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Exploring Students' Numerical Literacy on Statistical Problem-Solving in Indonesia

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Abstract
Numerical literacy is a skill that must be possessed by students. It is the ability to use numbers and mathematical symbols to solve practical problems in daily contexts. In statistics courses, it is identified that 73.3% of students could solve paired t-test problems using the SPSS 21 program, but 86.36% of these students could not understand the symbols and numbers in the output of the program. This indicates that students' numeracy literacy skills need further analysis. This study aims to analyze students' numeracy literacy by using paired t-test statistical problem-solving. The type of this research was qualitative descriptive research with a case study method. This study employed a purposive sampling technique. The subjects were 30 students of mathematics education. Data were analyzed using a triangulation technique between two assignments. This study has obtained sixth major results. First, 53.3% of students cannot write statistical hypotheses correctly. Second, 73.3% of students cannot determine the solution at the output of the SPSS 21 program. Third, 60% of students cannot conclude their answers correctly. Fourth, subjects with low numerical literacy skills could understand the meaning of the questions. Fifth, subjects with medium numerical literacy skills should get training on numeracy literacy-based questions to improve their numerical analysis skills. Sixth, subjects with medium numerical literacy skills could conclude the solution correctly and tend to reflect on the process before concluding a final solution.

Keywords: Numerical literacy; mathematics education student; statistical problem; problem-solving.

1. Introduction

Literacy is a person's ability to process and understand information in reading and writing. Meanwhile, numeracy is the ability to apply numeral concepts and arithmetic skills in daily life. These two definitions suggest that numeracy literacy is the ability to use numbers and mathematical symbols to solve practical problems in daily contexts (Setiyani. et al., 2022). The Ministry of Education and Culture states that numeracy literacy is the knowledge and skills to use various kinds of numbers and symbols related to basic mathematics to solve practical problems in daily life, analyze the information presented in various forms, and interpret the results of the analysis to predict and make decisions (Polat & Turhan, 2022). Numeracy literacy consists of three aspects: arithmetic, numeracy relations, and arithmetic operations. Meanwhile, the cognitive level shows that the thought processes are required to solve problems or questions (Jain & Rogers, 2019; Grotlüschen et al., 2020). Cognitive processes in reading literacy and numeracy are divided into three levels: finding information, interpretation and integration, as well as evaluation and reflection. Meanwhile, numeration consists of three levels: understanding, application, and reasoning (Güngören et al., 2022).

The numeracy literacy achievement is determined by the achievements of Indonesian students in the international arena; for this case, Indonesian students' reading literacy ranks 72 of 77 countries. The score of their reading literacy is 70% below the minimum competency. Meanwhile, their scores in

mathematical and scientific literacy skills are 71% and 60% below the minimum competency (OECD, 2014, 2016, 2019). These numerical literacy achievements denote that a numeracy literacy skill is a pivotal skill to master by students, including university students. However, the importance of numeracy literacy is contradictory to reality as shown in the operations of research lectures. It is identified that 73.3% of students in a lecture could solve paired t-test problems using the SPSS 21 program, but 86.36% of them could not understand the symbols and numbers in the output of the program. Ideally, if students can do a high maximum iteration of the algorithm, they can determine a better solution to the problem (Samdean et al., 2019). Such a phenomenon indicates that students' numeracy literacy skills need further analysis. This result is supported by Rosidah, et al. (2018), who have discovered that students have poor conceptions and reasoning in descriptive statistics. Therefore, this study was conducted to analyze students' numeracy literacy using paired t-test statistical problem-solving and examine the factors affecting students' numeracy literacy skills which influence the decision-making to solve statistical problems.

