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Research Article

Numeracy Literacy Ability Viewed by Characteristics of Students' Way of Thinking

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Abstract.
Thinking is a cognitive activity that produces different ways of solving problems which affects numeracy literacy ability. The numeracy literacy consists of two domains, namely change and relationship and quantity. This study aimed to describe students' numeracy literacy ability viewed by characteristics of students' way of thinking. This study was a qualitative research with a phenomenological design. The participants were eight 9th grade students from a junior high school in Central Java, Indonesia, who had different characteristics, that are concrete sequential (CS), concrete random (CR), abstract sequential (AS), and abstract random (AR). The data were collected by using written tests, questionnaires, and interviews. The results show that each characteristic had its own way of solving the numeracy literacy problems. In quantity domain, CS, CR, and AR students tend to answer the problem with one solution; however, AS students responded with various alternative answers. In change and relationship domain, a difference was observed between concrete thinkers and abstract thinkers. CS and CR students tend to solve problems by using an example to take a trial-and-error approach. Meanwhile, AS and AR students tend to work using existing concepts by manipulating the formulas in the question with logical and rational processes.

Keywords: characteristics of students' way of thinking, junior high school, numeracy literacy ability.

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1. INTRODUCTION

Mathematics is one of the abstract sciences that has been applied since a long time ago. It has been developed by mathematicians from ancient Egypt, Babylonia, and ancient Greece. Daily life problems such as trading, construction, and astronomy cannot be detached from the role of mathematics. The many uses of mathematics in various fields of life makes it an important science to learn and master. Therefore, mathematics and its application an obligation to be taught in schools as part of the subjects that must be mastered by students.

Mastery of mathematics and its application in solving daily life problems is part of an individual's mathematical literacy ability. Mathematical literacy is an individual's capacity

to reason mathematically and to formulate, employ, and interpret mathematics to solve problems in a variety of real-world context [1]. The word formulate refers to the ability of individuals to translate from a real-world setting to the domain of mathematics and how the individuals can provide the real-world problem with mathematical structure, representations, and specificity [1]. The word employ refers to the ability of individuals to apply mathematical concepts, facts, procedures and reasoning to solve mathematically formulated problems to obtain mathematical conclusions [1]. The word interpret (and evaluate) focuses on the ability of individuals to reflect upon mathematical solutions, results or conclusions and interpret them in the context of the real-life problem that initiated the process [1]. In the process of solving problems, the three processes in mathematical literacy are interrelated with one another.

Mathematical literacy is about dealing with 'real' problems [2]. In general, literacy questions are arranged by involving real-life problems to be solved by using mathematical concepts. Mathematical literacy has various scopes, one of which is numeracy literacy. Numeracy literacy is a skill to apply concept of numbers, arithmetic operations, and mathematical operations to real objects in everyday life and develop the ability to interpret quantitative information [3]. The numeracy literacy ability leads students to build mathematical thinking in solving daily life problems.

Individual ability to solve daily life problems is related to the process of their thinking. Different thinking processes and thinking characteristics will result in different ways of solving problem. It will affect the students' processes of formulating, employing, and interpreting in solving numeracy literacy problems. Therefore, it is important to know numeracy literacy ability viewed by characteristics of students' way of thinking, so that it can be seen how they process the information and solve the problems. When the process of students' thinking in each characteristic is identified, it will be easier to design learning method that can develop numeracy literacy ability which can reach all characteristics of students' way of thinking.

2. RESEARCH METHOD

The method in this research was qualitative with a phenomenological design which analyze numeracy literacy ability viewed by characteristics of students' way of thinking. The subjects were 8 students of 9^{th} grade of a junior high school in Central Java, Indonesia who had different characteristics, that are 2 students with Concrete Sequential (CS) characteristic, 2 students with Concrete Random (CR) characteristic, 2 students with Abstract Sequential (AS) characteristic, and 2 students with Abstract Random (AR)

characteristic. The data collection procedures were written test, questionnaire, and interview. The written test instrument consisted of 2 essay questions adapted from PISA 2012 questions to measure numeracy literacy ability. The questions were chosen based on numeracy literacy indicator which includes two contents of mathematical literacy, that are change and relationship domain, and quantity domain. These two problems are shown in Figure 1.

