

## STUDENTS' NUMERACY IN SOLVING PROBLEM OF COUNTING RULES AND ITS SCAFFOLDING

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### Abstrak

Numerasi merupakan kemampuan yang sesuai dengan keterampilan abad ke-21. Namun, hasil PISA 2018 menunjukkan bahwa sebagian besar peserta didik di Indonesia belum memiliki numerasi yang baik. Penelitian ini bertujuan untuk menganalisis numerasi peserta didik dalam menyelesaikan soal materi aturan pencacahan dan mendeskripsikan *scaffolding*-nya. Metode penelitian yang digunakan adalah deskriptif kualitatif. Subjek penelitian adalah tiga peserta didik kelas XII-B SMA Plus Ar-Rahmat Bojonegoro yang diberikan tes tulis dan wawancara. Tes tulis terdiri dari satu soal bertipe PISA materi aturan pencacahan. Hasil penelitian menunjukkan numerasi peserta didik dalam menyelesaikan soal materi aturan pencacahan belum baik. Setelah diberikan *scaffolding*, peserta didik mampu menjawab soal dengan benar serta memahaminya. Sehingga untuk meningkatkan numerasi peserta didik dalam menyelesaikan soal materi aturan pencacahan, diperlukan panduan berupa *scaffolding* yang diterapkan pada masing-masing indikator proses numerasi.

**Kata kunci:** Aturan pencacahan; kemampuan peserta didik; numerasi; pemecahan masalah; *scaffolding*.

### Abstract

Numeracy is an ability that suits 21st-century skills. However, the result of PISA 2018 shows that the majority of Indonesian students still do not have good numeracy. The purpose of this research is to analyze students' numeracy in solving problem of counting rules and to describe its *scaffolding*. The research method is descriptive qualitative. The research subjects were three students of XII-B SMA Plus Ar-Rahmat Bojonegoro who were given a written test and interview. The written test consists of one numeracy problem. The result indicates that students' numeracy in solving problem of counting rules is not good yet. Students are able to correctly answer and comprehend problem after receiving *scaffolding*. Hence to improve students' numeracy in solving problem of counting rules, a guide in the form of *scaffolding* is needed that is applied to each indicator of the numeracy process.

**Keywords:** Counting rules; numeracy; problem solving; *scaffolding*; student ability.



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## INTRODUCTION

Many organizations and educators contend students should acquire 21st-century skills, which include creativity, critical thinking, problem solving, communication and collaboration, as well as technological fluency, in order

to deal with a fast changing environment (Bray & Tangney, 2016; Voogt & Roblin, 2012). This is in line with the goals of mathematics education, which include preparing students to apply mathematics in both their personal and professional life (Gravemeijer et al., 2017).

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The word “numeracy” refers to the knowledge and abilities needed by students to meet the mathematical requirements of both personal and professional life as well as to participate in society (Geiger et al., 2015). Numeracy is an individual’s ability that includes three indicators, namely (1) formulating, (2) employing, and (3) interpreting, applying, and evaluating mathematics in various contexts (OECD, 2019a). Formulating is a process to recognize and identify contextual problems, then formulating them into mathematical form. Employing is a process for carrying out calculations and manipulations as well as for applying concepts and facts to obtain mathematical solutions. Interpreting, applying, and evaluating is a process to reflect mathematical solutions in the context of real-world problems and assess whether these are reasonable.

Numeracy is an ability that suits 21st-century skills (Rizki & Priatna, 2019; Tout & Gal, 2015). Therefore, students need to have good numeracy. However, the majority of Indonesian students still do not have good numeracy. According to PISA 2018 results, Indonesian students who are 15 years old or closer to the end of their compulsory education are ranked 72nd out of 78 countries in terms of their numeracy (OECD, 2019b).

