

Mathematical Ability Profiles in Solving Numeracy Problems

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ABSTRACT

This research aims to describe the mathematical ability profiles of prospective elementary school teachers in solving numeracy problems. The present study is qualitative research. The study results stated that prospective elementary school teachers with low mathematical abilities need more vital in understanding the information presented. Prospective elementary school teachers with moderate math abilities often need to catch up on the information provided, jump up and down in solving problems, and rarely interpret the analysis results. Meanwhile, prospective elementary school teachers with high mathematical abilities tend to be vital in understanding the information presented, proficient in calculations, focused on solving the problems of each problem, and frequent in reflecting on the whole.

Keywords: Numeracy problems, mathematical ability

INTRODUCTION

Literacy and numeracy are essential foundational skills that command significant wage premiums in the modern labor market (Borgonovi et al., 2021; Conica et al., 2023). In this era of increasingly advanced technology, numeracy skills are essential for all individuals in personal or professional development (Girard et al., 2023). Literacy and numeracy are a vital part of education development in Indonesia. In 2021, a National Assessment was held, which measured literacy and numeracy skills from elementary to public high school levels. Indonesia's government is very serious about literacy and numeracy. Numeracy is seen as the ability to properly handle the quantitative aspects of everyday life, while literacy is the ability to cope with

life's demands of reading and writing (Westwood, 2008). Previously, numeracy was presented as a companion to literacy skills (Westwood, 2008). In addition to literacy, numeracy symbolizes skills for the welfare of individuals and the community (Lechner et al., 2021). Numeracy is one of the essential life skills for community members who actively contribute (Hong et al., 2020). Formal education is the primary means to develop literacy and numeracy (Soler-Hampejsek et al., 2018).

PISA is one of the international assessments to measure the ability of school-age students. The literacy abilities measured were reading, mathematics, and science. At PISA 2018, Indonesia ranked in the bottom 10. PISA is organized by OECD (*Organisation for Economic Cooperation and Development*). PIAAC (The Program for International Assessment of Adult Competencies) is an international assessment of adult information processing skills conducted by the OECD. If PISA is an assessment of school students 15 years old, then PIAAC is an assessment that is intended for 16-65 years old. Numeracy is one of the skills assessed by PIAAC.

. PIAAC cycle one was implemented in 2011-2018. PIAAC cycle two was held from 2018 to 2024. Indonesia's numeracy has not yet developed (Han et al., 2017). Indonesia also participated in the PIAAC from 1 April 2014 to 31 March 2015. From a reported numerical review (OECD, 2016), Jakarta adults who score level 1 and below level 1 reach 60.0%. Adults with numerals below Level 1 can only perform a simple process.

The demographic age and technological advancements in the industry of society imply that throughout life, adults will always be required to continuously update their skills (Lechner et al., 2021). Numeracy is used in our daily lives with the intent of social purpose, and how it is used depends on the context in which it takes place (Griffiths & Stone, 2013). Today, to be considered numerate, individuals need to have the capacity to understand mathematical concepts when their contexts and needs as global, national, and local citizens are applied (Sellars, 2018). Being numerate is very important for us to manage our lives successfully (Blume et al., 2021). As prospective elementary school teachers (PEST), they must have good numeracy. They will later be the vanguard in developing the nation's children's numeracy. The results of PIAAC Indonesia are also not encouraging. According to PIAAC, only a tiny percentage of adults in Jakarta can reach level 3 and above. This result must be considered by this nation to compete with other countries. Numeracy and mathematical ability are interrelated. In numeracy, one uses mathematics. Previous research confirms the relationship between the practice of formal advanced numeracy and skills of symbolic math (Girard et al., 2023). A person's numeracy depends on their mathematical knowledge (Kolar & Hodnik, 2021). Previous research has also found a link between numeracy and mathematics achievement (Chan & Scalise, 2022). This study aims to see the mathematical ability profiles of PEST in solving numeracy problems.

METHOD

The present study is qualitative research. This research was conducted in a class that had taken an introductory math concept course consisting of 28 students at Universitas Negeri Semarang. Their level of mathematical ability is seen from basic mathematics result tests. This test was valid and reliable. This test consists of 30 questions. It was found that there were two candidates with low math ability, 22 candidates with medium math ability, and the rest with high math ability. Subjects were selected based on purposive sampling. Each of the two primary school teacher candidates with low, medium, and high math abilities participated in this study. The selection of research subjects also considers several aspects, including communication skills and activeness in the classroom. A1 and A2 are candidates for PEST with low mathematical ability (LMA). A3 and A4 have moderate mathematical ability (MMA). A5 and A6 have high mathematical ability (HMA).