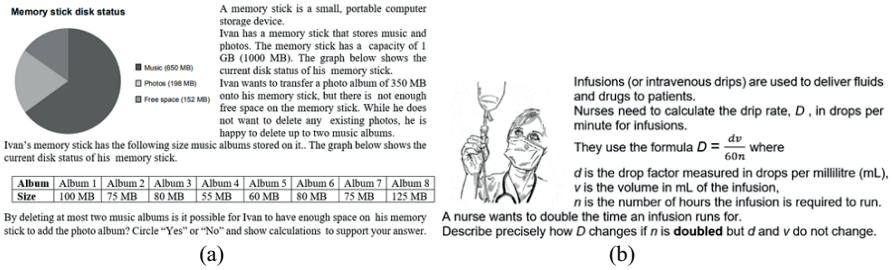
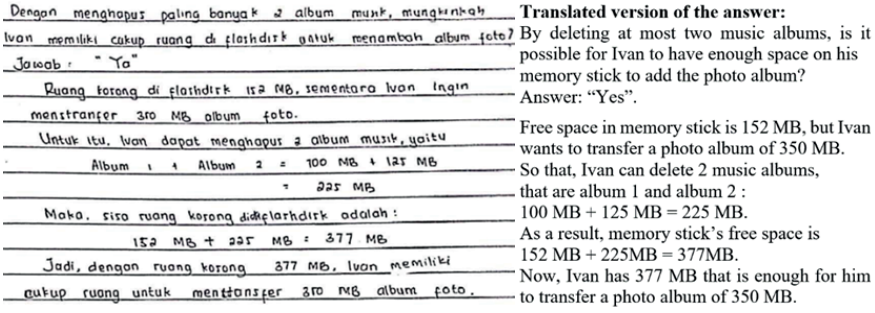


Figure 1: Numeracy literacy's questions in quantity domain and change and relationship domain.

Figure 1(a) is the essay question for written test in quantity domain and Figure 1(b) is the essay question for written test in change and relationship domain. The questionnaire characteristics of students' way of thinking adapted from John Park Le Tellier in De Potter & Hernacki [4]. Meanwhile, interview was conducted in an unstructured interview to obtain in-depth information about students' numeracy literacy ability and characteristics of students' way of thinking as well as support what they have been obtained from the written test and questionnaire.

3. RESULT AND DISCUSSION

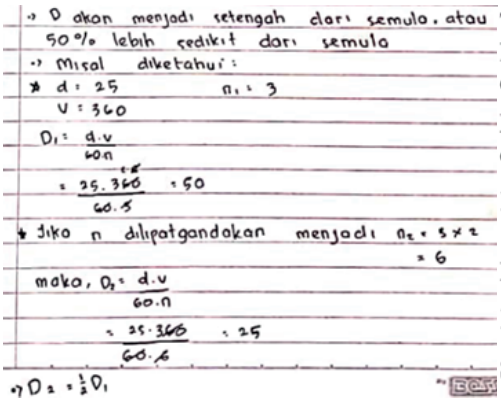
3.1. Students' Numeracy Literacy Ability with Concrete Sequential (CS) Characteristic


Dengan menghapus paling banyak 2 album musik, mungkinkah Ivan memiliki cukup ruang di flashdisk untuk menambah album foto?
Jawab : "Ya"
Ruang kosong di flashdisk 152 MB, sementara Ivan ingin mentransfer 350 MB album foto.
Untuk itu, Ivan dapat menghapus 2 album musik, yaitu
Album 1 + Album 2 = 100 MB + 125 MB
= 225 MB
Maka, sisa ruang kosong diflashdisk adalah :
152 MB + 225 MB = 377 MB
Jadi, dengan ruang kosong 377 MB, Ivan memiliki cukup ruang untuk mentransfer 350 MB album foto.

Translated version of the answer:
By deleting at most two music albums, is it possible for Ivan to have enough space on his memory stick to add the photo album?
Answer: "Yes".
Free space in memory stick is 152 MB, but Ivan wants to transfer a photo album of 350 MB.
So that, Ivan can delete 2 music albums, that are album 1 and album 2 :
100 MB + 125 MB = 225 MB.
As a result, memory stick's free space is
152 MB + 225MB = 377MB.
Now, Ivan has 377 MB that is enough for him to transfer a photo album of 350 MB.

Figure 2: Concrete sequential (cs) student's answers in quantity domain.

Figure 2 shows that in the quantity domain, students with Concrete Sequential (CS) characteristic have one solution. They answer that they need to delete albums 1 and 8 so that there will be 225MB of free space left.



