



Investigating Numeracy Skills: How Students Handle Data Representation Challenges

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Submitted: 12-05-2024

Revised: 20-12-2024

Accepted: 24-12-2024

Published: 27-12-2024

ABSTRACT

Adequate numeracy skills are essential, yet many students still face difficulties in solving numeracy problems. Previous studies have indicated that one of the challenges encountered by students relates to the representation of data or information in the problems to be solved. Therefore, the purpose of this study is to explore how students with various levels of numeracy skills address these obstacles in problem solving. The method used is descriptive with a qualitative approach, and data collection techniques include triangulation of test results and interviews. The research subjects are 30 eighth-grade students at one of the public junior high schools in Malang Regency. The results obtained show that students at a proficient level can represent data using mathematical expressions (creating patterns), capable students can represent data with words or written text, whereas students at the basic level still struggle with representing data due to difficulties in connecting available information, though they can read the charts presented. Students requiring special intervention are still unable to represent data from the graphs presented, and they also have difficulties in reading and finding information from graphs. Some students still struggle with writing mathematical arguments and reading information, and are not accustomed to contextual problems. Thus, it is advisable for teachers to familiarize students by providing numeracy problems, both PISA or AKM types.

Keywords: data representation; numeracy; numeracy problem; problem-solving

INTRODUCTION

Numeracy is the ability of students to use their mathematical abilities, both facts, procedures, and mathematical tools, in explaining an event, solving problems, and making decisions in life (Pusat Asesmen dan Pembelajaran, 2020). Numeracy is considered necessary because this ability is closely related to problem-solving, critical thinking, communication and creative abilities which are essential for students to have in solving problems (Annisavitri et al., 2020; Azzajjad et al., 2023; Handayani et al., 2021; Iswara et al., 2022) this has long been a concern of the world, one of which is the holding of PISA (Program for International Student Assessment) by the OECD where which is to look at the academic abilities of students throughout the world to evaluate the world education system, there are nine areas measured, one of which is numeracy literacy, (OECD, 2019, 2021).

In supporting students' numeracy skills, the Indonesian government carries out a national assessment known as MCA (Minimum Capability Assessment), focusing on literacy and numeracy. This assessment aims to enhance educational outcomes by identifying students' core competencies essential for daily activities (Khotimah et al., 2018; Purnomo et al., 2022; Sa'dijah et al., 2023). Specifically in mathematics, this is often called mathematical literacy or numeracy. The focus here extends beyond mere calculations to include the use of numerical and mathematical concepts in interpreting everyday problems across various

contexts, involving content, context, and mathematical processes (Fachrudin, 2022; Mardiana et al., 2020; Wijaya & Dewayani, 2021).

Despite these measures, previous research findings indicate that many teachers struggle to effectively assess and tailor learning experiences based on students' numeracy capabilities (Putra et al., 2023). The MCA categorizes student achievements into levels such as advanced, proficient, basic, and those needing specific intervention, which helps devise tailored educational strategies (Hartati & Nurhadi, 2021).

Teachers, as facilitators, must be well-versed in choosing suitable learning strategies to maximize students' numeracy abilities (Schoenfeld, 2022). Understanding the specific difficulties that students at each level encounter with numeracy problems is crucial (Aslan et al., 2020; Kruszewska et al., 2022), one of which is representing data. Apart from the information presented in the form of text or reading, a lot of details in numeracy questions, both PISA and AKM, is presented via graphs, charts, diagrams, and others (Ester Marsaulina Sihotang & Aisyah, 2021) Moreover, the ability to effectively represent data aids in developing conceptual understanding and enhances mathematical thinking (Fatmawati et al., 2022; Ismail et al., 2022).

Hence, this research endeavors to conduct an exhaustive investigation of the ways in which students with varying degrees of numeracy proficiency confront these obstacles. Data representation is an essential element of numeracy that necessitates practical problem-solving and academic decision-making abilities. Furthermore, it is critical to investigate efficacious pedagogical approaches in order to improve these abilities across all students; this underscores the significance and immediacy of this study.