Data validity used data triangulation through interviews, observations, and documentation. Previously, the researcher had given six numerical questions, each representing a numeracy level. The answer sheet document of PEST, along with the results of interviews and observations, were then analyzed in depth.

RESULTS AND DISCUSSION

The ability to understand and apply numerical information is called numeracy (Estrada-Mejia et al., 2016). The ability to use mathematical concepts in everyday life is numeracy, defined by PIAAC (Sikora et al., 2019). The capability to access, apply, interpret, and communicate mathematical information and ideas to involve in and administer mathematics demands in adult life is the definition of numeracy in cycle one by the PIAAC (OECD, 2012). Situation management and problem-solving are involved in numerical behavior (OECD, 2012). Accessing, using, and reasoning critically with mathematical material, information, and concepts represented in various ways to engage in and manage the mathematical demands of different situations in adult life is the definition of numeracy in cycle two of PIAAC (OECD, 2021). The ability to use various numbers and symbols to solve everyday problems, analyze multiple forms of information presented and then use the results of analytical interpretation in decision-making (Han et al., 2017). According to the OECD (OECD, 2021), the cognitive process of numeracy is (1) accessing and assessing situations mathematically (P1), (2) doing and using mathematics (P2), (3) evaluating, reflecting critically, and making judgments (P3). It is this cognitive process that we will see in this study. Attaching and assessing situations mathematically can be seen in how PEST writes down the problem's information and identifies what is asked. Doing and using mathematics can be seen in how the PEST solves numeracy problems. Evaluating, critically reflecting, and making judgments can be seen through how PEST explains the results of their calculations and makes their conclusions.

The first problem accommodates numeracy indicators of levels below 1. These level questions measure the respondent's ability to perform simple processes. This question contains quantity and number content. Context loaded is private. The mathematical ability profile of PEST to solve numeracy problem number one is described in Table 1.

In solving numeracy problems at levels below 1, A1 and A2 make errors in their mathematical calculations. Their calculation error made them have the incorrect result. There are differences in the calculation results of the first part carried out by A1, which is Rp 82,500.00 to only Rp 82,000.00. The same thing happened to A2, the first part of which was Rp 275,000.00 to Rp 285,000.00. A3 and A4 also made miscalculations. Meanwhile, A5 and A6 can solve this problem well.

TABLE 1. MATHEMATICAL ABILITY PROFILES OF PEST COMPLETING NUMERACY QUESTIONS LEVEL BELOW 1

Cognitive Process	LMA Teacher Candidates	MMA Teacher Candidates	HMA Teacher Candidates
P1	Understand all available information but misidentify the problem in question.	Understand all available information but misidentify the problem in question.	Understand all available information and correctly identify the problem being asked.
P2	Less thorough in performing simple mathematical calculations	Lack of thoroughness in performing simple mathematical calculations	Can perform simple mathematical calculations correctly.
P3	Interpret the results of the answer, not re-evaluate the answer.	Interpret the results of the answer. They had to check by reading the questions and steps.	Interpret the results of the answer. Conduct an overall evaluation.

Researchers try to confirm this through interviews. From the interviews, it was found that A2 did not recheck the answers. So, inaccuracies in her calculations were not detected. Excerpts from the interview between the researcher (R) and A2 are as follows:

R : Tell me about it!

A2 : This question asks me to calculate what price to pay from Rp 550,000.00 with a 50% +30% discount.

R : What steps did you take to solve this problem?

A2 : I first calculated a 50% discount from IDR 550,000.00, then only 30% from the regular price minus the previous 50% discount.

R : Do you double-check your answers?

A2 : I do not usually re-examine my work

Question number 2 accommodates level 1 numeracy. This question measures the ability to perform the processes of fundamental mathematics in a concrete general context. This question contains quantity and number content with personal context. Mathematical ability profiles of prospective elementary school teachers in solving this level question are described in Table 2.

TABLE 2. MATHEMATICAL ABILITY PROFILES OF PEST COMPLETING LEVEL 1 NUMERACY QUESTIONS

Cognitive Process	LMA Teacher Candidates	MMA Teacher Candidates	HMA Teacher Candidates
P1	Skip some explicit information. Write down what was asked correctly	Captures all information provided but incorrectly writes down the problem asked	Capture all the information presented and write down the problem asked correctly
P2	They are not performing the calculation process.	Perform a new one-step calculation process.	Complete the multi-step calculation process correctly.
P3	Not interpreting the answers or evaluating the process	Interpreting the answer but not evaluating the whole process.	Interpret the answers and evaluate the entire process.