Translated version of the answer:
D will be half or 50% less than the former condition.
For example:
$d = 25, v = 360, n_1 = 3$

$$D_1 = \frac{d.v}{60n} = \frac{25.360}{60.3} = 50$$

If n is doubled, $n_2 = 3 \times 2 = 6$

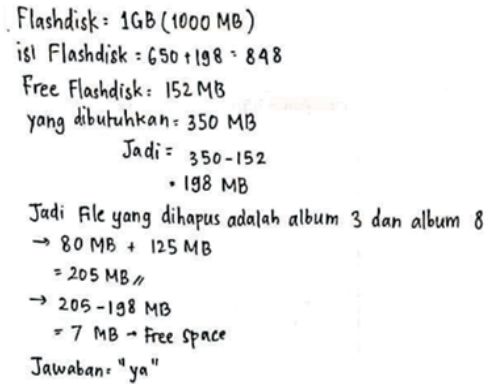
$$D_2 = \frac{d.v}{60n} = \frac{25.360}{60.6} = 25$$

So that, $D_2 = \frac{1}{2}D_1$.

Figure 3: Concrete sequential (cs) student's answers in change and relationship domain.

In the change and relationship domain in Figure 3, it can be seen that the subjects answer using an example. They write that D will be half or 50% less than the former condition by showing evidence through the example if all the values of d, v, and n are known, and after that they look for the proportion. Based on the results of the interview, the subjects argue that it is easier to work on a problem by bringing it to a real context and an example.

3.2. Students' Numeracy Literacy Ability with Concrete Random (CR) Characteristic



Translated version of the answer:
Memory stick = 1 GB (1000MB)
Used space = 650 +198 = 848,
Free space = 152 MB,
Space needed = 350 MB
So, 350 -152= 198 MB
Ivan can delete album 3 and album 8.
80 MB + 125 MB = 205 MB,
205 – 198 MB = 7 MB (free space).
Answer : "yes".

Figure 4: Concrete random (cr) student's answers in quantity domain.

Figure 4 shows that in the quantity domain, subjects with Concrete Random (CR) characteristic have one solution. Unlike the CS subjects, the CR subjects answer that

they only need to delete albums 3 and 8 so that they will get 205MB of free space. It is already enough because only 198MB of free space is needed.

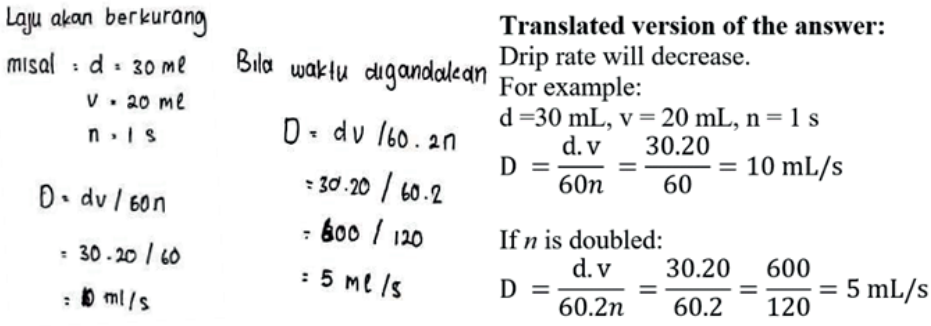


Figure 5: Concrete random (cr) student's answers in change and relationship domain.

In the change and relationship domain in Figure 5, it shows that the subjects answer using an example the same as the CS subjects. The CR subjects show the evidence through an example if all the values of d, v, and n are known. They only report that the drip rate will decrease without mentioning how much the reduced value is. The process of solving by the CR subjects in this domain has the same tendency as the CS subjects.

3.3. Students' Numeracy Literacy Ability with Abstract Sequential (AS) Characteristic

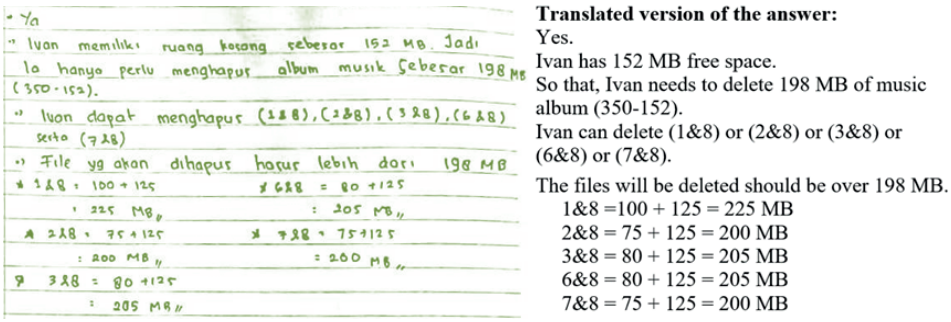
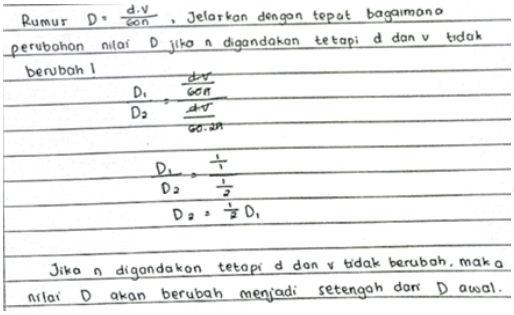


Figure 6: Abstract sequential (as) student's answers in quantity domain.

