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The numerical skills and scaffolding forms: The diagnosis of junior high school students

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Abstract

Cognitive learning outcomes consist of reading and numeracy as measured through a minimum competency assessment. The purpose of this research is to explore numeracy skills in the subject of numbers and determine its scaffolding form. The subjects in this study were 56 students of grade VII in Cirebon. The instruments used include the test of numeracy skills, documentation, and interview guideline. Determination of the subject of analysis of test results and interviews were selected by purposive sampling. The data were analyzed descriptively through the following stages, namely, data reduction, data presentation, and conclusion drawing. The results showed that the research subjects were still not familiar with numeracy questions which had the characteristics of always being preceded by texts, did not understand what was known and asked in the questions, so they tended to guess the answers and needed to be reminded of the prerequisite material. From the results of this study, teachers can develop learning media, develop project-based integrated with scaffolding, develop teaching materials that accommodate numeracy skills, or apply differentiated learning.

Introduction

Considering the intense competition in the 21st century, the role of mathematics for students has become crucial, as it is regarded as the fundamental science (Nahdi et al., 2020). One of the fields closely related to mathematics is numeracy. This aligns with Jablonka's (2015) view that mathematical skills are required for numeracy abilities. Numeracy requires knowledge of mathematics learned in the curriculum. However, learning mathematics itself does not necessarily develop numeracy skills. Mathematics as a subject that is given from the elementary education level is the foundation for critical thinking and is applied in activities of daily life (Wen-Chun & Su-Wei, 2015). Therefore, curriculum design in each education unit always focuses on how to connect school mathematics with real life.

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In daily life, for example, when buying something, organizing appointments, planning finances, constructing buildings, or in a medical context, all these activities require a strong numerical ability. As per Cockroft, numeracy is the skill of using various numbers to solve various everyday problems more quickly and easily (Goos et al., 2011). This definition aligns with Tout and Gal's (2015) perspective that numeracy is the capability to utilize mathematical numbers or symbols, identify and interpret information in the form of tables and the like to make informed decisions in effectively addressing daily issues.

Sayekti and Sukestiyarno (2021) argue that numeracy equips students with the skills to apply numerical concepts, computational skills, and the ability to interpret quantitative information. Furthermore, numeracy is required to make sound decisions in solving quantitative real-life problems. As Nye and Hillyard (2013) suggest, with numeracy, students can make confident decisions regarding quantitative issues. From the various elaborations above on numeracy, it can be concluded that numeracy plays a significant role in addressing various human life needs.

Primary and secondary school education, in particular, require every student to be able to solve mathematical problems found in everyday life through the given numeracy skills, but in reality, considering the results of PISA scores from year to year, it shows that the numeracy skills of Indonesian students are still low. Based on PISA results in 2018, only one percent of students in Indonesia have reached level 5 of the 6 levels tested (Efendi & Kismiantini, 2022). In the category of reading skills, Indonesia was ranked 74th while in the category of mathematics skills, Indonesia was ranked 73rd out of 79 countries. These results indicate that very few Indonesian students are able to solve problems by modeling situations and using appropriate strategies. This ability is related to numerical skill, which is the foundation for solving mathematical problems. So, it is necessary to introduce numeracy to students as early as possible. This is in line with the opinion of Yolanda and Panjaitan (2021) stating that numeracy must be introduced to support students' thinking skills.

Students at the basic education level are focused on improving their and numeracy competencies to go to further education levels (Kebudayaan, 2017). The numeracy of students is not only the task of Language and Mathematics Teachers (Liljedahl, 2015). All teachers have a responsibility to provide numeracy reinforcement in the learning process carried out.

When solving numerical problems, students often encounter many difficulties (Lockwood, 2013) and may require guidance to solve problems or perform tasks beyond what they can achieve independently. To assist students facing difficulties in solving numerical problems, appropriate learning support or scaffolding is needed (Mermelshtine, 2017; Saifurrisal et al., 2023). The improvement of this thinking structure is based on the belief that when students are in the Zone of Proximal Development (ZPD), they have the potential to develop optimally. Therefore, teachers must pay attention to the problems of each of their students before providing scaffolding (Waluya & Suyitno, 2018). Some forms of scaffolding that can be provided to students include teacher interventions through verbal instructions, peer interactions, or the provision of learning resources (Belland, 2014).