The indicators for analyzing students' numeracy literacy were referred to as numeracy literacy indicators of the OECD and PISA (Nusantara et al., 2021; Tampa et al., 2022). Several indicators were employed as a reference for measuring numeracy literacy skills as contained in the Organization for Economic Co-operation and Development (OECD). These skills include (1) communication skills, (2) mathematical ability, (3) representation ability, (4) reasoning and argumentation skills, (5) the ability to choose strategies to solve problems, (6) the ability to use language and symbolic, formal, and technical operations, and (7) the ability to use mathematical tools. Meanwhile, Lüssenhop and Kaiser (2019), state that according to PISA, the indicators of numeracy literacy skills consist of six levels. At the first level, students can answer questions in a general context, and all relevant information is available. At the second level, students can interpret and recognize situations with contexts demanding direct conclusions, work on basic algorithms, use formulas, carry out procedures or agreements to solve problems, and precisely conclude the results of the solution. At the third level, the students can carry out procedures clearly, including procedures that require sequential decisions, as well as create descriptions based on the results of their interpretation and reasons. At the fourth level, students can move with certain and complex methods effectively, concrete situations that may involve obstacles, make assumptions, as well as select and use different representations including symbols. At the fifth level, students can develop and work with models for statistical situations, use their thinking and reasoning, correctly connect the representation of symbols with the situation, as well as describe and formulate the results of their work. At the sixth level, students can conceptualize, generalize, and use information based on study and modeling in statistical situations as well as formulate the results of their work appropriately by considering their findings, interpretations, opinions, and accuracy in real situations. Based on the indicator frameworks of OECD and PISA, indicators for analyzing students' numeracy literacy was developed in the assignment of statistics (Nusantara et al., 2021).

2. Material and Method

This research employed a qualitative descriptive study using the case study method. The sampling technique employed purposive sampling. The research subjects were 30 students of mathematics education. Data were analyzed using a triangulation technique between two assignments. In each assignment, the students were asked to determine: 1) a statistical hypothesis, 2) a test step, and 3) conclusions from the existing research hypotheses on the problem. The assignment instruments of this research were shown in below.

This study aims to investigate differences between the number of seeds produced by each upper and lower flower of 10 mangrove plants. Is there any difference between the number of seeds produced by the upper and lower flowers of a plant?

	1	2	3	4	5	6	7	8	9	10
Upper	1,4	3,3	2,0	0,4	2,1	1,9	1,1	0,1	0,9	3,0
Lower	1,1	1,7	1,8	0,3	0,8	1,4	1,0	0,4	0,7	0,9

The following data are the results of measuring the I/E scale (internal external locus of control scale) from two groups of people, namely group A which consists of 20 smokers who want to stop smoking and group B which consists of 20 smokers who do not want to stop smoking habit.

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No	1	2	3	4	5	6	7	8	9	10
A	8	5	10	9	8	8	9	10	6	11
B	13	18	11	17	8	10	10	16	14	15
No	11	12	13	14	15	16	17	18	19	20
A	14	15	18	8	9	16	9	9	5	15
B	15	10	11	10	10	13	10	13	16	10

Test whether there is a difference in the-I/E scale between the two groups!

After the subject completed the two assignments above, the data were validated using technical triangulation. Conformity analysis was carried out to examine students' answers in the first and second assignments. The numeracy literacy indicators were derived from the definition of literacy used in the introductory chapter. After validating the data, the students' numeracy literacy was analyzed by considering the indicators of numeracy literacy in solving statistical problems. The numeracy literacy indicators are summarized in Table 1.

Table 1. Indicators of numerical literacy in statistical problem-solving.

Level of Numerical Literation		Description
low	**1**	Students can: a) determine the information on the problem, and b) determine the research hypothesis
	2	Students can: a) determine the information on the problem, b) determine the research hypothesis, and c) Determine the significance level and the value of the t-table.
Medium	**3**	Students can: a) determine the information on the problem, b) determine the research hypothesis, c) determine the significance level and the value of the t-table, and d) Determine the formula for the statistical test.

Level of Numerical Literation		Description
High	4	Students can: a) determine the information on the problem, b) determine the research hypothesis, c) determine the significance level and the value of the t–table, d) determine the formula for the statistical test, and e) Determine the t-value calculated using the formula of the statistical test.
	5	Students can: a) determine the information on the problem, b) determine the research hypothesis, c) determine the significance level and the value of the t-table; d) determine the formula for the statistical test, e) determine the t-value calculated using the formula of the statistical test, and f) Determine the rejection area of H_0.
	6	Students can: a) determine the information on the problem; b) determine the research hypothesis, c) determine the significance level and the value of the t–table, d) determine the formula for the statistical test, e) determine the t-value calculated using the formula of the statistical test, f) determine the rejection area of H_0, and g) Determine to accept or reject the research hypothesis.

3. Results and Discussion

Subjects did the assignment in Figure 1 on the first day (21 October 2022) and did the assignment in Figure 2 on the second day (28 October 2022). The assignments were done on different days and the data should be validated using technical triangulation by giving an interval between the two assignments. Therefore, the results are not just coincidence, and the subject is not affected by the answers of the previous assignment. The results of recapitulating the two assignments are described in Table 2.

Table 2. Simplex Table Assignment Results.