Figure 6 shows that in the quantity domain, students with the Abstract Sequential (AS) characteristic have various ways of solutions. They can find 5 possible answers to solve the problem. They write down all the answers that are suitable to answer the question.

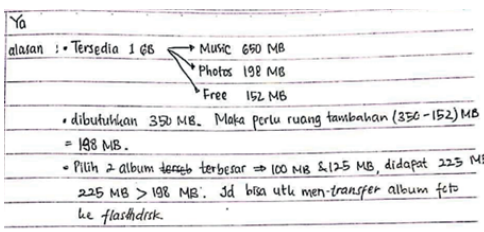
In the change and relationship domain in Figure 7, it shows that the subjects answer the question by manipulating and building concepts based on what is known from the question. They write the answer in a logical and rational process.



Translated version of the answer:
Formula $D = \frac{dv}{60n}$,
Describe how D changes if n is doubled, but d and v do not change.
$\frac{D_1}{D_2} = \frac{\frac{dv}{60n}}{\frac{dv}{60.2n}} \Leftrightarrow \frac{D_1}{D_2} = \frac{\frac{1}{1}}{\frac{1}{2}} \Leftrightarrow D_2 = \frac{1}{2}D_1$
If n is doubled but d and v do not change, D will be half of the former condition.

Figure 7: Abstract sequential (as) student's answers in change and relationship domain.

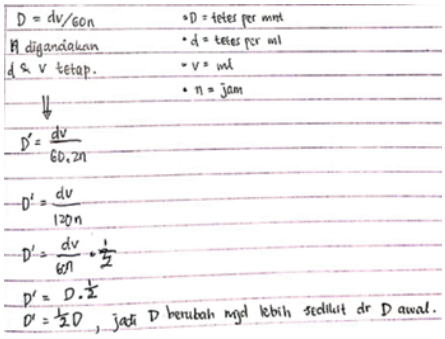
3.4. Students' Numeracy Literacy Ability with Abstract Random (AR) Characteristic



Translated version of the answer:
Yes.
Proof: Memory stick = 1 GB, Music 650 MB, Photos 198 MB, Free 152 MB.
Space needed 350 MB.
Ivan need (350-152) MB = 198 MB free space.
Choose 2 largest albums = 100 MB & 125 MB, we can get 225 MB, 225 MB > 198 MB.
So that, Ivan can transfer a photo album into his memory stick.

Figure 8: Abstract random (ar) student's answers in quantity domain.

Figure 8 shows that in the quantity domain, subjects with the Abstract Random (AR) characteristic have one solution. It is almost the same as the CS and CR subjects.



Translated version of the answer:
D = the drip rate per minute,
d = the drop factor measured in drops per millilitre (mL)
v = mL, n = the number of hours,
$D = \frac{dv}{60n}$
n is doubled, but d and v do not change.
$D' = \frac{dv}{60.2n} = \frac{dv}{120n} = \frac{dv}{60n} \times \frac{1}{2}$
$D' = D \times \frac{1}{2} \Leftrightarrow D' = \frac{1}{2}D$
So that, D will be decrease.

Figure 9: Abstract random (ar) student's answers in change and relationship domain.

In the change and relationship domain in Figure 9, it can be seen that the subjects write D' as a new drip rate, and then processes it to produce a proportion with the old drip rate. However, they only argue that the rate would get lower without mentioning the value of the change. Their process of solving problems in this domain has the same tendency as the AS subjects.

Based on the results of the analysis on students' answers in both domains and the results of the interviews, it shows that students in four characteristics of way of thinking

have similar numeracy literacy ability. All students are able to answer the problems presented in the quantity domain as well as in the change and relationship domain. Students in each characteristic are able to justify rightness their answers. However, the process of formulating, employing, and interpreting is not carried out systematically and completely. They still tend to write down their answers directly without following the coherent steps.