In this question number two, A1 and A2 do not work on the question. A3 and A4 are just working one step on a problem: calculating the discount amount in money. The results of A4's work can be seen in Figure 1. A4 has not continued the calculation until the percent form. A5 and A6 work until finished, calculating the discount amount in percent form.

2. Diketahui \rightarrow Kemeja warna biru = Rp 299.000,00
 \rightarrow Special price : Rp 150.000
 \rightarrow Kemeja warna merah : 25.000 lebih mahal dibanding kemeja biru
 \rightarrow Kemeja warna biru + 25.000
 $299.000 + 25.000 = 324.000$
 \rightarrow kemeja selain warna biru dan merah 35.000 lebih murah dibanding kemeja merah \Rightarrow kemeja merah - 35.000
 $324.000 - 35.000 = 289.000$
 Ditanya : diskon dari Kemeja Anto ...?
 Jawab : Ayah Anto kemeja warna ungu = 289.000
 Anto warna hijau = 289.000
 Adik Anto warna merah = 324.000
 Diskon dari kemeja Anto (warna hijau) = 289.000 - Special price
 $= 289.000 - 150.000$
 $= \text{Rp } 139.000$
 Jadi diskon dan kemeja Anto adalah Rp 139.000,00

<p>Knowned: blue shirt: Rp 299.000,00 Shirts special price: Rp 150.000,00 a red shirt is twenty five thousand rupiahs more expensive than a blue shirt=> $299.000+25.000=324.000$ shirts other than red and blue are thirty-five thousand rupiah cheaper than red shirts => $324.000-35.000=289.000$ Asked: discount on Anto's shirts...? Answer: Anto's father shirts is purple = 289.000 Anto shirts is green = 289.000 Anto's brother shirt is red = 324.000 discount from anto shirt (green)= 289.000-special price=$289.000-150.000 = 139.000$ So the discount of Anto shirt is Rp 139.000,00</p>
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FIGURE 1. WORK RESULTS FROM NUMBER 2 BY A4

Question number three is based on the indicator at level 2 numeracy. It measures the ability to identify and act based on ideas and mathematical information in various general contexts. This question contains the content of personal, contextual spaces and forms. The mathematical ability profiles of prospective elementary school teachers solved at this level question can be viewed in Table 3.

TABLE 3. MATHEMATICAL ABILITY PROFILES OF PEST SOLVING LEVEL 2 NUMERACY QUESTIONS

Cognitive Process	LMA Teacher Candidates	MMA Teacher Candidates	HMA Teacher Candidates
P1	They misunderstand the visual information presented. Write down the problem being asked correctly.	They missed some of the visual information presented. Write down the problem being asked correctly.	They capture all visual information presented. Write down the problem being asked correctly.
P2	Wrong in performing the calculation process using mathematics	Wrong in performing the calculation process using mathematics	Wrong in performing the calculation process using mathematics
P3	They interpret the answer but do not evaluate the whole process.	They interpret the answer but do not evaluate the whole process.	Interpret the answers and evaluate the entire process.

In question no. 3, A1 and A2 made mistakes in understanding the information presented, which resulted in incorrect steps. A3, A4, A5, and A6 can understand the information correctly. Figure 2 will compare the understanding of information from A1 and A5. The capability for information interpretation must be together with comprehension and implementation of mathematical material in the problem context

(Subekti et al., 2020). There is already an illustration that the short side faces the road, but A1 still misunderstood the information presented. This question calculates the number of trees planted around the land other than those facing the road and is also planted as a land boundary between siblings. The distance between one tree and another is 1 meter. In their calculations, A3, A4, A5, and A6 have not been able to see that two trees in the corner are counted double, and one tree in the middle is counted triple, so the answer becomes wrong. Many students find it challenging to solve geometric problems even though geometry is an exciting field of mathematics (Ismail, 2023). Previous research has suggested that spatial visualization improves math capabilities (Kahl et al., 2022).