So far, many studies have discussed data representation in the context of mathematics or statistics in general, such as (Rizki Hardianti et al., 2021) which analyzed the mathematical representation ability of 9th grade students, (Azkiah et al., 2022) which analyzed students' representation ability based on self-efficacy, and (Ridho et al., 2023) which analyzed students' mathematical representation ability in the Pythagorean theorem, but fewer specifically relate it to numeracy ability. This study has the potential to fill the literature gap by narrowing the focus on the numeracy aspect, which involves the ability to interpret, process, and use numbers to understand data. A combination of in-depth exploration of students' numeracy skills with a specific focus on the challenges of data representation, which have not been discussed in detail in previous literature.

RESEARCH METHODS

This study is a descriptive study with a qualitative approach, which aims to describe students' numeracy skills based on their numeracy ability levels in working on numeracy problems in the context of climate change. The data collection technique used is triangulation, where the instruments are tests, questionnaires and interviews, and the analysis techniques used consist of reduction, data presentation and drawing conclusions. The research subjects in this study were 30 grade 8 students at one of the schools in Malang, which consisted of high, medium, and low-ability students. Data were analyzed using qualitative descriptive techniques to describe students' numeracy abilities based on ability level after working on numeracy questions.

This research went through three stages, 1) preparation stage, when the researcher made observations at the school and conducted joint interviews with subject teachers, 2) implementation, the stages were carried out after preparing research instruments and validation with expert lecturers. Implementation at school on January 24, 2024, where students work on questions, fill out questionnaires, and conduct interviews with students, and 3) final stage, researchers analyzed student answers, student questionnaire responses, and interview results, after which conclusions were drawn from the research that had been carried out.

The questions used are questions that have been validated by expert lecturers consisting of four stimuli totaling 12 questions with different levels of difficulty and cognitive levels as well as varying question forms, the material in the questions is linear functions and number patterns with an algebraic domain, the context used is scientific about climate change. Figure 1. Below is one of the stimuli used or carried out by students in determining their' numeracy abilities

Stimulus 3

Domain	Algebra
Subdomains	Relations and Functions (including Number Patterns)
Class	8
Stimulus Context	Scientific
Competence	Understand patterns in number sequences and object configurations
Cognitive Level	Question 7: <i>Knowing</i> Question 8: <i>Applying</i> Question 9: <i>Reasoning</i>
Question Form	Question 7: Complex Multiple-Choice Questions 8, 9: Essay

EXTREME RAIN IN INDONESIA

Rain is divided into several levels according to rainfall (amount of rain) where 0.5 – 20 mm/day: Light rain, 20 – 50 mm/day: Medium rain, 50 – 100 mm/day: Heavy rain, 100 – 150 mm/day: Very heavy rain, >150 mm/day: Extreme rain and within the month itself is categorized into low (0 – 100 mm), medium (100 – 300 mm), high (300 – 500 mm), and very high (>500 mm), extreme rain occurs when daily or annual rainfall is high or very high. *Djakorita* explained that initially, the extreme rain cycle in Indonesia occurred around once every 10-20 years, but now it comes more quickly due to climate change (source: narotama.ac.id). Below is a graph of rainfall that occurs in Central Sulawesi

Question 7

Based on the data in the reading above, give a mark (✓) for each of the following statements that you think is true!

Pernyataan	Benar	Salah
a. The highest rainfall from the data above occurred in 2003	<input type="checkbox"/>	<input type="checkbox"/>
b. The lowest rainfall occurred in 2000	<input type="checkbox"/>	<input type="checkbox"/>
c. There were 4 extreme rainfall events in the period 1998-2017	<input type="checkbox"/>	<input type="checkbox"/>

Question 8

The 6th extreme rain based on the data above will occur in what year?

Question 9

An analyst predicts that extreme rain will occur at least 10 times from 1998. Extreme rain will occur until 2030. Do you agree with the analyst? Give your argument.

Figure 1. Examples of Questions Used

RESULTS AND DISCUSSION

Analysis of student work results is carried out based on scoring guidelines; after being given a score, four students will be selected based on their level of numeracy ability and will be interviewed, where the category of numeracy ability level is divided into four, namely score criteria $0 \leq score \leq 25$ level students need particular intervention (NSI), $25 < score \leq 50$ students at basic level, $50 < score \leq 75$ students at proficient level, and $75 < score \leq 100$ students at advanced level.