Evaluation Aspect	Statistical Hypothesis	Test Step	Final Solution	Level		
				Low	Medium	High
Problem 1	10	12	18	19	14	4
Problem 2	6	8	16	26	8	3

After obtaining the data in Table 2, each subject was selected from each level using a purposive sampling technique. This technique was selected because the students have a relatively similar cumulative grade point index, different numeracy literacy levels, and good communication skills. The numerical literacy analysis of the three selected subjects is described as follows:

Analysis of the Subjects' Numeracy Literacy at the Low Numeracy Level (SR)

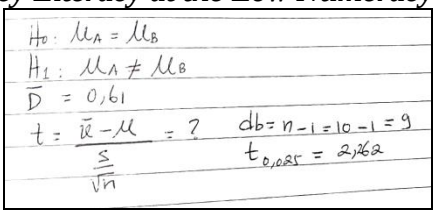
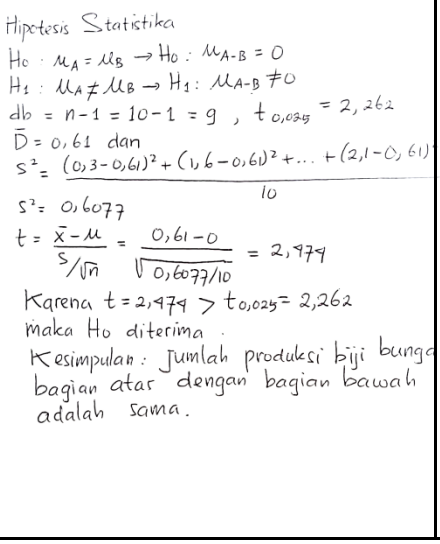


Figure 1. The results of the SR subjects' assignment

SR subjects' results are presented in Figure 3. The SR subjects took a similar step when completing both assignments. SR subjects read both issues aloud. During the first assignment, they stated that this research hypothesis was "is there an average difference between the first population and the second population". This step is in accordance with the indicators of numeracy literacy in solving statistical problems (2a). SR could write statistical hypotheses (H_0 and H_1). This ability is in accordance with the indicators of numeracy literacy in solving statistical problems (2b). Afterward, SR subjects could determine the t-value in the t-students table and could write the formula of the test correctly. However, they were still confused about entering the value for the variable in the question. The steps taken by SR subjects are not in accordance with the indicators of numeracy literacy to solve statistical problems (2c). Therefore, their numerical literacy is categorized as low in level 1.

Students with low numerical literacy skills are able to understand the meaning of the questions but cannot identify what is known correctly (Woodart & Lee, 2020). Students have difficulty representing algebraic symbols and their translation changes correctly (Santia et al., 2019). Therefore, they will find it difficult if they are asked to apply a combination of two-dimensional data to obtain new concepts and reflect them in certain classes (Susilowati et al., 2020, 2023).

Analysis of the Subjects' Numeracy Literacy at the Medium Numeracy Level (SS)



Translete

Statistical Hypothesis

$H_0 : \mu_A = \mu_B$ □ $H_0 : \mu_D = 0$

$H_1 : \mu_A \neq \mu_B$ □ $H_1 : \mu_D \neq 0$

db = n – 1 = 10 – 1 = 9, $t_{0,025}$ = 2,262.

$\bar{D}$ = 0,61 dan $s^2 = \frac{(0,3-0,61)^2 + (1,6-0,61)^2 + \cdots + (2,1-0,61)^2}{10}$ =0, 6077

$t = \frac{\bar{x} - \mu}{s/\sqrt{n}} = \frac{0,61 - 0}{\sqrt{0,6077/10}} = 2,474$

Because t=2,474 > $t_{0,025}$ =2,262, so H_0 accepted.

Conclusion: the number of seeds produced by the upper flower of the plant and the lower flower of the plant are the same.