Students encounter numeracy concerning problem-solving in certain mathematical topics and contexts from personal and professional life (Bolstad, 2021). The accessible context of the problem helps students to experience that mathematics is useful for solving everyday problems (Sawatzki & Sullivan, 2018). Counting rules are one of the most important mathematical topics because of their rich potential as

a problem-solving context and for their application to probability. However, students tend to experience many difficulties when facing increasingly complex counting rules problems (Lockwood, 2013). Students must be guided to solve problems or carry out tasks beyond what they can achieve independently, which is called scaffolding (Mermelshtine, 2017).

Scaffolding is a gradual support process characterized by dialogue or its adaptation so that the skills and knowledge needed by students can be internalized (Puntambekar, 2022). Scaffolding can be manifested as teacher intervention through verbal instructions called one-to-one scaffolding, interaction with peers called peer scaffolding, and the provision of teaching materials or even computer programs called computer/paper-based scaffolding (Belland, 2014).

There are three levels of scaffolding in mathematics learning according to Anghileri namely (1) environmental provisions, (2) explaining, reviewing, and restructuring, and (3) developing conceptual thinking (Dove & Hollenbrands, 2014). Environmental provisions are carried out before engaging with students. Explaining, reviewing, and restructuring involves direct interaction with students or its adaptation related to the mathematical topic being studied. Developing conceptual thinking involves developing concepts using unique techniques including generalization, extrapolation, and abstraction.

Several earlier researchers have conducted studies on the use of scaffolding to help students solve problems. The types of scaffolding used include support provided via instruments (Schukajlow et al., 2015), teaching materials (Mamun et al.,

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2020), and computer programs (Kazak et al., 2015), in alongside teachers (Martin et al., 2019; Stender & Kaiser, 2015; van de Pol et al., 2014) and peers (Frederick et al., 2014). However, there has not been any specific research done on the use of scaffolding to improve students' numeracy in solving counting rules problems.

Based on the background of the problem above, this research aims to (1) analyze students' numeracy in solving problem of counting rules, and (2) describe scaffolding to improve students' numeracy in solving problem of counting rules.

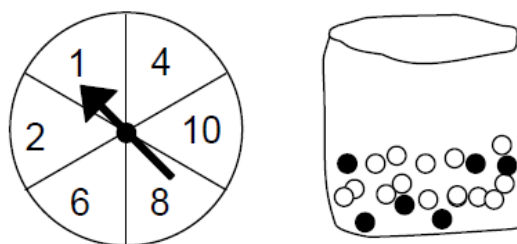
## METHOD

This research uses a qualitative method with a qualitative descriptive approach. The research was conducted on May 30 2022 at SMA Plus Ar-Rahmat Bojonegoro. Based on the results of initial observations, students

experienced difficulties in solving counting rules problems. Furthermore, 25 class XII-B students were given a written test to see the inability of students to solve problems based on numeracy indicators. The test instrument as shown in Figure 1 consists of one question adapted from a PISA problem with modifications to suit the context that is relevant to students and has been validated by two mathematics lecturers at the State University of Malang. The results of the students' written test were grouped based on the inability that occurred in each numeracy indicator. Then, three students who represented inability in each numeracy indicator were selected as research subjects. Selection of subjects using purposive sampling which is based on the relevance of information gathered on the test and the research objectives (Creswell, 2012).

## GOFUN

A game at the Gofun booth using spinner media. As for the rules, if the spinner stops at an even number, the player is allowed to take a marble from the bag. If the spinner stops at 1, the player loses. The image of the spinner and marbles in the bag is shown below.



Prizes are awarded if a black marble is drawn. Susan played the game once. How likely is Susan to win the prize?

Figure 1 Test instrument (Numeracy Problem)

The next step is conducting semi-structured interviews with the three research subjects. Interview instruments were arranged to confirm the written answers and students' initial understanding. From the results of the

interviews, students were given scaffolding. The provision of scaffolding refers to the three levels proposed by Anghileri with a focus on the inability of students to solve problems based on numeracy indicators.

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Based on the purpose of this study, students' numeracy in solving problem of counting rules was analyzed

based on numeracy indicators adapted from OECD (2019a) presented in Table 1.