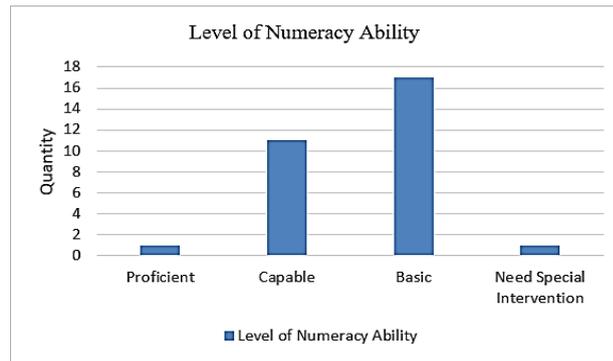


Figure 2. The Number of Students Based on The Level of Numeracy Ability

Based on the score criteria above, the researcher interviewed four students to represent each level of numeracy ability. The four students are TA, KA, RA, and RR, which consist of 4 students with proficient, capable, basic, and need intervention or NSI.

Description of Student's Numeracy Abilities at Proficient Level

Students with a professional level of numeracy ability in working on questions can answer up to the level of reasoning questions; students are also able to identify and apply mathematical concepts that are relevant to the problems being worked on, students are also able to formulate and reason in solving complex and non-routine problems based on concepts in mathematics, even though he can do it up to the reasoning level.

Students with a proficiency level in representing data using words or written text where students previously create patterns which are presented with mathematical symbols as seen in Figure 3, TA presents answers by first writing down the patterns obtained once every five years, which then written down the pattern with a code he made himself if it was interpreted as year one in 1998, year two in 2003 and so on.

Transcript 1.

- I : But TA knows the answer, or knows where this conclusion comes from?
 TA : From the previous questions and answers ma'am, adjusted
 I : how can it be explained?
 TA : Let me write the year, ma'am, so every 5 years, 2023 will be the sixth, 2028 will be the seventh, just add 5 years, ma'am, so the answer is no, I can't write the reason, ma'am.

8) Hujan yang tinggi terjadi pada 5 tahun sekali jadi Hujan tinggi ke 6 kalinya terjadi pada
¹ 1998, ² 2003, ³ 2008, ⁴ 2013, ⁵ 2018, ⁶ 2023, jadi hujan tinggi ke 6 terjadi pada tahun 2023

Translated to English: Heavy rain occurs once every 5 years, so the 6th rain occurred in
¹ 1998 ² 2003 ³ 2008 ⁴ 2013 ⁵ 2018 ⁶ 2023 So the 6th highest rainfall will occur in 2023

Figure 3. TA's Answer to Question Number 8 Stimulus 3

In answering question number 9, where the questions in this stimulus are interconnected, TA confirmed that the answer to question number 9 was based on

information found in the text and graphs as well as data from the analysis results after answering question number 8. This was confirmed through the results of the interview in Transcript 1; even though TA can interpret the existing graphic data and understand the problem, TA still experiences difficulty in writing answers to number 9, where TA has difficulty writing arguments mathematically, which makes TA only answer the conclusion from what he got that he 'disagrees' without writing down the reasons, which can be seen in Transcript 2 below. This means that students with this ability have represented data in writing, where students present data from graphs in writing, write down patterns obtained from data interpretation, and write conclusions from the analysis results, as well as fulfilling the three existing indicators of numeracy ability.

Transcript 2.

- I : From your answer, why do you immediately answer yes or no without giving a reason? and when you write reasons, why not use mathematical reasons?
- TA : If I answer with a reason, I'm confused ma'am, I'm confused when I conclude
- I : If it's like this, TA just answers 'no', there's no mathematical reason? ('like this' refers to question number 9 stimulus 3)
- TA : That was the last question I answered ma'am, because I was confused about writing the reason, the time was running out so I didn't have time ma'am

In answering questions, TA tends to work on questions by analyzing whether the questions are related to each other, then concluding the results of the answers, such as when answering question number 9 in stimulus three where information from the interview results was obtained that the results of the answers were based on previous questions where the questions were related to each other.