Several studies related to numeracy skills have been carried out (Widiantari et al., 2022) developed e-module electronic teaching materials containing ethnomathematics to improve numeracy skills. Meanwhile, (Widiastuti & Kurniasih, 2021), developed learning media using Cabri 3D V2 software, which is integrated with a problem-based learning model to improve numeracy skills. Other efforts to improve numeracy skills based on several studies that have been carried out include applying HOTS questions (Muniri et al., 2023), applying a blended learning model (Borba et al., 2016), applying STEAM Learning (Prihartini & Dahlan, 2023), applying realistic mathematical approach (Maghfiroh et al., 2021), and using Youtube media (Ambarwati & Kurniasih, 2021). However, a study exploring the numeracy skills of junior high school students and scaffolding forms, has never been carried out. The problem formulation in this research is as follows: How is the numeracy of 8th-grade students and the form of scaffolding provided for number-related materials? Therefore, this study aimed to explore the numeracy skills of students of grade VII in solving mathematical problems on the material of numbers and scaffolding forms. Knowing the thinking patterns of students' numeracy can help teachers in preparing appropriate models, methods, strategies, or learning tools in order to improve students' numeracy skills.

Methodology

Research Design

This type of research is descriptive qualitative research that aims to reveal the numeracy thought process of 8th-grade students and its scaffolding forms. This study was carried out at two junior high schools in Cirebon from June to July 2022.

Respondent

The subjects of this study were 56 students who were then grouped into three categories based on Initial Mathematical Ability Test (IMA). For the student IMA grouping technique, the researcher used a modified Noer rule, as detailed in Table 1.

Table 1 Criteria for Students IMA Grouping

interval	Criteria
$\bar{x} \geq 70$ %	IMA High
$60\% \leq \bar{x} < 70\%$	IMA Moderate
$\bar{x} < 60\%$	IMA Low

Source: Agustina (2021).

Based on criteria IMA in Table 1, the subjects consisted of 2 students who were in the high group, 2 students in the moderate group, and 2 students from the low group. Some of the considerations that the researcher took into account when selecting research subjects included: having knowledge and experience in basic mathematics material as they have gone through elementary school, which includes topics like integers, fractions, and exponentiation. Additionally, the researcher chose students with good communication skills, enabling them to express the relationships that exist, such as recounting what they have done (in their minds). Each subject was interviewed by the researcher about the tasks they had done based on indicators of numeracy skills. Interviews are not only conducted to verify the data from written tests but also to gather new information that may not be obtained through written tests. It is possible that students may think of things but not write them down, and this may be revealed during the interview. To test the credibility of the data, the researcher employed triangulation. In this research, the triangulation used is temporal triangulation, which involves checking with written tests and interviews at different times or in different situations. If the data obtained are consistent (showing many similarities), then the data from the numeracy ability test and interviews are considered valid. If not, the researcher collects data at a different time from before and compares it with the previous data. This in-depth interview process took place in July 2022.

Instrument

The instruments used in this study were an interview guideline and the test of numeracy skills. Before being given to the subjects, the instruments that need validation are validated for their construct and content by experts through the Forum Group Discussion (FGD). The test results were analyzed using qualitative data analysis based on the process of numeracy skills. The numeracy questions on the material of numbers that have been tested for the quality of the questions using validity, reliability, discriminating power, and index of difficulty are listed in Table 2.

Table 2 Numerical questions on numbers

Question	Indicator
City X's population is 3×10^5 people, while City Y' population is 6×10^6 people. Put a check list (✓) on the correct statement ☐ City Y's population is twenty times more than City X's ☐ City X has more population than City Y ☐ The difference between City X' and City Y's populations is 5.7×10^6 people	(*to use a variety of numbers and symbols related to basic mathematics to solve problems in a variety of contexts of everyday life*)
To make a jumbo size sweet bun, you will need the following ingredients: Necessary ingredients — Quantity (g) Flour 250 Sugar 40 Milk powder 10 Butter 30 Salt 2 Yeast 4	(*to use interpretation of analysis results in tabular form to predict and make decisions*)
Pay attention to the information on the bun. In the warehouse, the following ingredients are still available in stock. Necessary ingredients — Quantity (g) Flour 25,000 Sugar 4,000 Milk powder 950 Butter 5,000 Salt 350 Yeast 750	