Figure 2. The results of the SS subjects' assignment

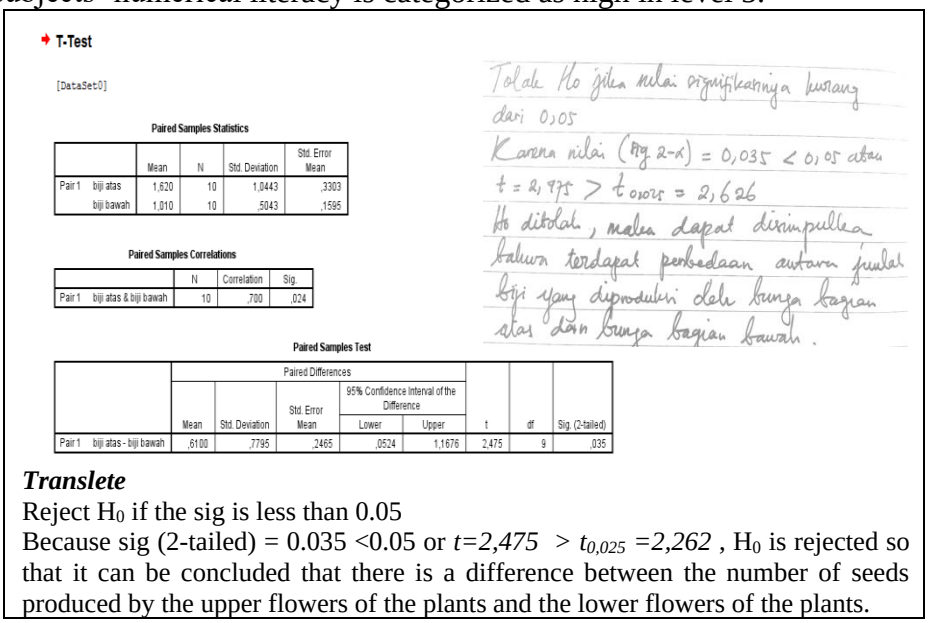
SS subjects' results are presented in Figure 4. The first step taken by SS subjects when completing both assignments was to read the questions carefully. During the first assignment, they stated that this research hypothesis was "is there an average difference between the first population

and the second population." They could write statistical hypotheses (H_0 and H_1). This ability is in accordance with the indicators of numeracy literacy in solving statistical problems (4a and 4b). SS could also determine the t-value in the t-students table and write the formula of the test correctly. They could calculate the question correctly and determine the criteria for rejecting H_0 correctly. This ability is in accordance with the indicators of numeracy literacy in solving statistical problems (4a, 4b, and 4c). However, SS subjects made a wrong conclusion. SS subjects were not aware of errors in adding variables that required subtracting other variables. As a result, the value in the objective function was not negative when the iteration was completed. Thus, SS subjects' numerical literacy is categorized as medium in level 4.

Students with moderate numeracy skills need to receive training on numeracy-based questions to improve their numerical analysis skills (Grotlüschen et al., 2020; Alimudin et al., 2022). Related to numeration, Adirasari et al. (2021) said that one of some concepts in mathematics theory that combine these two concepts is resolving dominating number. Therefore, numeracy skills need special attention. The same thing was also expressed by Susilowati et al. (2021) that a person can have a different representation from other people when they understanding mathematical concepts. This can be seen when students are faced with graph theory problems, they tend to have different representations. This indicates that, solving a problem, it requires the ability to understand the language of symbols through numeracy literacy.

Analysis of the Subjects' Numeracy Literacy at the High Numeracy Level (ST)

ST subjects' results are presented in Figure 5. ST subjects started completing both assignments by observing the problem without reading the questions. During the first assignment, they wrote down the criteria for rejecting H_0. This step is in accordance with the indicators of numeracy literacy in solving statistical problems (6a and 6b). Moreover, they explained the flow of hypothesis testing with SPSS 21 and concluded the solution correctly. These abilities are in accordance with the indicators of numeracy literacy in solving statistical problems (6c until 6f). In contrast, in the second assignment, ST subjects had difficulty adding variables but still managed to answer and conclude the final solution. They could correctly conclude the final solution because they took into account the significance value of the paired t-test and the calculated t-value from the SPSS 21 calculation process. In this case, they do not meet the indicators of numeracy literacy in solving statistical problems (6f). Therefore, ST subjects' numerical literacy is categorized as high in level 5.



T-Test

[DataSet0]

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	biji atas	1,620	10	1,0443	,3303
	biji bawah	1,010	10	,5043	,1595

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	biji atas & biji bawah	10	,700	,024

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	biji atas - biji bawah	,6100	,7795	,2465	,0524	1,1676	2,475	9	,035

Tolak Ho jika nilai signifikannya kurang dari 0,05

Karena nilai (Sig. 2-tailed) = 0,035 < 0,05 atau $t = 2,475 > t_{0,025} = 2,626$

Ho ditolak, maka dapat disimpulkan bahwa terdapat perbedaan antara jumlah biji yang diproduksi dalu bunga bagian atas dan bunga bagian bawah.