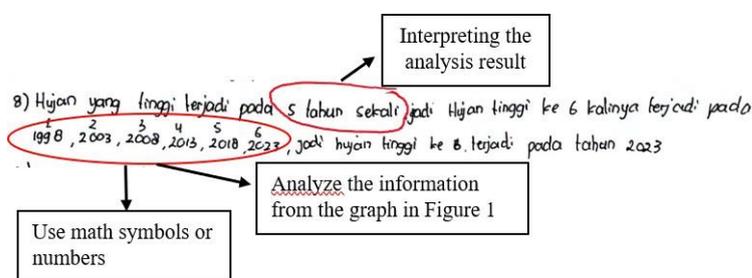


Figure 4. Explanation of Answers to TA Number 8

Based on the student's answers in Figure 4, it can be seen that students write their answers in their way, but the three indicators of numeracy are still visible; indicators of using numbers and basic mathematical symbols in solving daily life problems have been fulfilled, they use numbers and mathematical symbols in writing. Number patterns which are the result of their analysis of the information from the graphs displayed, the indicators for analyzing and interpreting the results are also fulfilled, students succeed in analyzing and interpreting the data with the ability and understanding of the graphs displayed, then conclude 'once every five years which is essential information in answering questions the results of analyzing and interpreting activities, so that students can answer questions in stimulus three correctly, however in answer number 9 the three numbering indicators do not appear in the students' answers but the activities of the three indicators are depicted in the students' answers in figure 3 and Transcript 2.

Description of Student's Numeracy Abilities at The Capable Level

Students with a proficient level of numeracy ability in working on problems have been able to identify and apply mathematical concepts relevant to the problem then students with this level of ability have also been able to create or formulate appropriate mathematical models, students with this level of proficient numeracy ability have been able to work on questions efficiently level of applying questions. Students at this level admitted having difficulty getting information presented only through text. KA represented the data using words or written text. KA explained that by looking at the existing graph she concluded that rain occurs once every five years, without writing down the pattern, presenting the data with different forms, as seen in Figure 5. In answering question number 9 , KA wrote an argument, not mathematically, but in simple sentences based on the text and her logical thinking, which is confirmed in Table 6. Both answers are correct based on KA's answer, even though it was written in words and based on KA's logic. This means that KA can read and understand the information displayed via graphics, it's just that the representation used via words is not accompanied by a mathematical explanation, where the process of finding the conclusion that extreme rain occurs once every five years is not visible.

Transcript 3

- I** : So it's difficult for KA to choose or identify and use information from what he's reading, but what about questions like this? ('like this' refers to stimulus 3)
- KA** : you can, it's easier, it's better
- I** : So it would be better if there were visualizations, pictures or graphs like that, right?
- KA** : yes ma'am, like that

Just like the others, KA tends to answer description questions using sentences rather than more mathematical explanations, as shown in Figure 5.

8. Tahun 2023	<u>translate :</u> 8. Year 2023
9. Secara dengan melihat grafik rata-rata curah hujan bulanan 1998-2017, saya tidak setuju. Karena hujan ekstrem terjadi lima tahun sekali dengan jarak 4 tahun.	9. By Looking at the graph of average monthly rainfall from 1998-2017, I disagree, <u>Because</u> extreme rain occurs once every five years with a gap of 4 years

Figure 5. KA's Answer to Stimulus 3 No. 8 and 9

This is because when KA forgets what formula to use in answering a question but he understands the problem, in answering, KA uses logical thinking in solving existing problems based on existing information and using his own method; this is explained by KA in the interview in Transcript 4.

Transcript 4.

- I** : Questions like numbers 9 and 12 here KA answer using sentences, why isn't the answer like number 11 using mathematical reasoning?
- KA** : I don't know the formula, ma'am, so I'll just explain the answer using sentences
- I** : So when KA answered using this sentence, what was his answer based on?
- There's just no calculation
- KA** : based on information in the text ma'am, with logic

In KA's answer to answer number 8, the indicator uses numbers and symbols and interprets the existing results, which are in the form of the correct answer to the question, but for analyzing indicators, it is not visible on KA's answer sheet. Meanwhile, in answer number 9, it does not appear that KA uses numbers and symbols in answering this question, as can be seen from Figure 6.