Table 2 Continued

Question	Indicator
With the amount of ingredients available in stock, how many jumbo buns are possible?	
How to calculate fluid needs in the body Every person has their own fluid needs, depending on activity, gender, age, height, and weight. While there are general rules that suggest the ideal amount of water for a person to drink, you can calculate your personal fluid needs in several ways. The body fluid needs of each person can be determined through a formula based on age, height, and weight. • Fluid requirement formula (in liters) for men 2.7 + (0.09 x age) + (0.13 x height in cm)–(0.31 x weight in kg) • Fluid requirement formula (in liters) for women 2.1 + (0.1 x age) + (0.11 x height in cm)–(0.25 x weight in kg) If you are active in sports, it takes an additional 0.35 liters per hour. Fahira is a 14-year-old girl in grade VIII and her height is 150 cm. She weighed herself and the results are shown in the following picture. Fahira exercises actively for 2 hours every day. The amount of fluid needed by Fahira every day is liters.	*(to interpret the results of the analysis to predict and make decisions)*

Table 2 explains the tasks used to analyze the numeracy skills of eighth-grade students in the topic of numbers. In addition to numeracy tests, another instrument used is interview guidelines. Broadly, the questions to be asked in these interviews are not structured in advance. The questions posed are adapted to the student's work results after completing the given tasks. The interview guidelines refer to the descriptors of numeracy thinking. The interview guidelines used in this research are as Table 3.

Data Analysis

The data analysis technique used consisted of 3 stages according to Miles and Huberman (Miles & Huberman, 1994), namely: (1) Data reduction, (2) Data display, and (3) Conclusion. The purpose of data reduction, among others, is to refine, select, focus, abstract, and transform the raw data obtained in the field into meaningful data. In this research, the raw data obtained from the field study are reduced to obtain the data needed to describe students' numeracy skills in the topic of numbers. The collected data, after reduction, are organized and categorized. Subsequently, the data are presented in a simpler narrative format, allowing for conclusions to be drawn from the data. Drawing conclusions involves summarizing the data and verifying the accuracy of the data collected regarding how eighth-grade junior high school students' numeracy skills are in solving numerical problems.

Results

The researcher analyzed the results of student assignments that had been given by the teacher based on indicators of numeracy skills, and 6 people were taken to be research subjects. Subjects were taken based on different groups of numeracy skills, namely, the high (H), moderate (M) and low (L) groups. The student data are described as follows.

Table 3 The interview guideline

Numeracy Indicator	Question
Using various numbers or symbols related to basic mathematics to solve problems.	What information did you obtain from question number 1? Tell me the meaning of ">" or "<"? How do you find the difference between the two numbers? How do you multiply numbers with exponents? Are you confident that the method you used is correct?
Analyzing information presented in various forms (graphs, tables, charts, etc.).	Try to explain what you understand from the problem in question number 2. Tell me the numbers listed in the table. How did you solve the problem in question number 2? Are you confident that the method you used is correct?
Interpreting the results of the analysis to predict and make decisions.	Try to explain what you understand from the problem in question number 3. Tell me which formula you used to solve the problem, and why? How did you solve the problem in question number 2? Are you confident that the method you used is correct?

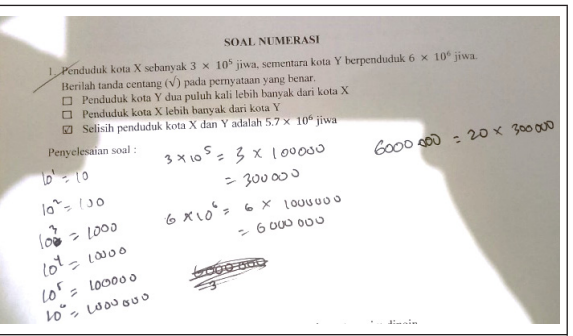
Note: To ensure that no information is missed and that the obtained data are secure, interviews are recorded using a mobile phone recording device.

Based on Figure 1, students in the moderate category, namely, S1 and S2 understood the concept of powers, even though their answers were not well explained. Meanwhile, students in the low category, namely, S3 and S4 did not understand the concept of powers, so they answered (the question) by guessing. This was revealed when a question and answer session was conducted with the researcher. S2 said that they didn't understand and just guessed the answer. As for students in the high category S5 and S6, they understood the concept of powers and were good enough in explaining the answers. Based on students' answers, either in writing or in interviews, it is shown how weak the students' ability is in working on numeracy questions in the material of powers of numbers. This is in line with the opinion of (Effendi, 2022) stating that powers are one of the many materials in mathematics that are considered difficult for students. This encouraged the researcher to provide scaffolding assistance, especially for the low category students. The following Figure 6, shows the results of the S3 after being given scaffolding assistance.