Table 1. Numeracy indicators

<b>Indicator</b>	<b>Students' Activities</b>
Formulating	<ul style="list-style-type: none"> <li>• Identifying the important variables and the mathematical aspects of a problem with a real-world context.</li> <li>• Making a situation or problem simpler so that it could be mathematically analyzed.</li> <li>• Identifying the limitations and assumptions that underlie any mathematical modeling and context-based simplifications.</li> <li>• Using the proper variables, symbols, diagrams, and standard models to mathematically represent a situation.</li> <li>• Translating a problem into mathematical language or a representation.</li> </ul>
Employing	<ul style="list-style-type: none"> <li>• Devising and implementing strategies for solving mathematical problems.</li> <li>• Applying mathematical facts, rules, algorithms and structures to solve problems.</li> <li>• Manipulating numbers, graphical and statistical data and information, algebraic expressions and equations, and geometric representations.</li> <li>• Using several representations to solve problems and transitioning between them.</li> <li>• Generalizing from the results of using mathematical procedures to solve problems.</li> </ul>
Interpreting, applying, and evaluating	<ul style="list-style-type: none"> <li>• Interpreting a mathematical solution back into the real-world context.</li> <li>• Determining if a mathematical solution in the context of a real-world problem is plausible.</li> <li>• Justifying whether or not a mathematical solution or conclusion makes sense given the context of a problem.</li> </ul>

Utilizing the triangulation method, data were evaluated. Triangulation is the process of bolstering data from several sorts of sources (Creswell, 2012). The research's supporting evidence is strengthened by examining the correctness of the findings and how the same data were interpreted using various methods, namely through the students' work in the written test and interviews. Through the Miles & Huberman (1984) stages of data

reduction, data presentation, and drawing conclusions, triangulation was implemented.

## **RESULTS AND DISCUSSION**

The percentage of students who were unable to solve the problem correctly reached 52% of the 25 students who took the written test. Meanwhile, the inability of students based on each numeracy indicator is presented in Table 2.

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Table 2 Percentage of students who were unable to complete the process correctly

Numeracy Indicator	Percentage of Students who were Unable to Complete the Process Correctly
Formulating	36%
Employing	44%
Interpreting, applying, and evaluating	52%

Then three subjects were selected representing the inability in each numeracy indicator presented in Table 3.

Table 3 Inabilities experienced by research subjects

Numeracy Indicator	S1	S2	S3
Formulating	-	√	√
Employing	-	-	√
Interpreting, applying, and evaluating	-	-	-

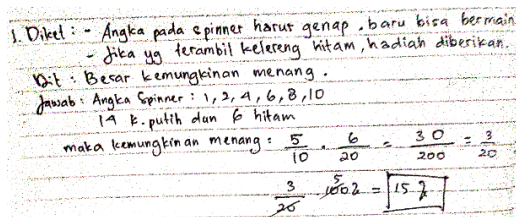


Figure 2 Subject 1 (S1) answer

Figure 2 shows the answer of S1 in the written test. According to the results of the written test and interviews, in the process of formulating, S1 is able to carry out the process of recognizing and identifying the contextual problem well, but is unable to formulate it into mathematical form correctly. The student is able to determine what is known and asked in the question but makes a mistake by writing down the probability of getting an even number on the spinner as 5/10.

To help S1 carry out the process of formulating correctly, scaffolding is provided in the form of reviewing and restructuring. Reviewing is provided

through prompting and probing, for example by asking what is the first condition for Susan to win the prize. Restructuring is provided through negotiating meanings, for example by requesting the students recheck information between what they get and what is presented in the visual representation of the problem regarding how many even numbers are on the spinner. To help S1 carry out the process of employing correctly, scaffolding is provided in the form of reviewing through prompting and probing. In the process of interpreting, applying, and evaluating, scaffolding is provided in the form of making connections and generating conceptual discourse. After getting scaffolding, S1 can correct 5/10 to 5/6 and recalculate until S1 gets the correct answer.