In the process of working, there are differences in how students process information and solve the problems. Each characteristic has multiple lines of thought in working on mathematical problems. In quantity domain, students with Concrete Sequential (CS), Concrete Random (CR), and Abstract Random (AR) characteristics tend to answer the problems with one solution. Meanwhile, students with the Abstract Sequential (AS) characteristic respond the problems with various alternative answers, even up to 5 answers. This condition is related to the characteristic possessed by the AS students where individuals tend to emphasize important details related to the answers. For the AS students, evaluating important things such as key points and important details are quite easy to perform [4].

In the domain of change and relationship, students in four characteristics are able to answer correctly and explain the process of solving problems completely. In this domain, students in each characteristic have different ways to solve the PISA problems. Students with Concrete Sequential (CS) and Concrete Random (CR) characteristics tend to solve problems by using an example, so that the answers can be found in the form of numbers to get the solution and find the proportion. This kind of solution is related to the tendency of concrete thinkers to have experimental attitudes [4]. They do something based on reality, but they also want to take a trial and error approach [4]. Concrete learners love specific directions and procedures and hard to work the abstract concepts and imagination [5]. Meanwhile, students with Abstract Random (AR) and Abstract Sequential (AS) characteristics tend to work using existing concepts by manipulating the formulas in the questions to find the proportion. This is related to the tendency of abstract thinkers who have logical, rational, and intellectual mindsets. Abstract learners have high reasoning abilities and tends to be critical and analytical because they have a strong imagination [5].

Working on the problem using different ways is not wrong as long as the concepts applied are correct. For students with concrete thinking, it will be more effective to make something concrete by trying to connect with what they know and understand [6]. For those with abstract thinking, it will be easier to build concepts. These different ways of thinking require the teacher to apply a variety of learning models in the learning

process. Various learning models allow students to be able to learn according to their way of thinking so that they can achieve better learning outcomes [7].

4. CONCLUSION

Based on the result and discussion, it shows that the numeracy literacy ability of students with Concrete Sequential (CS), Concrete Random (CR), Abstract Sequential (AS), and Abstract Random (AR) characteristics do not have a significant difference. All students in these four characteristics are able to answer the questions completely, even though they have not been able to apply the formulating, employing, and interpreting processes coherently. Students in each characteristic has its own way to solve the numeracy literacy problems in both domains. The difference between each characteristic lies in the way students in writing the information obtained from the problem and writing in its solution. In quantity domain, students with Concrete Sequential (CS), Concrete Random (CR), and Abstract Random (AR) characteristics tend to answer the problem with one solution, meanwhile Abstract Sequential (AS) students respond with various alternative answers. In change and relationship domain, there is a difference between concrete thinkers and abstract thinkers. Concrete thinkers (Concrete Sequential and Concrete Random) students tend to solve problem by using an example to take a trial-and-error approach, so that the answers can be found in the form of numbers to get the solution and find the proportion. Meanwhile abstract thinkers (Abstract Sequential and Abstract Random) students tend to work using existing concepts. They answer the problem by manipulating and building concepts based on what is known from the question with logical and rational process.

Acknowlegment

We thank those who have supported this research.

References

[1] OECD, “Pisa 2021 mathematics framework (draft),” 2018.

[2] Malasari PN, Herman T, Jupri A. “The construction of mathematical literacy problems for geometry.” Journal of Physicsrence Series (2017). https://doi.org/10.1088/1742-6596/895/1/012071.

[3] Aunio P, Räsänen P. Core numerical skills for learning mathematics in children aged five to eight years – a working model for educators. Eur Early Child Educ Res J. 2015;24(5):37–41.

[4] Deporter B, Hernacki M. “Quantum learning: membiasakan belajar nyaman dan menyenangkan, ed. ke 1.,” Terjemahan: Alwiyah Abdurrahman & Sari Meutia. Bandung: Kaifa. p. 2015.

[5] Utami LF, Pramudya I, Slamet I. “Students’ mathematical communication ability in solving trigonometric problems,” In: IOP Conference Series: Earth and Environmental Science (2021). https://doi.org/10.1088/1742-6596/1796/1/012008.

[6] Gravemeijer K. “How concrete is concrete? ” vol. 2, no. 1, pp. 1–14, 2011. https://doi.org/10.22342/jme.2.1.780.1-14.

[7] Nurnugroho BA, Arfinanti N, Kartika I. Mathematical literacy on rectangles and triangles based on the characteristics of students’ way of thinking. Journal of Physics. Conference Series; 2020. https://doi.org/10.1088/1742-6596/1613/1/012047.