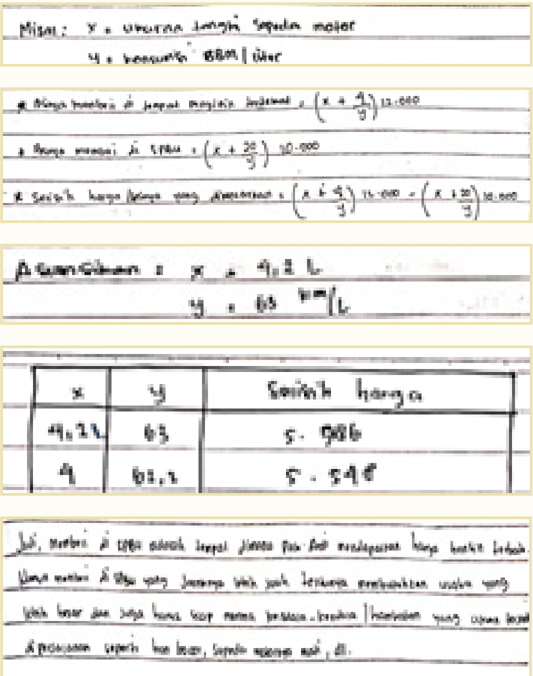
L3 : The travel cost is reduced because filling up petrol also costs money, so the overall cost during the trip is reduced

According to the interviews conducted with the Level 3 subjects, it has been determined that they were able to determine the best price by considering both the distance and petrol price factors. These subjects have the ability to create mathematical models based on certain assumptions. However, the mathematical model created was somewhat imprecise as it subtracts the cost of travel from the cost of filling up, rather than adding them together. The subjects tended to calculate the price difference between two petrol stations to assess which one is cheaper. Based on these interviews, it was suggested that purchasing from a gas station 10 km away would be more economical due to its lower price. However, the subjects tended to make mistakes when solving problems or performing calculations. As a result, it is concluded that according to these findings, level 3 subjects have only achieved the stage of mathematizing sub-competency.

5. Mathematical Modelling Competence of Preservice Teacher Level 4 (L4)

Level 4 subjects performed calculations using a given model and as well as obtained the correct mathematical results. However, these subjects did not connect the problem to real-world scenarios, they did not interpret or validate the results. In this research, the response provided by a subject at level 4 can be seen in the following description:

To sum up, buying at a distant place was where Mr. Ardi got the best price. However, buying at a distant place required more effort and must have been prepared to accept potential obstacles on the way such as flat tires, dead motorcycle, etc.



x = size of motorcycle tank
y = petrol consumption in meters/liter
Cost of buying at the nearest place =
(x + 4/y)12,000
Cost of buying at a distant place =
(x + 20/y)10,000
Price difference =
(x + 4/y)12,000 – (x + 20/y)10,000

x	y	price difference
4.2	63	5,986
4	62,2	5,548

To sum up, buying at a distant place was where Mr. Ardi got the best price. However, buying at a distant place required more effort and must have been prepared to accept potential obstacles on the way such as flat tires, dead motorcycle, etc.

Figure 7 Level 4 subjects' answers

The following is the results of the interview done with the level 4 subject:

R : What are you doing next after you get the mathematical model?

L4 : After obtaining the mathematical model, I proceeded by substituting various assumed values for x and y, where x represents the size of the motorcycle tank and y represents the petrol consumption per liter. This led to the conclusion that Mr. Ardi should refuel at a petrol station located 10 km away. However, refueling at a distant petrol station would take longer, and he needed to be prepared to encounter obstacles such as flat tires, breakdowns, and other challenges.

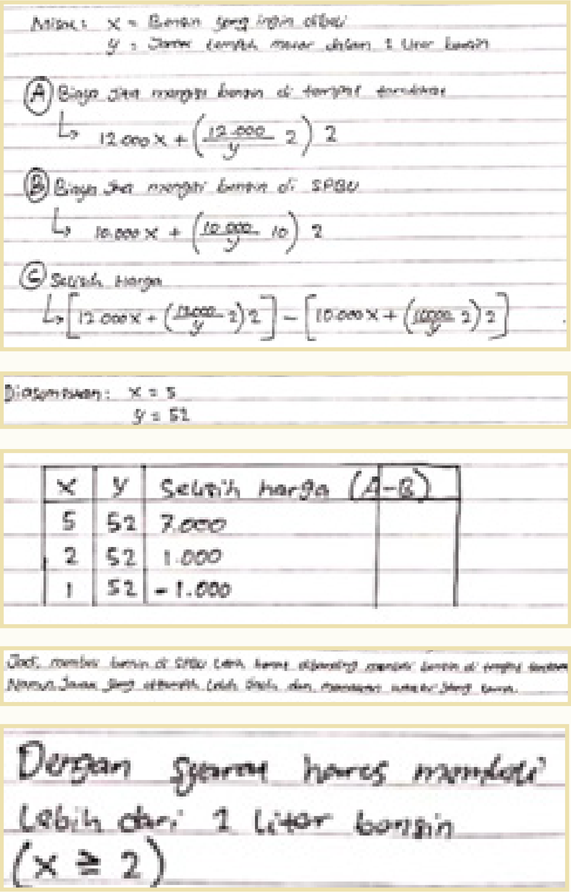
R : This implies that you assumed the petrol tank was full, right?