Based on Figure 2, S3 were able to solve the problem by explaining the powers and being approached with the concept of powers with a base number of 10. S1, S2, S3 and S4 were guided intensively and reminded of the prerequisite material so that they were able to solve question number 1. Furthermore, the results of S4's answer to question number 2 are presented as follows (Figure 3).

Based on Figure 3, students added up all the variables to make a jumbo bun and added up the stock of ingredients variables. Next, finding out the minimum number of buns that can be made, is obtained from the quotient between the stock of ingredients and the ingredients needed to make a jumbo bun. To reveal the numerical thinking process, the researcher conducted in-depth interviews with students, as follows:

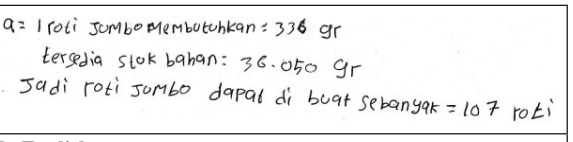
P : How do you solve problem number 3?
S4 : This table (pointing to the top) is added up for all the ingredients and this too, (pointing to the bottom) then the big one is divided by the small one
P : Can you add 250 wheat flour with 40 sugar?
S4 : Yes ma'am, 290…
P : 290, what?
S4 : 290 grams
P : Yes, I mean what gram?
S4 : Hehehe… I am confused
P : Okay, if there are 2 cows added with 2 cats, how many do you get, *dear*?
S4 : Hehehe... you can't add it up, *ma'am*, it's different....
P : Yes, because the units are different... Then why did you use that method?
S4 : Yes, ma'am, because if you make a jumbo bun, all the ingredients are mixed...



Translate :

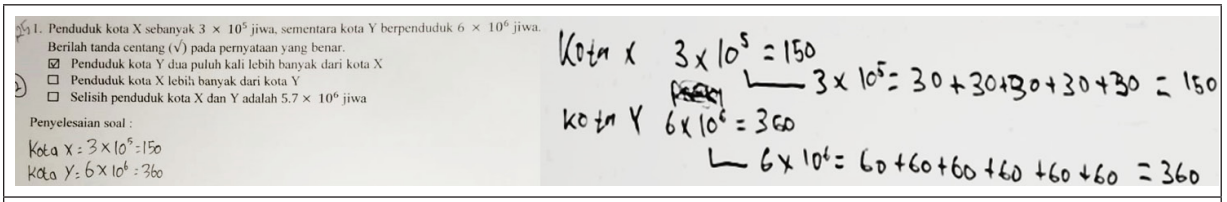
$10^1 = 10$	3×10^5	$= 3 \times 100000$	$= 300000$
$10^2 = 100$	6×10^6	$= 6 \times 1000000$	$= 6000000$
$10^3 = 1000$			
$10^4 = 10000$	6000000	$= 2 \times 300000$	
$10^5 = 100000$			
$10^6 = 1000000$			

Figure 2 Students' answers to question number 1 in the low category after being given scaffolding



In English :
1 jumbo bread requires = 336 grams.
Available ingredient stock = 36,050 grams.
So, we can make a total of 107 jumbo breads.

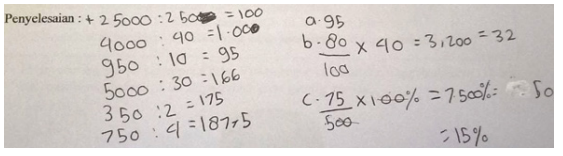
Figure 3 Results of students' answers (S4) to question number 2



Translate :
City X = $3 \times 10^5 = 30 + 30 + 30 + 30 + 30 = 150$
City Y = $6 \times 10^5 = 60 + 60 + 60 + 60 + 60 = 360$

Figure 1 Students' answers to questions 1 in the low category

Based on the interview excerpts, students used this method because they thought that when making a jumbo bun they have to mix all the ingredients. In this question, it was revealed that students did not understand the concept of variables and their operations. For example, students added up the weight of flour, sugar, milk powder, butter, salt, and yeast. The form of scaffolding given to S4 included being reminded of the concept of variables and providing examples of its application in everyday life. The answers of S4 after being given scaffolding assistance are presented in the following Figure 4.