Figure 3 shows the answer of S2 in the written test. According to the results of the written test and interviews, in the process of employing, S2 was unable to devise and implement the plan to find mathematical solution correctly. The student solves the problem using the addition rule when it should be by using the multiplication rule.

$$\begin{aligned}
 & \text{1. Cari } n(S) \text{ dulu:} \\
 & n(S) = C_5^1 + C_{20}^1 \\
 & = \frac{5!}{4!1!} + \frac{20!}{19!1!} \\
 & = 5 + 20 \\
 & n(S) = 26 \\
 & \text{Cari } n(A) = \text{angka genap lalu bola hitam} \\
 & n(A) = C_5^1 + C_6^1 \\
 & = \frac{5!}{4!1!} + \frac{6!}{5!1!} \\
 & = 5 + 6 \\
 & n(A) = 11 \\
 & \text{Peluang menang} = \frac{n(A)}{n(S)} = \frac{11}{26}
 \end{aligned}$$

Figure 3 Subject 2 (S2) answer

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S2 recognizes and identifies the contextual problem, then formulates it into mathematical form correctly. Hence in the process of formulating, the scaffolding provided is only in the form of reviewing through students explaining and justifying. To help S2 carry out the process of employing properly, scaffolding is given in the form of reviewing and restructuring. Reviewing is provided through prompting and probing, for example by asking how many conditions must Susan meet to win the prize. Reviewing is provided through negotiating meaning, for example by asking whether the outcome of the first event affects the number of possible outcomes of the second event thus students are brought to the concept of independent events and multiplication rules. In the process of interpreting, applying, and evaluating, scaffolding is provided in the form of making connections and generating conceptual discourse. After getting scaffolding, S2 can correct the addition operation to become a multiplication operation until S2 gets the correct answer.

Figure 4 shows the answer of S3 in the written test. According to the results of the written test and interviews, in the process of interpreting, applying, and evaluating, S3 was unable to write a conclusion. The student does not interpret the result back into the real-world context, assess how sensible the mathematical solution is in the context of a real-world problem, and explain whether or not the mathematical result or conclusion makes sense given the context of a problem.

1. Diketahui

- Spinner berhenti pada angka genap, pemain diperbolehkan mengambil satu kelereng
- Angka di spinner = 1, 2, 4, 6, 8, 10
- 14 kelereng putih, 6 kelereng hitam
- Hadiah diberikan jika kelereng hitam terambil

Ditanya

Seberapa besar kemungkinan pengambilan hadiah?

$$n(A) = n(S) = 6C_1 \cdot 20C_1$$
$$n(S) = 6 \cdot 20 = 120$$
$$n(A) = 5C_1 \cdot 6C_1 = 5 \cdot 6 = 30$$
$$\frac{30}{120} = \frac{1}{4}$$

Figure 4. Subject 3 (S3) answer

S3 recognizes and identifies the contextual problem, then formulates it into mathematical form correctly. Hence in the process of formulating, the scaffolding provided is only in the form of reviewing through students explaining and justifying. Because the strategy for finding the solution used by S3 is correct, in the process of employing, the scaffolding provided is only in the form of reviewing through students explaining and justifying. To help S3 carry out the process of interpreting, applying, and evaluating correctly, scaffolding is provided in the form of making connections and generating conceptual discourse. An example of making a connection is asking the meaning of  $1/4$  and asking if it is a high possibility, while an example of generating a conceptual discourse is asking whether the probability obtained makes sense given the context of the problem. After getting scaffolding, S3 can write the correct conclusion. Scaffolding provided to students who have disabilities in each numeracy indicator is presented in Table 4.