L4 : Yes

In analyzing the interview and written work results for the level 4 subjects, it was found that the subject was capable of determining the optimal price by considering both distance and petrol prices. The subject had developed symbolic mathematical models for petrol stations (x + 4/y)12,000 and (x + 20/y)10,000, as well as a model to compare both of them. Subject could calculate the mathematical results of the model. They had not verified it. The subject's focus was on filling up the petrol tank completely without considering minimum refills. The subject's recommendation to buy from a petrol station located 10 km away did not consider the time and obstacles associated with traveling to a distant petrol station. Based on these findings, subject L4 had only achieved a sub-competency level in working mathematically.

6. Mathematical Modelling Competence of Preservice Teacher Level 5 (L5)

Subjects at level 5 were those who were capable of connecting the problem to the real world and providing appropriate recommendations, as well as taking into account the relevant factors during petrol filling. In this research, the response provided by a subject at level 5 can be seen in the following description:



x = petrol to be purchased
y = distance travelled by 1 liter of petrol
Cost of filling up at the nearest place = 12,000x + (12,000/y. 2)2
Cost of filling up at a distant place = 10,000x + (10,000/y. 10)2
Price difference =
[12,000x + (12,000/y. 2)2] –
[10,000x + (10,000/y. 10)2]
Assumption : x = 5   y = 52

x	y	price difference
5	52	7,000
2	52	1,000
1	52	-1,000

In short buying petrol at a distant place was found to be more economical than filling up at a nearby place. However the distance traveled was longer and took a longer time, on condition that you had to buy more than 2 liters of petrol.
(x≥2)

Figure 8 Level 5 subjects' answers

The following is the results of the interview done with the level 5 subjects

R : Based on the calculated results, what is the recommendation for Mr. Ardi?

L5 : Based on the calculations, if Mr. Ardi purchases only 1 liter, it is better for him to go to the nearest place. However, if he buys more than 1 liter or fills up his tank, I recommend that he is better to go to a petrol station located 10 km away, as it offers cheaper prices. Nevertheless, filling up at the petrol station located 10 km away would increase the distance traveled and take more time.

Based on the interview results regarding the written work of the level 5 subject, it was evident that the subject could use a mathematical model to determine the best price by combining the distance factor and the price of petrol. The subject had successfully created a symbolic mathematical model for each petrol station 12,000x + 48,000/y and 10,000x + 200,000/y. Ultimately, the subject compared both prices and recommended that if Mr. Ardi bought 1 liter, he should go to the nearest place. However, if he bought a full tank, he should go to a petrol station that was further away, as the price difference was only slight and it was closer. Additionally, the subject took into consideration that filling up at a distant petrol station took a longer time and might have other obstacles. Based on these results, subject L5 could reach the interpreting, validating, and exposing sub-competency stage.

DISCUSSION

Several studies had explored the factors that hindered the process of creating mathematical models for example Galbraith, Stillman, Brown, and Edwards [23] Klock and Siller [24]. Temur [25] studied 39 prospective teachers who were teaching problem-solving and mathematical modeling. The study focused on the experiences of junior-year prospective classroom teachers while they were enrolled in the teaching experience course and visiting public primary schools. The findings were as follows: i) prospective teachers had difficulties in selecting problems and teaching due to their limited experience; ii) prospective teachers had difficulties to find non-routine problem situations. Schaap, Vos, and Goedhart [26] found that students encounter and overcome obstacles when creating mathematical models. Their results indicate that the cyclic process framework for modeling needs to be supplemented with frameworks related to problem-solving, metacognition, and beliefs.

The analysis of our research revealed that most of the participants were at level 1, indicating that many prospective mathematics teachers still have a low level of competence in mathematical modelling. Both written responses and interview findings showed that they faced numerous challenges in solving mathematical modelling problems. The research also declared that most subjects struggled to comprehend the given problem, which hindered their ability to complete it.