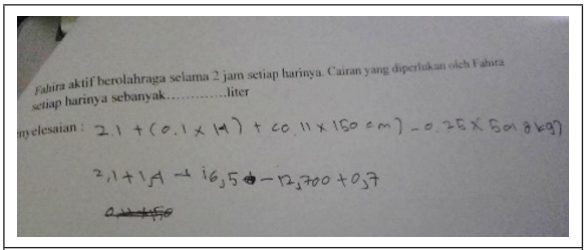
In English
25000 : 250 =100
4000 : 40 = 100
950 : 10 = 95
5000 : 30 = 166
350 : 2 = 175
750 : 4 = 187, 5
a. 95
b. $\frac{80}{100} \times 40 = 3{,}200 = 32$
c. $\frac{75}{500} \times 100\% = 15\%$

Figure 4 Results of students' answers to question number 2 after being given Scaffolding Assistance

Furthermore, in question number 3, S4 did not answer the questions thoroughly and looked unconvincing from the way of writing, and after confirmation, the results were the same. For S2, there were still some errors, including not being careful in adding up integers and decimals. Meanwhile, S6 were able to complete the calculation algorithm well and were able to interpret the results of the analysis to predict and make decisions. An example of a student's answer in the S4 category is presented in figure 5.

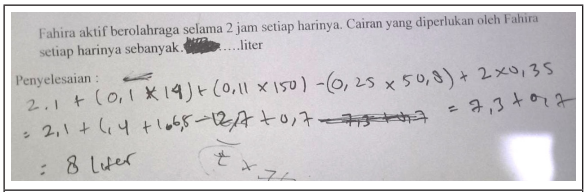
Based on figure 5, S3 did not master basic skills in operating decimal forms, seeing this condition the researcher provided scaffolding by means of a "walking comma" where students were asked to make number cards bearing the numbers 1–9, 5 cards bearing the number 0, and 1 card bearing the comma (,). After that, the teacher gave the signboard in front of the students. When divided, the comma (,) will jump to the left as much as the number of zeros in the divisor. When multiplied, the comma (,) will jump to the right as much as the number of zeros in the divisor. If in front of the comma (,) is empty / no number, then it is filled with the number 0 (zero). The teacher gave practice questions to students. This is in accordance with (Tóth et al., 2024) stating that misconceptions often occur due to imperfect concepts that are absorbed, resulting in concept incompatibility. This is further supported by (Afriyansyah & Putri, 2014) that misconceptions often occur, especially in decimal numbers and their operations. Figure 6 shows the results of S3 after being given scaffolding assistance.

Based on Figure 6, S2 was able to solve the problem after being given scaffolding assistance. In order to help students who have difficulty in solving numeracy problems, appropriate learning aids or scaffolding are needed. The improvement of this thinking structure is based on the belief that when students are in the Zone of Proximal Development (ZPD), they have the potential to develop optimally. Scaffolding reflects Vygotsky's idea of the Zone of Proximal Development (ZPD), which describes the gap between what students achieve on their own and what can be achieved with mentoring (Fani & Ghaemi, 2011; Wass & Golding, 2014). Therefore, teachers must pay attention to the problems of each of their students before providing scaffolding (Waluya & Suyitno, 2018).



In English:
2,1 + (0,1 × 14) + (0,11 × 150 *cm*) – 0,25 × 5018 *kg*)
2,1 + 1,4 – 16,5 – 12,700 + 0,7

Figure 5 Results of Students' answers to question number 3 before being given Scaffolding Assistance



In English :
2,1 + (0,1 × 14) + (0,11 × 150) – (0,25 × 50,8) + 2 × 0,35
= 2,1 + 1,4 + 16,5 + 0,7 = 7,3 + 0,7 = 8 *liter*

Figure 6 Results of students' answers to question number 3 after being given Scaffolding Assistance

Discussion

Numeracy skills are very important in supporting life. A person with low numeracy skills may not be able to read books, understand price tags, understand road signs, understand public transport departure times, read directions for drugs, or even use the internet. Numeracy skills have been extensively studied in previous research. The literature review on the importance of numeracy skills has been examined by Oughton, (2007), Straesser (2015), Torgerson et al. (2003). Gender differences in numeracy skills have been investigated by (Soler-Hampejsek et al., 2018). Numeracy assessment tools were developed by Purnomo et al. (2022), and Mangelep et al. (2023). According to the findings of Sa'dijah et al. (2023), the numeracy skills of junior high school students fall into the low category. Students have not fully understood the lesson materials and the context of word problems, struggle to identify correlations, patterns, and generalizations, and their ability to determine mathematical models is still considered low. This research complements previous studies. After analyzing numeracy skills, the researcher provides appropriate scaffolding to address the learning difficulties experienced by students in the topic of numbers.