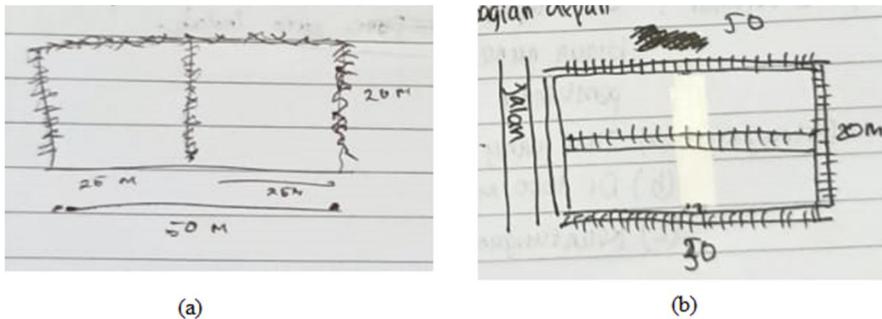


FIGURE 2. COMPARISON OF INFORMATION UNDERSTANDING BY A1 (A) AND A5 (B)

Question number four accommodates level 3 numeracy indicators. It measures the capability of mathematical information understanding that may be less declared, not always familiar, and complex ways of representation. This question contains the content of changes and contextual relationships in the community. The mathematical ability profiles of elementary school teacher candidates in solving this level question are reported in Table 4.

A1 and A2 do not answer this question. They both confirmed that they did not know how to answer it. A3 and A4 work on this problem, but the pattern found is not yet suitable. A5 and A6 have seen the pattern. A5 made a mistake in the calculation. A5 is wrong in summing the terms. The result should be 21,450, not 31,800. A6 has not completed the calculation. This problem cannot be solved directly with the formula number of n term because what is asked is the number of odd rows.

TABLE 4. NUMERACY OF PEST COMPLETING LEVEL 3 NUMERACY QUESTIONS

Cognitive Process	LMA Teacher Candidates	MMA Teacher Candidates	HMA Teacher Candidates
P1	Skip the less explicit information. Write down what was asked correctly	Skip the less explicit information. Write down what was asked correctly	Capture all less explicit information well and write down what issues are being asked correctly
P2	Does not perform the calculation process using mathematics	Did not complete the calculation process using mathematics	The calculation process used the pattern correctly, but the answer was wrong.

P3	Not interpreting the answers or evaluating the process	Not interpreting the answers or assessing the process	They have not analyzed the response and have not considered the entire process.
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Question number five accommodates level 4 numeracy indicators. This question measures the understanding ability of various mathematical information. This question contains data content and opportunities. The context used in this question is the job. We can view the mathematical ability profiles of prospective elementary school teachers in solving this level question in Table 5.

In question five, A1 and A2 just wrote down the information on the presented bar chart. A3 and A4 have made calculations but have not provided conclusions from the calculation of answers. A4 calculates the average value obtained by each person but forgets to consider that cognitive abilities are calculated by 30%, Cooperation skills are calculated by 20%, leadership is calculated by 20%, public speaking is 15%, and English skills are 15%. A4 immediately adds up all the values divided by the number of data. After that, he does not continue selecting people recommended for internships. After further research, this is because A4 often jumps around in working on problems. He does not focus on solving each problem. This action can be seen in the results of observations in Table 7. A5 and A6 do the same thing as A3 and A4, namely calculating the average without regard to the composition of the amount for each value. It is just that A5 and A6 continue the process by trying to argue and make a decision even though it is still wrong. Becoming skilled at arguing requires basic material proficiency, methodological knowledge, and a strategy of problem-solving (Sommerhoff et al., 2023).

TABLE 5. NUMERACY OF PEST COMPLETING LEVEL 4 NUMERACY QUESTIONS

Cognitive Process	LMA Teacher Candidates	MMA Teacher Candidates	HMA Teacher Candidates
P1	Can read diagrams well. Captures what is being asked correctly.	Can read diagrams well. Captures what is being asked correctly.	Can read diagrams well. Captures what is being asked correctly.
P2	Did not complete calculation	Did not complete calculation.	Complete the calculation even though the answer is wrong.
P3	Not interpreting the answers or evaluating the process	Has not made any arguments or conclusions. Not reflecting on the process as a whole.	Give an argument against the answer. Not reflecting on the process as a whole.

Question number six accommodates level 5 numeracy. It measures the understanding capability in complicated representations, abstract, academic mathematical, and statistical concepts. This question contains quantity and number content as well as the context of the work. Mathematical ability profiles of prospective elementary school teachers' solved numeracy problems at this level are described in Table 6.