Understanding the problem is a crucial step in solving mathematical modelling problems. This finding aligns with Blum's statement [27] that students often encounter difficulties when addressing modelling problems. They face challenges in understanding real-world situations, as well as in organizing and simplifying the provided information [28]. Blum [29] also firstly noted that mathematical modelling problems are challenging because they require cognitive skills. Modelling involves translating between mathematics and real-world situations in both directions, as well as necessitating corresponding mathematical ideas and real-world knowledge.

In order to solve mathematical modelling problems, students need to translate real-world situations into mathematical models. Typically, these scenarios are presented in the form of text. To successfully complete the translation process, problem solvers must first grasp the real-world situation. According to Krawitz, Chang, Yang, and Schukajlow [28], reading comprehension plays a crucial role in solving modelling problems, and improving reading comprehension can enhance modelling competence. Mathematical modelling competence is an essential component of mathematical literacy [30].

In addition, students struggle to differentiate between important and unimportant elements in questions. For example, they may overlook the remaining ½ liter of petrol on a motorcycle when considering distance, even though this is crucial for ensuring the motorcycle can reach the petrol station. According to research by Schaap, Vos, and Goedhart [24] students who are in the process of facing modelling problems tend to ignore important elements in the question text and lack algebraic skills.

When solving problems, students often fail to use different types of representations, such as images, even though doing so would help them solve the problems more effectively. According to Geiger, Galbraith, Niss, and Delzoppo [12], having a good understanding of different mathematical representations is essential for successfully solving problems. Those who can switch between different representations tend to be more successful than those who only work within a single representation [31; 32]. The ability to work with different representations also affects the problem-solving skills of future teachers [33; 34].

This study focused on teachers who taught modelling problems to their students. Subsequently, the result of this study can be interpreted as the teaching of modelling problems to the students is based on the principle that for students to become successful modelers, they need to develop mathematical modelling competence, which should be nurtured through mathematical modeling instruction in the classroom, facilitated by competent teachers [35]. The professional mathematical modelling competence of teachers is widely recognized as a crucial factor in the successful implementation of mathematical modelling in mathematics education [36].

In research, when a problem is assigned, it is important to consider whether it as a holistic issue or not. This means that if subject encounters a problem at one stage, they will succeed at that stage. Additionally, in research, we can attempt to address specific problems at each stage of the modelling process.

CONCLUSION

Based on our research findings, the distribution of the subjects can be written as: 5.88% were at level 5, 2.94% were at level 4, 5.88% were at level 3, 11.76% were at level 2, 64.71% were at level 1, and 8.82% were at level 0. The majority of preservice teachers were at level 1 (64.71%), meaning that they could understand the problem but struggled to move on to the next stages. This was a concern because they believed that they already had enough information to answer the question, when in fact, solving the problem required making assumptions, and not all subjects could make assumptions. The difficulties faced in doing this research included: the trouble of understanding the problem, difficulty organizing and simplifying provided information, inability to differentiate between essential and unimportant elements, lack of algebraic skills, and limited use of various types of representation. These findings finally declared that the modelling competence of preservice teachers was relatively low, and it was important to focus on finding solutions to improve this. To overcome this, preservice teachers should receive mathematical modelling learning and get them used to solving mathematical modelling problems.

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Authors

Sri Irawati
(Surabaya, Indonesia)
Doctoral Candidate in Mathematics Education,
Study Program of Mathematics Education,
Universitas Negeri Surabaya
E-mail: sri.21033@mhs.unesa.ac.id
ORCID ID: 0009-0003-2328-1060

Manuharawati
(Surabaya, Indonesia)
Professor, PhD in Mathematics,
Study Program of Mathematics Education Universitas Negeri Surabaya
E-mail: manuharawati@unesa.ac.id
ORCID ID: 0000-0003-1030-7295

Abadi
(Surabaya, Indonesia)
Doctor in Mathematics Education,
Study Program of Mathematics Education
Universitas Negeri Surabaya
E-mail: abadi@unesa.ac.id
ORCID ID: 0000-0002-8475-922X

Author's contribution

Sri Irawati: Conceptualization, Methodology, Formal analysis, Investigation, resources, Data curation, Writing - Original Draft, Visualization, Project administration, Funding acquisition
Manuharawati: Methodology, Validation, Writing - Reviewing & Editing, Supervision, Project administration, Funding acquisition
Abadi: Methodology, Validation, Writing - Review & Editing, Supervision, Project Administration, Funding acquisition

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