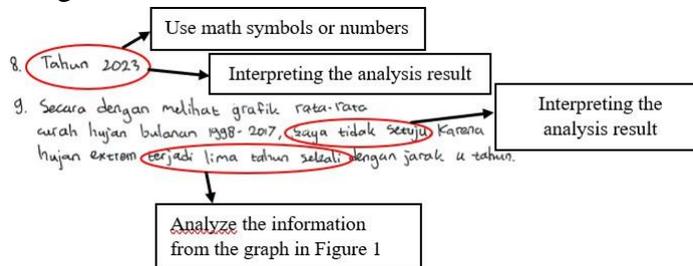


Figure 6. Explanation of KA's Answers to Questions No. 8 And 9

Description of Student's Numeracy Abilities at The Basic Level

Students with a basic level of numeracy skills in working on problems can identify relevant concepts or principles and apply these simple concepts in routine concepts but still have difficulty when combining several concepts to solve problems that are not simple, as seen in Figure 7 below. Students at this level can answer questions at the knowing level but still need help answering questions at the applying and reasoning level.

Salah, benar, benar	<u>Translate:</u> 7. False, True, True
<u>1988</u> dan 2013	8. 1988 and 2013

Figure 7. RA's Answer to Questions 7 and 8 Stimuli 3

Students at this level still have difficulty in representing data which can be seen from the results of RA's answer in Figure 7; RA does not present data in any form; RA's answer is only correct for question number 7, which is the form of true or false, it could be that RA happens to answer correctly but When asked several things about the graph, such as "what does this graph mean" RA managed to answer without looking at the answer himself or when asked to show where the highest and lowest graph was, RA pointed correctly, which means RA could read the graph well but could not interpret and relate it. Information presented in graphs to answer questions no. 8 and 9, RA still had difficulty connecting the information which made him fail to find patterns in the graph, this indicates that students still had difficulty analyzing the information presented.

In general, students with these basic abilities have basic mathematical skills such as basic computing, basic concepts of geometry and statistics as well as solving simple, routine mathematical problems. From the answers in Figure 6, it can be seen that only the indicators use numbers and mathematical symbols. In contrast, the analyzing and interpreting indicators do not appear either from answer number 8 or from the interview results for stimulus 3.

Description of Student's Numeracy Abilities at Need Special Intervention Level

Students with this level of NSI numeracy ability only have limited mathematical knowledge, and they show partial mastery of concepts and limited computing skills. In working on RR questions, there are still many difficulties in identifying information and problems, difficulties in determining what mathematical concepts should be used, errors in calculations for some questions, and difficulties in reading the graphs displayed. Students with this ability still have difficulty in representing data; this is because students are still unable to read graphs or get information displayed via graphs, so when answering questions, students do not answer correctly. When allowed to explain answers through interviews, students can only remain silent. As seen in Transcript 5, whereas when asked other questions, RR could not answer fluently, this indicates that the students did not understand the information presented or the problems at all.

<p>7. Salah salah benar</p> <p>8. 1988 dan 2013</p> <p>9. Tidak karena hujan ekstrim</p>	<p><u>Translate :</u></p> <p>7. False False True</p> <p>8. 1988 and 2013</p> <p>9. <u>Dissagree</u>. Because Extreme Rain</p>
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Figure 8. RR's Answer to Questions No. 7 to 9 in Stimulus 3

Where from RR's answer in Figure 7, it can be seen that for answer number 7 (knowing), RR answered 2 of the three answers correctly, while for number 8 (applying), RR's answer was wrong, and for number 9 (reasoning) RR's answer was correct but the reason given was not. Accordingly, during the interview, RR admitted that he could read graphs, but when asked to explain the graph in stimulus 3, as in Figure 1.

Transcript 5.