In question number six, all respondents could not capture the complex information presented and felt confused about how to solve this problem. There is some information related to the ingredients needed in making some bread, the price of bread ingredients per kg, and the selling value of bread per 500 gr jar. All respondents could not understand this very complex information.

TABLE 6. NUMERACY OF PEST COMPLETING LEVEL 5 NUMERACY QUESTIONS

Cognitive Process	LMA Teacher Candidates	MMA Teacher Candidates	HMA Teacher Candidates
P1	They missed much information presented. Write down what was asked correctly.	They missed much information presented. Write down what was asked correctly.	They missed much information presented. Write down what was asked correctly.
P2	Did not complete calculation	Did not complete calculation	Did not complete calculation
P3	Not interpreting the answers or evaluating the process	Not interpreting the answers or evaluating the process	Not interpreting the answers or evaluating the process

Researchers also made observations while respondents worked on questions and interviews. The observation results are reported in Table 7.

TABLE 7. OBSERVATION RESULTS OF PEST WITH LOW, MEDIUM, AND HIGH MATHEMATICAL ABILITY

LMA Teacher Candidates	MMA Teacher Candidates	HMA Teacher Candidates
They saw reading the problem entirely. Write down the problem being asked correctly.	They read questions quietly. Write down the problem being asked correctly.	They underline a few words. Write down the problem being asked correctly.
Many answers are empty or incomplete.	Often jumps around in working on questions—lack of focus for each question.	Finish the calculation in order. Dare to make conclusions and argue.
Did not look back at the answer	Several times, they was seen doodling to evaluate the calculation step.	They often seen doodling to evaluate the calculation step.

The researcher saw that A5 often doodled and looked like he was going back to work on the question. Therefore, in the interview, the researcher confirmed this. Excerpts from the interview are as follows:

R : You seem to be doodling a lot while looking at your answers. What are you doing?

A5 : I double-checked my answer, ma'am.

R : What are the technical details of your steps?

A5 : I am working on it again on another paper, ma'am. For details, I reread the question and matched what I wrote on the answer sheet about what is known. Then I see if the problem asked is under what I wrote. I just checked every step of my count.

This research shows that primary school teacher candidates still struggle with numeracy problems. A mistake in understanding the information provided is often a weakness. Teacher candidates tend to look globally and are often not careful when reading information. Reading is essential to understanding a discipline (Shepherd & van de Sande, 2014). Learning mathematics is not only decisive by mathematics material but also by reading methods in mathematical tasks. (Y. Cai & Yang, 2022). Language proficiency is crucial for learning and discussing mathematics inside and outside school (Greisen et al., 2021).

According to recent research, students who perform well in reading are likelier to excel in mathematics (Ding & Homer, 2020). Thus, low mathematical ability indicates low reading ability, which causes difficulties in understanding the information presented. In other words, mathematical ability shows how proficient the prospective teacher is in understanding the information provided. In addition to calculation skills, especially accuracy calculation, still need to be trained. Calculation fluency is one of the math skills besides problem-solving (D. Cai et al., 2018). The subsequent weakness is the ability to do overall reflection, which must also be trained, especially for prospective teachers with low and moderate mathematical abilities. Good reflection skills enable students to achieve better learning motivation, understanding, and performance (Lin et al., 2014). Reflection supports educational efforts by framing new knowledge on previous understanding and minimizing learning mistakes (Doron et al., 2023). Having stated that the quality of education is essential, national policymakers must determine how to improve the education system to achieve literacy and numeracy goals for all (Piper et al., 2018). Identifying students who need help can help schools plan improvements for students to improve their numeracy (Getenet & Getenet, 2023).

CONCLUSION

From the research above, it can be concluded as follows. Prospective elementary school teachers with low mathematical ability tend to miss a lot of the information presented, are unable to carry out a simple calculation process, and rarely describe the results of the analysis carried out (recorded only two times explain the investigation results of the six questions), do not reflect on the entire process. Prospective elementary school teachers with moderate mathematical ability tend to miss some of the information presented, are unable to perform simple calculations, often skip and skip in solving problems, and rarely interpret the outcomes of their analysis (only recorded two times out of 6 times that should have been done), several times to reflect on the entire process. Prospective elementary school teachers with high mathematical ability tend to understand all information well, can perform a simple calculation process, can complete several calculation steps correctly, dare to argue, often clarify the analysis results, and often reflect on the calculation process. The suggestion in this study is the need to strengthen the ability to comprehend information comprehensively and also the ability to reflect as a whole.

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