From the results of the diagnosis of numeracy questions on the material of numbers, it was revealed that some students made mistakes in operating variables, which is an indication that students lack a key understanding of variables, so that it becomes an obstacle in their understanding of algebraic concepts (Booth et al., 2014). Therefore, it is important for students to know the rules for combining variables in algebraic operations (Malihatuddarojah & Prahmana, 2019). In story problems, students often make mistakes in understanding, identifying the problems presented, explaining the concepts, principles and operations (Jumiati & Zanthy, 2020). This happens because students do not understand the material completely or understand the material only partially. This partial understanding makes it impossible for them to apply mathematics, including in the context of daily life problems.(Laurens et al., 2017). Whereas based on Webb's theory, students can understand the problem if given a more concrete understanding of the problem at hand (Nugraha et al., 2019). This is in line with the opinion of (Agnesti & Amelia, 2020) stating contextual problems that originate from reality and are close to life situations in the environment will be easier for students to understand. This is also in line with the opinion of (Ginting et al., 2018) stating that mathematical material which is dominated by abstract objects should be modified to be more concrete so that students can imagine through contextual problems (Swanson & Williams, 2014). But in reality, even in contextual problems, students find it difficult to do it. Therefore, appropriate learning assistance is needed so that it can overcome or minimize errors that occur. One of the learning aids that can be used is by guiding students who have difficulty by explaining what the questions really want and what the questions have.

Based on the results of this research, teachers can provide scaffolding when presenting numeracy problems to students. The scaffolding process involves asking students to carefully reread the problem and ensure the correctness of their work, explaining how to write down what is known and what is asked, revisiting prerequisite material, having students repeat what is known and what the problem is asking, and engaging in a question-and-answer session to guide students in improving their responses. The form of scaffolding in general can be in the form of printed teaching materials, interactive teaching materials, learning media, and so on (Badri et al., 2019; Waluya et al., 2022). One form of scaffolding that is often used is teaching materials. Based on the results of a study conducted by (Lin et al., 2012), the combination of scaffolding from humans (the teacher) and the involvement of technology can support learning in complex situations.

The research presented here is limited to diagnosing numeracy skills and providing appropriate scaffolding. The scaffolding provided to students will undoubtedly vary, depending on the specific learning difficulties they experience. Therefore, the limitations of this research do not allow for generalizing the numeracy skills of students, as well as the forms of scaffolding. In the next phase, we will test the effectiveness of scaffolding and develop mathematics learning materials based on the findings from this research, with the hope of improving numeracy skills among junior high school students.

Conclusion and Recommendation

Based on the results and discussion, students in the low and moderate categories did not master numeracy well. Low and moderate category numeracy students were not able to use various kinds of numbers and symbols related to basic mathematics to solve problems in various contexts of everyday life, use the interpretation of the results of the analysis in tabular form to predict and make decisions and interpret the results of

the analysis to predict and make decisions. Therefore, some scaffolding assistance was needed to enable them to complete their task. It is recommended for teachers to strengthen students' numeracy skills for the material being studied and carry out habituation to students in working on varied questions so that skills and accuracy in analyzing questions can increase. This numeracy contains knowledge, skills, and attitudes. At every level of education, the government has determined the competency standards for graduates. This numeracy is a learning outcome that prioritizes knowledge which is reviewed annually and used as a data source for the annual evaluation. This numeracy is related to the ability of students to understand, apply, and evaluate various types of text contexts in solving problems, and the ability of students to develop thinking skills using concepts, stages, and facts to solve problems in everyday life. Also, to think critically and creatively in solving problems in making decisions.

It is hoped that further researchers who want to measure students' numeracy skills modify their learning by integrating scaffolding and implementing it with certain learning models, such as project-based learning. In addition to improving numeracy skills, the project-based learning model is thought to be integrated with characters such as Pancasila students. The implementation of this learning model aims to determine its effectiveness in improving students' numeracy thinking skills. In addition to innovative learning models, the use of technology such as gadgets, smartphones, and social media needs to be developed to support the learning process.

Conflict of Interest

The authors declare that there is no conflict of interest.

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