Translete

Reject H_0 if the sig is less than 0.05

Because sig (2-tailed) = 0.035 <0.05 or $t=2,475 > t_{0,025} = 2,262$, H_0 is rejected so that it can be concluded that there is a difference between the number of seeds produced by the upper flowers of the plants and the lower flowers of the plants.

Figure 3. The results of the ST subjects' assignment

What ST has done shows that students' numeracy literacy is also influenced by cognitive style (Bolstad, 2020; Santia et al., 2021). Students with a reflective cognitive style like student with hight

numeracy literacy skills tend to reflect on the process before concluding a final solution (Santia et al., 2019; Susilowati et al., 2020). The same thing was also expressed by Aisyah et al. (2020) and Umilasari et al. (2022) that problem solvers must be able to determine the mathematical attributes that are known in the problem, then generalize in a broader concept appropriately. As well as determining the exact value of the dominant local metric dimension is positively correlated to the product graph. The several statements above, it shows that cognitive style and the ability to determine the initial attributes of a concept are needed by problem solvers.

The Results of Numeracy Literacy of SR, SS, and ST

The results showed that there were differences in numeracy literacy for each subject when solving statistical problems. The results of this analysis are based on the exploration of the results of working on statistical problems for each subject which are analyzed based on the indicators in Table 1. The differences in SR, SS, and ST numeracy literacy in solving statistical problems, in the case of testing the hypothesis are shown in Figure 6. In these diagram, it can be seen that the numerical literacy of the three subjects differs in indicators d, e, f, and g. SR does not meet indicators d, e, f, and g. Therefore, based on the results, SR's numerical literacy is categorized at level 1 (low). SS also does not meet the indicators f and g. Therefore, based on the exploration results, the SS numerical literacy is categorized at level 4 (medium). While ST does not fulfill only one indicator, namely indicator g. Therefore, based on the exploration results, ST's numerical literacy is categorized at level 5 (high). These results indicate that there is a relationship between cognitive absorption abilities (Noerman et al., 2021; Güngören et al., 2022), and numerical literacy, and the success of solving mathematical problems is also influenced by numerical literacy (Alimudin et al., 2022 ; Bolstad et al., 2020).

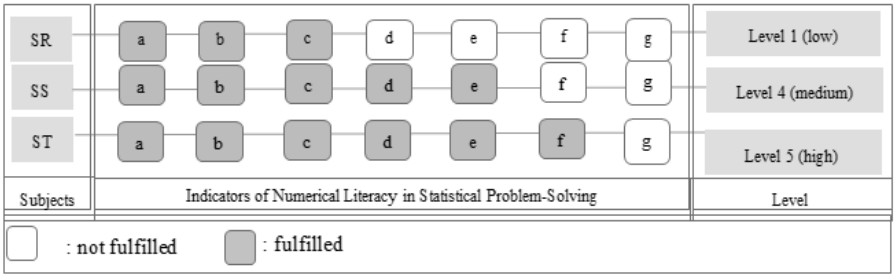


Figure 4. The three subjects' numerical literacy in statistical problem-solving

4. Conclusion

This research explored mathematics students' numerical literacy in solving statistical problems based on numeracy levels. Moreover, this study involved a low numeracy level (SR), a medium numeracy level (SS), and a high numeracy level (ST). There are several factors affecting students' numeracy literacy skills which influence the decision-making to solve statistical problems, including cognitive style, understanding of symbol language, and determining the initial attributes of a concept.

This study has revealed six major findings. First, 53.3% of 30 mathematics students could not write statistical hypotheses correctly. Second, 73.3% of 30 mathematics students could not determine the solution at the output of the SPSS 21 program. Third, 60% of 30 mathematics students could not conclude their answers correctly. Fourth, subjects with low numerical literacy skills could understand the meaning of the questions. However, they could not identify the information correctly and have difficulty representing algebraic symbols and translating changes correctly. Fifth, subjects with medium numerical literacy skills should get training on numeracy literacy-based questions to improve their numerical analysis skills. Sixth, subjects with medium numerical literacy skills could conclude the solution correctly and tend to reflect on the process before concluding a final solution.

This study suggests that further studies, which are interested in the same topic, will increase the number of subjects and prolong the study period. Therefore, the results can characterize mathematics students' numerical literacy in solving statistical problems. The result of characterizing these problems can develop students' numerical literacy to solve other mathematic problems.

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