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Table 4 Scaffolding Provided in Each Numeracy Indicator

<b>Numeracy Indicator</b>	<b>Scaffolding Level</b>	<b>Scaffolding Type</b>	<b>Information</b>
Formulating	Reviewing	Prompting and probing	Prompting encourages students to try to guess the desired response while probing encourages students to provide their thoughts.
	Restructuring	Students explaining and justifying	Students are asked to explain and justify their thinking.
Employing	Reviewing	Negotiating meanings	Teachers and students negotiate interpretations or solutions.
	Reviewing	Prompting and probing	Prompting encourages students to try to guess the desired response while probing encourages students to provide their thoughts.
Interpreting, applying, and evaluating	Restructuring	Students explaining and justifying	Students are asked to explain and justify their thinking.
		Negotiating meanings	Teachers and students negotiate interpretations or solutions.
	Developing conceptual thinking	Making connections	Students are encouraged to make connections between ideas in mathematics.
	Developing conceptual thinking	Generating conceptual discourse	Students are encouraged to be able to provide an acceptable mathematical explanation.

Based on Table 1, the students' numeracy in solving counting rules problems was not good. The percentage of students who cannot solve problems correctly is 52%. The percentage of students who are unable to formulate is the smallest and the percentage of students who are unable to interpret, apply, and evaluate is the biggest. This results is consistent with prior studies conducted by Dewantara et al. (2015).

Students who are not able to formulate, cannot translate the problem into mathematical language or representations. This results is consistent with prior studies conducted by Jupri & Drijvers (2016) that formulating problems into mathematical models is one of the causes of students' difficulties in solving word problems. For this reason,

the scaffolding provided is in the form of instructions through prompting and probing, as well as raising alternative problem formulations from students through negotiating meanings.

Students who are not able to employ, cannot devise and implement strategies to find a mathematical solution. This is in accordance with previous research conducted by Triliana & Asih (2019) that in solving counting rules problems, students cannot identify the operation or sequence of operations needed to solve the problem. According to Anggara et al. (2018), this is because students have difficulty understanding the principles of certain events such as disjoint events or independent events. For this reason, the scaffolding provided is in the form of instructions through

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prompting and probing, as well as raising alternative problem solving strategies from students through negotiating meanings.

Students who are not able to interpret, apply, and evaluate, cannot write a conclusion. This indicates that the results of their work are not reviewed by the students (Pratikno & Retnowati, 2018). Additionally, cannot write a conclusion shows that students do not understand the problem (Saygılı, 2017). For this reason, the scaffolding provided is in the form of making connections between students' mathematical ideas through making connections, as well as generating acceptable mathematical explanations through generating conceptual discourses.

Students who are already able to formulating and employing are given scaffolding in the form of reinforcement through students explaining and justifying. After being given scaffolding, students are able to answer the counting rules problem correctly and understand it.

The scaffolding provided to improve students' numeracy in solving problem of counting rules is shown in Table 4. This is in accordance with previous research that the scaffolding needed to help students solve PISA-type math problems (Sari & Valentino, 2017) and counting rules (Anggara et al., 2018) is reviewing, restructuring and developing conceptual thinking. However, this study uses scaffolding which limited to that are provided by the teacher.

## CONCLUSION AND SUGGESTION

From the results of students' work and interviews, it was found that students' numeracy in solving problem of counting rules was not good yet. Students are able to correctly answer

and comprehend problem after receiving scaffolding. Hence to improve students' numeracy in solving problem of counting rules, a guide in the form of scaffolding is needed that is applied to each indicator of the numeracy process.

Students who are not able to formulate and employ correctly, are given scaffolding in the form of reviewing by prompting and probing, and scaffolding in the form of restructuring by negotiating meanings. Meanwhile, students who are able to formulate and employ correctly, are given scaffolding in the form of reviewing by students explaining and justifying. In the process of interpreting, applying, and evaluating, students are given scaffolding in the form of making connections and generating conceptual discourse.

This study uses scaffolding which limited to that are provided by the teacher. Henceforth, conducting research on the use of scaffolding with peers or assistive devices in the form of instruments, teaching materials, or computer programs to improve students' numeracy in solving problem of counting rules is required.

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