- I** : When it comes to graphs like this, RR have you ever worked on a problem like this? RR can you read the graph?
- RR** : I have, ma'am, I can
- I** : RR, can you read this graph? How can the meaning of this graph be explained?
- RR** : ... (RR doesn't answer and is confused)
- I** : RR said earlier that if he could read this graph, what would RR know? Or from RR's answer?
- RR** : ... (RR doesn't answer and is confused)

From the interview with RR, information was also obtained that RR was used to doing routine questions, and RR also said that RR preferred routine questions. For the numeracy indicator, from RR's answer to stimulus 3 in Figure 8, it can be seen that there is only an indicator of using numbers and mathematical symbols in solving problems in everyday life even though the answer is not precise, while the other two indicators, namely analyzing and interpreting, do not appear either from the answer or results of interviews that have been conducted.

The findings in this research are some students present information or write down analysis results in their own words and simple ways, such as making patterns, which is in

line with that when information is presented in graphic form, it allows students to explain the graph using simple vocabulary or using mathematical sentences to make it easier for them (Nusantara et al., 2021) to understand the graph or by using mathematical symbols they simplify the explanation of the phenomenon or information from the graph presented. The representation used by students in this research is representation using words or writing their sentences and making patterns or using symbols or mathematical expressions , which is in line with (Pasehah, 2019) in data representation, there are four ways, namely visual representation, pictures, mathematical equations and expressions, as well as words or written text

Some students did not write arguments on questions that asked them to write arguments, some students did not write mathematically, and some students did not write at all. This is in line with the research (Simarmata et al., 2023) where one of the students' mistakes in solving MCA-type questions is a transformation error that occurs because students have difficulty changing the information about the problem and are unable to write the correct mathematical sentence for the problem, where the ability that this student lacks according to (Sa'adah & Sumartini, 2021) is called mathematical communication ability because students do not master the concept -basic concepts that must be used to solve existing problems, or lack of understanding of existing problems. Apart from that, some students have difficulty reading the information presented through the graphics displayed. This is in line with what was found (Giannakopoulou, 2023) that not only students but university students also still have difficulty reading and understanding the information displayed through graphs, tables, diagrams, etc. charts, and more.

From the results of interviews with four students, it can be concluded that one of the factors that there are still many students who have basic level numeracy skills and there are students who have NSI level numeracy skills is because students are rarely given numeracy questions either PISA or AKM type questions, and students are always given routine questions. Usually, this is in line with the statement (Tresnasih et al., 2022) that one of the factors causing students' low numeracy skills is that students are not yet familiar with contextual questions. This is confirmed by teachers who teach that students who have a professional and capable level have a dominant visual learning style; this is in line with the research (Karmeliana & Ladyawati, 2023) that students who learn visually meet the indicators of numeracy ability, which is also supported by the statement (Rosidi et al., 2022) that students with a visual learning style do not experience difficulties in solving problems, they can convert information into mathematical models and use the strategies they choose in working.

CONCLUSION

Based on the results of the discussion, it can be concluded that: 1) students at the professional level, can represent data with mathematical expressions (making patterns), 2) students at the capable level, can represent data with words or written text, 3) students at the basic level, still have difficulty representing data due to difficulties in connecting existing information, but they can read the graphs presented, and 4) students need special intervention, they still cannot represent data from the graphs presented, students also still

have difficulty reading and finding information from graphs, some students still have difficulty writing arguments mathematically and reading information and are not yet familiar with the questions contextual, so teachers should familiarize students with giving numeracy questions of either the PISA or AKM type.

Some students are still classified as having low numeracy skills at the basic level and need particular intervention, one of which is because students are still not used to good numeracy questions. PISA and AKM types. Therefore, teachers need to familiarize students with working on numeracy questions while still paying attention to the reading text and displays (graphs, pictures, charts, tables, etc.). Teachers or other researchers can develop either formative or diagnostic assessments to increase students' level of numeracy abilities, and it is hoped that after knowing the level of students' numeracy abilities, teachers can provide learning or assessments that are appropriate to students' numeracy abilities.

Further research in this area is essential to identify how more effective learning approaches can be implemented to address the data representation challenges that students face, as well as to understand the factors that influence data understanding at different levels of education, such as developing and evaluating learning interventions to help students overcome difficulties in data representation, for example through project-based learning, investigating the relationship between numeracy, data representation, and learning in STEM (Science, Technology, Engineering, and Mathematics) subjects, and developing and testing a range of assessment methods to measure students' numeracy skills, particularly in the context of working with data and its representation.

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